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Does oral health influence school performance and school attendance? a systematic review and meta-analysis

Abstract

Aim: To examine the evidence on the influence of oral health status on school performance and school attendance in children and adolescents.

Design: A systematic review was performed in accordance with PRISMA included epidemiological studies that assessed concomitantly oral health measures, participants' school performance and/or school attendance. Electronic search was conducted on Medline, SCOPUS, Web of Science, ScienceDirect and LILACS. Studies published up to May 2018 in any language were eligible. The risk of bias was assessed using the Newcastle-Ottawa Scale. Meta-analysis was used to obtain pooled estimates between oral health measures and school performance and school attendance.

Results: Eighteen studies were included. Of them, fifteen studies were used for the meta-analyses. Most studies were assessed as moderate quality. Children with one or more decayed teeth had higher probability of poor school performance (OR = 1.44 95%CI: 1.24-1.64) and poor school attendance (OR = 1.57 95%CI: 1.08-2.05) than caries-free children. Poor parent's perception of child's oral health increased the odds of worse school performance (OR = 1.51 95%CI: 1.10-1.92) and poor school attendance (OR = 1.35 95%CI: 1.14-1.57).

Conclusions: Children and adolescents with dental caries and those reporting worse oral health experience poor school performance and poor school attendance.

Introduction

Enhancing universal primary education is one of the 17 Sustainable Development Goals (SDGs) objectives proposed by the United Nations to reduce poverty, promote development and improve health[1]. All SDGs goals are intimately interconnected which means that developing quality education across different socially deprived groups has the potential to influence other SDGs targets, including eradication of extreme poverty and hunger[2]. Although national sustainable development strategies vary across UN countries, there is a consensus that the development and implementation of sectoral and local government planning should concomitantly address the economic, social and environmental SDGs dimensions[2].

Several aspects are related to access to education and school achievement in children and adolescents. The effects of environmental factors (eg. family structure and socioeconomic condition) and health status (eg. chronic conditions and oral diseases) on school performance are complex due to the multiple interactions between these characteristics[3-5]. Nonetheless, the main mechanisms by which the above mentioned factors influence children's school progress include the disruption on cognitive abilities and poor school attendance. For example, the effects of schooling on cognitive development are stronger for children with low socioeconomic background[4] and chronic pain affects cognitive function in children and adolescents[3].

The possible role of oral conditions in school performance and school attendance in children and adolescents has been investigated. Although some studies have been claiming that poor oral health status negatively affects school performance and school attendance, previous research have been conducted in different populations and assessed distinct oral health measures[6-8]. To date, two reviews explored whether oral health conditions influence school performance and school absenteeism[5,9]. In the first critical review paper, descriptive studies such as those using ecological design were included, and quality assessment was not performed. In addition, another relevant limitation was the use of oral health-related quality of life measures to evaluate school performance. The second review focused on the possible link between dental clinical status and school performance[9]. Therefore, subjective oral health and school attendance were out of scope. Only 6 studies were included and meta-analysis on the relationship between oral health and school performance was not conducted[9]. The former review concluded that oral diseases appear to impact on lost school days by children and adolescents and on school performance[5]. However, the latter did not reach a conclusive finding on association between oral health conditions and academic performance of children and adolescents[9].

To date, this subject has not been rigorously and comprehensively reviewed since there

is no systematic review with meta-analysis on the impact of oral health on school performance and school absenteeism in children and adolescents evaluating clinical and subjective oral health measures. Therefore, the aim of this study was to systematically review the evidence on the possible influence of oral health on school performance and school attendance in children and adolescents.

Material and Methods

The protocol of this systematic review was registered on the National Institute of Health Research Database (PROSPERO: registration number CRD42016036909), and presented according to the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA Statement) checklist[10].

Eligibility criteria

Epidemiologic studies involving participants aged 18 years or under that assessed oral health measures concomitantly with information regarding participants' school performance and/or school attendance were selected. Clinical trials and observational (cohort, case-control and cross-sectional) studies published in any language were eligible. Editorials, letters to editors, review papers, descriptive studies (case reports and case studies) and duplicated studies were excluded.

Information sources and search strategy

The following electronic libraries were searched without publication period restrictions to May 2018: MEDLINE (via PubMed), SCOPUS, Web of Science, ScienceDirect and LILACS. No search of the grey literature was undertaken.

Three themes were first derived that were then combined by using the Boolean operator ''AND''. Each theme was created by using the operator ''OR'' to search for terms appearing as either explored subject headings (MeSH) or text words. The first theme was created for 'children' or 'adolescence' or 'adolescent', the second for 'oral health' or 'dental health' or 'oral conditions' or 'dental conditions' or 'dental problems' or 'oral problems' or 'dental needs' or 'dental care' or 'dental treatment' or 'dental pain' or 'dental decay' or 'caries' or 'oral infections' or 'dmft' and the third for 'school performance' or 'academic performance' or 'school attendance' or 'school absence' or 'school absenteeism' or 'absenteeism'. The full search strategy for the PubMed/MEDLINE data base is presented as online Supplementary Data file S1. The search strategy was adapted for the other database.

Selection of studies

All the retrieved studies were screened for inclusion by three reviewers (M.A.B.R., J.M.R.V and J.V.P.) independently. Disagreements between the three reviewers were resolved by

discussion with a fourth reviewer (M.V.V.). First, duplicated studies were removed according to the title of studies. The remaining studies were assessed for inclusion based on the abstracts. Potential eligible studies were then assessed in full for eligibility according to selection criteria. Manual searches were conducted in the reference lists of the identified papers for identification of additional relevant studies. Finally, the selected studies were for inclusion in the meta-analyses.

Data extraction

Data extraction was carried out independently by the three reviewers in a similar method to that used for assessment of studies for inclusion. Data extraction forms were used to record the following information: (1) authors and year of publication; (2) study design; (3) country and study setting; (3) age group and sex; (4) participants sample size; (5) oral health condition and measurement; (6) outcomes: school attendance and/or school performance; (7) number of confounders assessed; and (8) summary of the main findings.

Risk of bias in individual studies

The methodological quality assessment was performed by the same three researchers using the Newcastle-Ottawa Scale (NOS) for cohort studies and case-control, and the modified Newcastle-Ottawa Scale for cross-sectional studies[11-13]. NOS for cohort, case-control studies and cross-sectional studies are made up of 8, 8 and 6 items, respectively. Each item may receive one point (one star) except from the item "Comparability" which score ranges from 0 to 2 stars. Low risk of bias studies could receive a maximum score of 9 stars for cohort and case-control studies, and 7 stars cross-sectional studies. Cohort and case-control studies from 6 to 8 stars were classified as of moderate quality and those with 5 stars or less were considered of low quality. Cross-sectional studies rating between 4 and 6 stars were evaluated as moderate quality and those with 4 stars or less were considered to have low quality[14].

Meta-analysis

The meta-analysis included papers where the effect size (Odds ratios) and 95% of CIs were reported or could be extracted. Continuous effect size measures (eg. mean differences) were translated into Odds ratio standardized effect size using information from the comparison groups, including sample size, mean and standard deviation. Detailed information about data transformation for meta-analysis is available elsewhere[15]. Since only observational studies were included in the meta-analysis, the random effect method was used to obtain pooled estimates, according to the outcome (school performance and school attendance) and the different oral health exposures. Heterogeneity amongst studies was tested by Cochran's Q test. The proportion of the variance between studies due to heterogeneity was assessed using I^2. Meta-analyses reporting $I^2 \geq 75\%$ were rated of high heterogeneity[16]. Potential publication bias

was not tested since the meta-analyses included less than ten studies[17]. All tests were performed using STATA statistical software, version 14.0 (Stata Corp, TX, USA). The level of significance for all tests was 5%.

Results

Fig. 1 presents the flow chart of the identified, screened and selected articles. The initial search identified 9308 potential papers. Of them, 3706 studies remained after excluding duplicated documents. All titles and abstracts were then reviewed and 3638 documents were considered irrelevant and were also excluded. The full text of the remaining 68 papers was analysed for inclusion. Of them, 50 were thereafter excluded according to the inclusion criteria. In the end, a total of 18 studies were included in this systematic review. No additional paper was identified through manual search of the reference lists of the selected papers. Meta-analyses were carried out using data from 15 studies.

Study characteristics

The characteristics of the 18 selected studies are described in Table 1. One cohort[18], one case-control[19] and 16 cross-sectional studies[6-8,20-27] assessed the relationship between different oral health measures and school performance. Of them, five cross-sectional studies also evaluated the association between oral health and school attendance[6,7,22,24,25]. In addition, further 5 studies tested the relationship between oral health and school attendance[28-32].

Most studies were conducted in schools and the sample sizes varied between 312 and 65680 participants[6,29]. Dental caries was the most investigated dental exposure as it was assessed in 9 studies[6-8,19,23,25,27,28,30]. The DMFT and ICDAS were the predominant clinical indices employed to evaluate dental caries. Other oral clinical measures were gingivitis[8,19], dental trauma[6,31], and malocclusion[8,31]. Parent's perception of child's oral health was investigated in 6 studies[8,18,21,22,24,29], while three studies investigated self-perceived oral health[6,8,20] and other three studies assessed toothache[25,26,31]. Of the 12 studies on school performance, eight used information from school registers[6,7,18,19,22,23,26,37], and nearly a third of studies on school attendance obtained information from school reports[6,7,31].

Assessment of risk bias

The risk of bias assessment, according to the specific Newcastle-Ottawa scales for cohort, case-control and cross-sectional studies, of the included studies is presented as online in Supplementary Data files S2, S3, and S4, respectively. One cohort (6 stars) and one case-control study (8 stars) on school performance were considered of moderate quality. Of the 10 cross-sectional studies on school performance, one (3 stars) was considered of low quality[23]

and the remainder were considered to be of moderate quality (4 to 6 stars). One cross-sectional study (2 stars) on school attendance was assessed as low quality[30] and 9 studies were of moderate quality (4 to 6 stars).

Meta-analysis of the association between oral health and school performance

Meta-analysis was used to derive pooled adjusted odds ratios (OR) on the relationship of oral health measures with school performance (Fig. 2) and school attendance (Fig. 3). The pooled effect size of the association between dental caries and school performance was obtained using data from 3205 children from 5 studies[6-8,19,23]. Children with one or more decayed teeth had 44% higher probability of poor school performance than caries-free children (OR: 1.44 95%CI: 1.24-1.64) (Fig. 2). Data from 30995 children from 5 studies were used to obtain the pooled effect size between parent's perception of child's oral health and school performance. Poor school performance was significantly associated with poor paternal perception of children's oral health (OR: 1.36 95%CI: 1.16-1.57)[8,18,19,21,22]. No heterogeneity was observed in both analyses (dental caries: Q: 0.94, P=0.918; parent's perception of child's oral health: Q: 8.88, P=0.064). Meta-analysis of the estimates of the association of gingivitis (Q: 4.14, P=0.042, I^2: 75.9%)[8,19] and toothache (Q: 24.42, P<0.001, I^2: 91.8%)[7,20,26] with school performance revealed high heterogeneity.

***Meta-analysis of the association between oral health and* School attendance**

Children with decayed teeth had significantly higher odds of having poor school attendance than those without dental caries (OR: 1.57 95%CI 1.08-2.05). The pooled effect size was obtained from 5 studies using data from 4416 children[6,7,25,28,30]. Parents of children with poor school attendance were 1.35 times more likely to report poor oral health of their child when data 108214 children from three studies were combined (95%CI 1.22-1.42) (Fig. 3)[22,24,29]. There was no statistical association of dental trauma and toothache with school attendance. The study of Krisdapong et al[25] presented their findings in two age groups in separate (12 and 15 years old). Thus, data on the association of dental caries and toothache with school attendance of each age group was considered for meta-analyses. Heterogeneity tests on the meta-analyses for school attendance were not statistically significant (dental caries: Q: 2.24, P=0.816; dental trauma: Q: 0.53; P=0.467; parent's perception of child's oral health: Q: 4.37; P=0.113); toothache: Q: 0.31; P=0.580).

Discussion

This is the first review paper that systematically investigated the evidence on the influence of oral health status on school performance and school attendance in children and adolescents using a meta-analytic approach. Our findings showed that oral diseases and poor subjective oral health are meaningful determinants of school performance and school attendance in children and adolescents. Children and adolescents with decayed teeth had 44% higher probability of poor school performance and 57% greater likelihood of poor school attendance. In addition, poor paternal perception of children's and adolescent's oral health was associated with 51% higher odds of poor school performance and 35% higher likelihood of poor school attendance. Overall, most of the primary studies selected showed moderate methodological quality, though no study was considered of high quality. The association between toothache and school attendance was not statistically significant. This was an unexpected finding since dental pain is considered the main mechanism by which dental diseases influence missing days at school[22,25].

The results are in agreement with the findings of a former critical review of the relationship between oral conditions and oral health-related quality of life as a proxy measure to assess student's school performance[5]. However, contrary to another previous systematic review, dental clinical status was significantly associated with poor school performance[9]. School performance and school attendance are important aspects in the routine of children's lives and may reflect into some extent their quality of life. The importance of oral health as one of the key elements for good quality of life and wellbeing has been investigated. Recent studies support the impact of oral diseases on children's and adolescent's quality of life and daily life activities[33-35]. Untreated dental caries was a meaningful predictor of functional oral health status, a relevant dimension of quality of life[34]. Similarly, decayed teeth predicted poor oral health-related quality of life and daily life activities[33-35]. In addition, there is evidence on the benefits of dental interventions, such as treatment of dental caries and malocclusion to improve children's quality of life[36,37].

The implications of our results for children's development and educational attainment and subsequent future life opportunities are noteworthy. Significant aftermaths of poor oral health may result in missing schooling opportunities and low academic achievement with clear negative social and economic consequences[38]. Toothache and oral infections affect children both physically and psychologically since oral diseases influence dietary intake, sleeping habits, social interaction resulting in learning difficulty[39]. Thereof, dental caries affects children's ability to feed properly resulting in poor nutritional status as well as impaired growth and weight gain which in turn compromise cognitive function and learning process[40]. A

previous review reported that children with inadequate dietary intake and insufficient food consumption are at a disadvantage academically[41].

Time and costs associated with dental care and managing chronic dental pain can result in devastating consequences to children and their families, increasing the stress burden with great impact on the society due to direct and indirect large costs[42]. In the US, affordability of needed dental care is the leading indicator of missing school days even when dental insurance and deprivation are taken into account[38]. Direct costs of dental treatment worldwide were estimated at $298B in the year 2010. Indirect costs due to dental diseases, including parents taking time off to take their children to dental care, were $144B. It is important to highlight that $2.09B (1%) were related to indirect costs to untreated dental caries in deciduous teeth[43].

The findings of the present systematic review should be interpreted with caution by reason of the following methodologic limitations. Expectedly, all papers included in this review were observational study designs. Of them, only a single study was longitudinal[18]. Therefore, the strength of evidence is limited due to biases and confounding effect regularly seen in observational research. For example, children's oral health, school performance, and school attendance may be influenced by common factors such as family structure, family composition, and socioeconomic status. However, only nearly half of the studies (61%) took into account socioeconomic conditions[6,8,18,19,21,22,24,27,28,29,32] and only one study considered familial structure[19] when testing the association of oral health with poor school performance and school attendance. Most studies were of moderate quality and no study was considered to be of high quality, reflecting the methodological limitations of the original studies to some extent. The details of risk of bias assessment are reported in the Supplementary Data files and must be addressed in future research. It is also important to note that most studies included in the meta-analyses were conducted in countries with considerable social inequalities related to oral health and school achievement, such as US and Brazil, and there are no studies in European countries. Meta-regression to investigate the sources of heterogeneity between studies and to identify potential sub-group analysis was not conducted since our systematic review included few studies.

The amount of evidence concerning some oral conditions on this topic might be considered too low to reach reasonable conclusions. For example, meta-analyses on the relationship between gingivitis and school performance, and on the association of dental trauma and toothache with school attendance included few studies. Distinct meta-analyses were conducted according to the exposure (oral health) and the outcome (school performance and school attendance). Nevertheless, important methodological discrepancies were observed among the included studies, such as the age range of the participants and the use of different

clinical indices to assess similar clinical oral conditions. In addition, different respondents and questions were employed to evaluate subjective child's and adolescent's oral health. Similarly, the assessment of school performance and school attendance used in the original papers were not similar. These variations are relevant factors that may explain the heterogeneity of the meta-analyses of the association between gingivitis and school performance, and between toothache and school performance.

Conclusion

The currently available evidence suggests the need for high-quality longitudinal studies to ascertain whether poor oral health influences school performance and school attendance. The use of reliable information from school records regarding school performance and school attendance and valid oral health measures are paramount to reach more definitive conclusions on this subject. In addition, socioeconomic status and family structure are important aspects to be considered in future studies.

The findings from the present meta-analysis provide grounds for the harmful effect of untreated dental caries and poor subjective oral health on the child's and adolescent's inadequate school performance and poor school attendance. Effective public health approaches to reduce oral diseases are available and can impact on the Target 2A of the Millennium Development Goals: completion a full course of primary schooling.

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Why this paper is important to paediatric dentists

- This systematic review shows that poor oral health status is a meaningful aspect of children's and adolescents' school performance and school attendance.
- It reveals that different clinical and subjective oral health measures may have different impact on school performance and school attendance among children and adolescents.
- It offers evidence on the relevance of considering interventions to improve oral health to enhance school performance and reduce school absenteeism in children and adolescents in future intervention studies.

Figure 1. Flow chart of studies on the relationship of oral health with school performance and school attendance

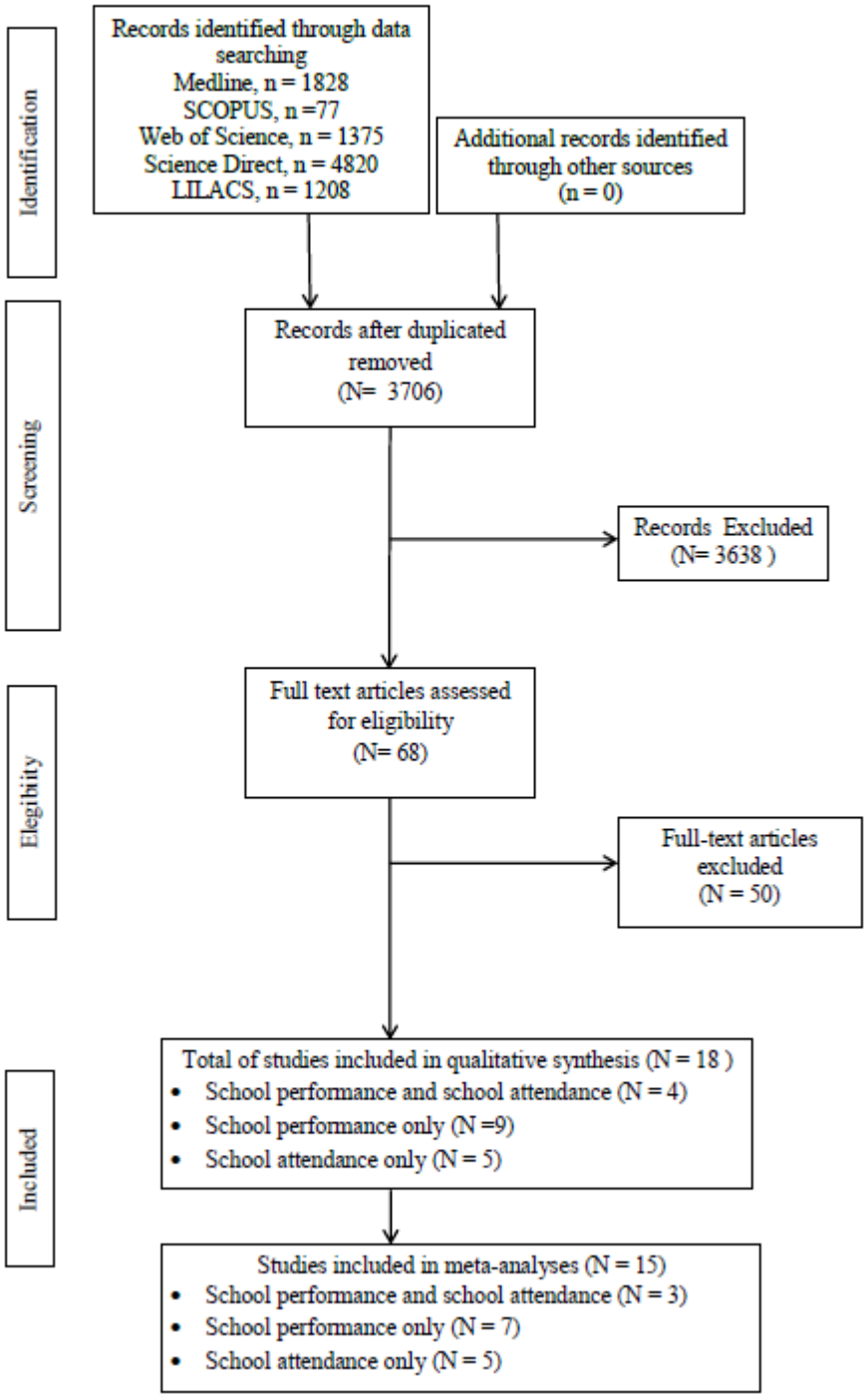

Figure 2. Forest plots presenting the Odds Ratio (OR) and 95% confidence intervals (CI) for the studies on the association between oral health measures and poor school performance.

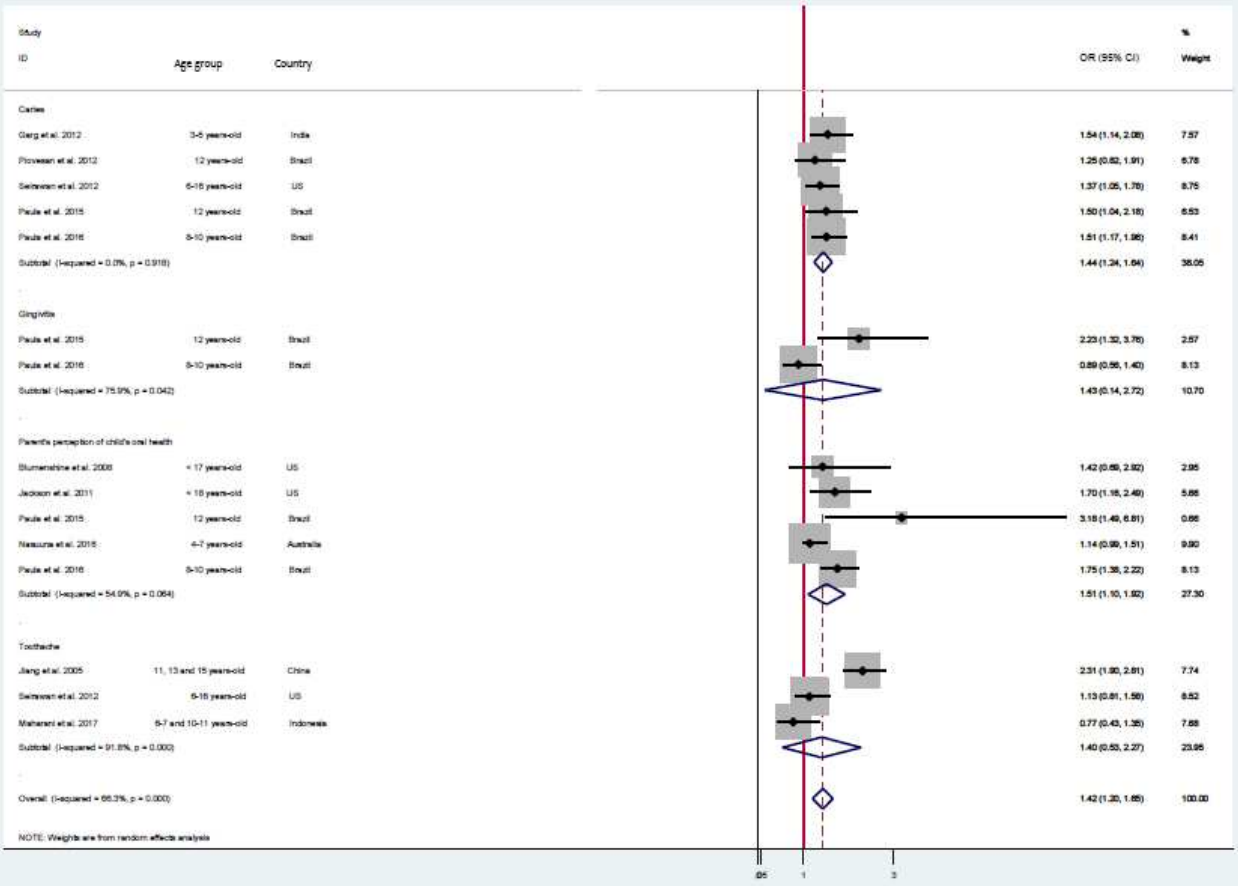

Fig 3. Forest plots presenting the Odds Ratio (OR) and 95% confidence intervals (CI) for the studies on the association between oral health measures and poor school attendance.

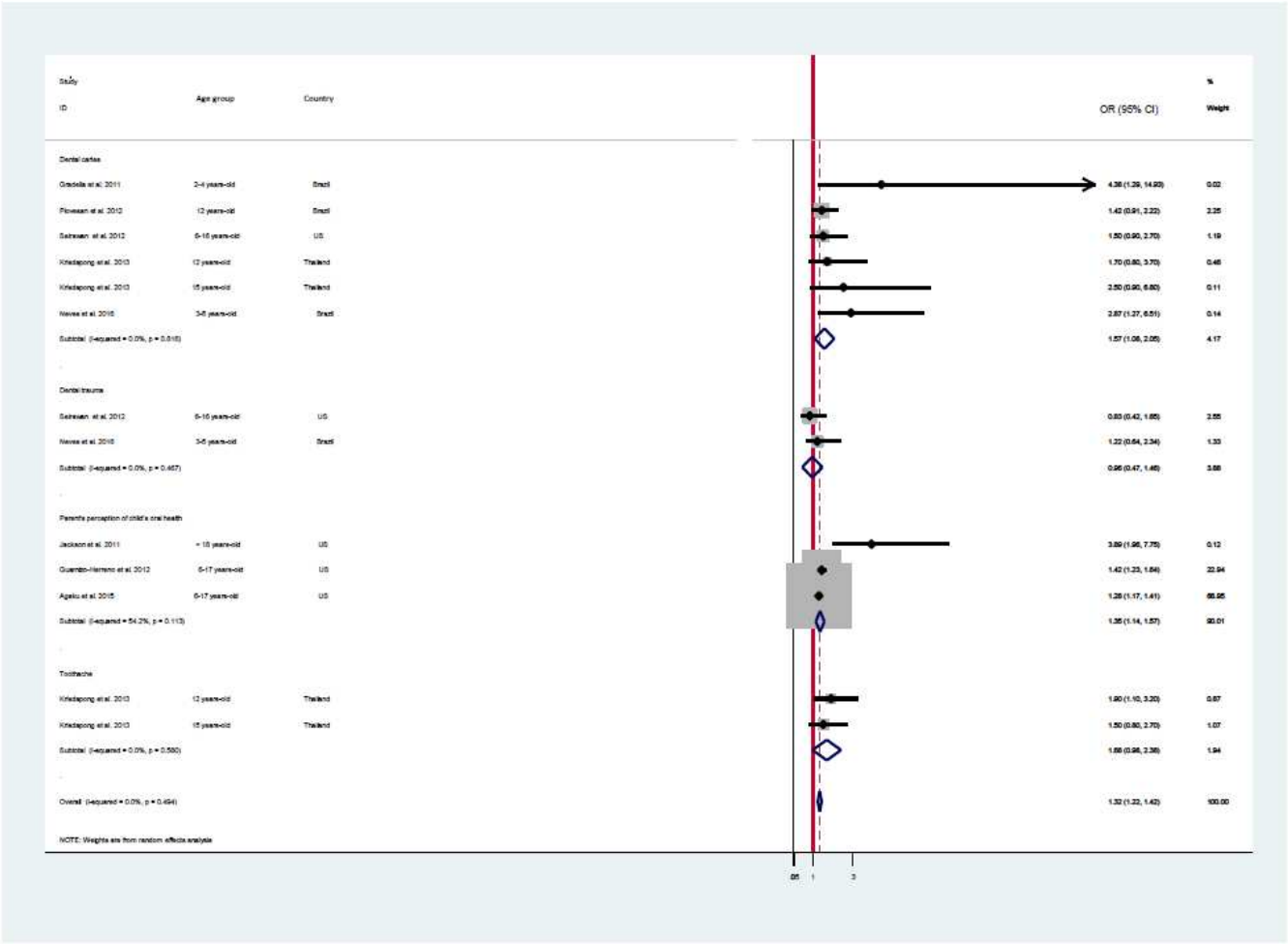

Table 1. Characteristics of studies assessing the relationship of oral health with school performance and school attendance.

Author, year	Study Design	Setting and country	Age (years)	Sample size, sex	Exposure and Measurement of Exposure	Outcome	Outcome assessment	N confouders controlled	Main findings
Nasuuna *et al*., 2016[18]	Cohort	Schools, Australia	4-7	N = 24678 48.6% females 51.4% males	Parents' perception of child's oral health	School performance	Score in numeracy and reading ≤ national miminum standard	6	Dental problems predicted poor reading skills
Paula *et al*., 2016[19]	Case-control	Public schools, Brazil	8-10	N = 1149 51.3% females 48.7% males	Untreated caries (DMFT); bleeding on probing	School performance	Final grades at the end of the year	6	Caries lesions, even if treated, were risk indicators for poor school performance.
Jiang *et al*., 2005[20]	Cross-sectional	Schools, China	11, 13 and 15	N = 2662 % sex not specified	Self-perceived dental health	School performance	Unclear	None	Perceived dental health status and needs were associated with poor school performance,
Blumenshine *et al*., 2008[21]	Cross-sectional	Households (telephone), US	< 17	N = 2871 49% females 51% males	Parents' perception of child's oral health	School performance	Parental perception of school performance	9	Children who have poor oral health are more likely to have poor school performance.
Gradella *et al*., 2011[28]	Cross-sectional	Health centres, Brazil	2-4	N = 765 49.5% female 50.5% male	Dental caries (DMFT) and caries severity (PUFA)	School attendance	Domain "Absence from school" Parental Perceptions Questionnaire	5	Having caries was significantly related to absent from school.
Jackson *et al*., 2011[22]	Cross-sectional	Households (telephone), US	< 18	N = 1782 % sex not specified	Parents' perception of child's oral health	School attendance and school performance	School grades and missing school days reported by the parent	11	Children with poorer oral health status were more likely to experience dental pain, miss school, and perform poorly in school.
Garg *et al*., 2012[23]	Cross-sectional	Private schools, India	3-5	N = 600 47.5% females 52.5% males	Dental caries (N decayed and filled teeth)	School performance	Overall marks obtained from school teachers	None	Poor oral health has impact on lowering school performance
Guarnizo-Herreno *et al*., 2012[24]	Cross-sectional	Households (telephone), US	6-17	N = 40752-41988 49.04% female 50.96% male	Maternal report on specific dental health problems and on child's dental health	School performance and school attendance	School report about any problems at school, homework completion, health-related missed school days during the last year reported by the parent	19	Poorer child dental health was associated with reduced school performance.
Piovesan *et al*., 2012[6]	Cross-sectional	Public schools, Brazil	12	N = 312 55.5% females 44.5% males	Self-perceived oral health, dental trauma and dental caries (DMFT)	School performance and school attendance	Score in Portuguese language and number of school days missed in the last 3months from school register	7	Children with dental caries had lower mean school performance than other children, although the difference was not significant.
Seirawan *et al*., 2012[7]	Cross-sectional	Public schools, US	6-16	N = 629 55% females 45% males	Decayed teeth (1+ cavitaed teeth), types of dental needs	School performance and school attendance	Tests scores of proficiency levels for English language, arts and mathematics, and	3	Oral health affects students' academic performance.

							grade point averages, number of absent days from school register		
Krisdapong *et al*., 2013[25]	Cross-sectional	Households, Thailand	12-15	12 years-old N = 1063 50.4% females, 49.6% males 15-year-old N = 811 51.8% females 48.2% males	Dental caries (DMFT, untreated caries); toothache	School performance and school attendance	Self-reported difficulties in attending school, learning in class, doing homework (Child-OIDP), School absence due to toothache in the last 3 months	8	School absence due to toothache was positively associated with the current year of study and with toothache.
Agaku et al., 2015[29]	Cross-sectional	Households, US	6-17	N = 65680 48.8% females 51.2% males	Parents' perception of child's oral health	School attendance	Missed school days during the last year because of illness or injury reported by the parent	8	Unmet therapeutic dental need in the presence of a dental condition was associated with increased likelihood of school absenteeism.
Paula *et al*., 2015[8]	Cross-sectional	Public and private schools, Brazil	12	N = 515 56.3% females 43.7% males	Parents' perception of child's oral health, self-perceived oral health, dental caries, malocclusion, bleeding on probing	School performance	School report on overall grade (average score 60 or above for pass)	5	Carious lesions, influence school performance.
Neves *et al*., 2016[30]	Cross-sectional	Public and private schools, Brazil	3-5	N = 836 48.5% females 51.5% males	Dental caries, dental trauma and malocclusion	School attendance	Missed school days because of dental problems reported by the parent	4	The prevalence of absenteeism due to oral problems was associated with dental caries.
Shaikh *et al*., 2016[31]	Cross-sectional	Public schools, Saudi Arabia	16-18	N = 480 49.6% females 50.4% males	School days missed due to toothache	School attendance	School attendance records for 6 months	None	Is important to consider the adverseness of orodental problems on school attendance along with academic performance.
Maharani *et al*., 2017[26]	Cross-sectional	Public schools, Indonesia	6-7 and 10-11	N = 984	Toothache in the previous 12 months	School performance	Score in mathematics	None	Children aged 10–11 years who had experienced toothache were found to have lower school performance than their peers.
Kaewkamnerdpong *et al*., 2018[27]	Cross-sectional	Public and private schools, Thailand	12	925 (50.3% females, 49.1% males)	Dental caries (DMFT) and Oral hygiene (OHI-S)	School performance	Total score of the National Standard Examination	14	Dental caries experience were associated with lower school performance. Oral Hygiene Index scores was not.
Naavaal et al., 2018[32]	Cross-sectional	Households, USA.	5-17	3833 (50.4% females, 49.6% males)	Acute/unplanned dental care	School attendance	School hours missed due to acute/unplanned dental care reported by parents	7	Relevant school-hours are lost due to acute/unplanned dental care

Supplemental File 1. PubMed/MEDLINE full search strategy

PubMed/MEDLINE full search strategy

(children OR adolescence OR adolescent) AND (oral health OR dental health OR oral conditions OR dental conditions OR dental problems OR oral problems OR dental needs OR dental care OR dental treatment OR dental pain OR dental decay OR caries OR oral infections OR DMFT) AND (school performance OR academic performance OR school attendance OR school absence OR school absenteeism OR absenteeism)

Supplementary File S2. Quality assessment of cohort study on the relationship between oral health and school performance based on the Newcastle-Ottawa scale.

Supplemental File 2

Table 1. Quality assessment of cohort studys on the relationship between oral health and school performance based on the Newcastle-Ottawa scale.

	Selection				**Comparability**	**Outcome**			Total Score
	Representativeness of the exposed cohort	Selection of the non exposed cohort	Ascertainment of exposure	Demonstration that outcome of interest was not present at start of study	Comparability of cohorts on the basis of the design or analysis	Assessment of the outcome	Was follow-up long enough for outcomes to occur	Adequacy of follow up of cohorts	max. 9 stars
Nasuuna *et al*., 2016[18]	a*	a*	c	b	b**	a*	a*	d	****** (6)

Selection: (Maximum 4 stars)
1) Representativeness of the exposed cohort: a) truly representative of the average individuals in the community*, b) somewhat representative of the average individuals in the community*, c) selected group of users, d) no description of the derivation of cohort.
2) Selection of the non exposed cohort: a) drawn from the same community as the exposed group*, b) drawn from a different source, c) no description of the derivation of the non-exposed-group.
3) Ascertainment of exposure: a) secure record*, b) structured interview or questionnaire*, c) written self reports, d) no description
4): Demonstration that outcome of interest was not present at start of study: 4 a) yes*, b) no
Comparability: (Maximum 2 stars)
1) Comparability of cohorts on the basis of the design or analysis: a) study control for one confounding variable*, b) study control for 2 or more confounding variables**
Outcome: (Maximum 1 star)
1) Assessment of the outcome: a) independent blind assessment*, b) record linkage*, c) self reports d) no description
2) Was follow-up long enough for outcomes to occur: a) yes (select an adequate follow up period for outcome of interest)*, b) no
3) Adequacy of follow up of cohorts: a) complete follow up - all subjects accounted for *, b) subjects lost to follow up are unlikely to introduce bias ≤20% loss or ≥80% follow up, or description provided of those lost*, c) ≥20% loss or ≤80% follow up, or no description of those lost, d) no statement.

Supplementary File S3. Quality assessment of case-control study on the relationship between oral health and school performance based on the Newcastle-Ottawa scale.

Supplemental File 3

Supplemental Table 2. Quality assessment of case-control study on the relationship between oral health and school performance based on the Newcastle-Ottawa scale.

	Selection				**Comparability**	**Exposure**			**Total score**
	Is the case definition adequate?	Representativeness of the cases	Selection of Controls	Definition of Controls	Comparability of cases and controls	Ascertainment of exposure	Same method of ascertainment for cases and controls	Non-Response rate	max.9 stars
de Paula *et al*., 2016[19]	a*	a*	a*	a*	ab**	a*	a*	-	******** (8)

Selection: (Maximum 4 stars)
1) Definition of case: a) Adequate with independent validation or record linkage using clinical indices by calibrated examiners*, b) Self report or clinical indices without description of calibration, c) No description.
2) Representativeness of the cases: a) consecutive or obviously representative series of cases*, b) potential for selection biases or not stated
3) Selection of Controls: a) community controls*, b) hospital controls, c) no description
4) Definition of Controls: a) no history of disease (endpoint)*, b) no description of source
Comparability: (Maximum 2 stars)
1) Confounding factors are controlled. a) The study controls for socioeconomic status*, b) The study control for any additional factor**, c) No description related to the adjustment analysis for confounding factors.
Exposure: (Maximum 3 stars)
1) Ascertainment of exposure: a) secure record (eg surgical records)*, b) structured interview where blind to case/control status*, c) interview not blinded to case/control status, d) written self report or medical record only,e) no description.
2) Same method of ascertainment for cases and controls: a) yes*, b) no
3) Non-Response rate: a) same rate for both groups*, b) non respondents described, c) rate different and no designation

Supplementary File S4. Quality assessment of cross-sectional studies on the relationship of oral health with school attendance and school performance based on the Newcastle-Ottawa scale.

Supplemental File 4

Supplemental Table 3. Quality assessment of cross-sectional studies on the relationship of oral health with school attendance and school performance based on the Newcastle-Ottawa scale.

	Selection			**Comparability**	**Outcome**		**Total Score**
	Representativeness of the sample	Non-respondents	Ascertainment of the exposure	The subjects in different outcome groups are comparable	Assessment of the outcome	Statistical test	Max.7 stars
School performance							
Jiang *et al*., 2005[20]	a*	b	a*	ab**	c	a*	***** (5)
Blumenshine *et al*., 2008[21]	a*	b	b	ab**	c	a*	**** (4)
Jackson *et al*., 2011[22]	a*	b	b	ab**	c	a*	**** (4)
Garg *et al*., 2012[23]	a*	c	a*	c	b*	b	*** (3)
Guarnizo-Herreno *et al*., 2012[24]	a*	c	b	ab**	c	a*	**** (4)
Piovesan *et al*., 2012[6]	a*	c	a*	ab**	b*	a*	****** (6)
Seirawan *et al*., 2012[7]	a*	b	a*	a*	b*	a*	***** (5)
Krisdapong *et al*., 2013[25]	a*	b	a*	ab**	c	a*	***** (5)
Paula *et al*., 2015[8]	a*	c	a*	ab**	b*	a*	****** (6)
Maharani *et al*., 2017[26]	b*	a*	a*	c	b*	b	**** (4)
Kaewkamnerdpong *et al*., 2018[27]	a*	b	a*	ab**	b*	a*	****** (6)
School attendance							
Gradella *et al*., 2011[28]	a*	c	a*	ab**	c	a*	***** (5)
Jackson *et al*., 2011[22]	a*	b	c	ab**	c	a*	**** (4)
Guarnizo-Herreno *et al*., 2012[24]	a*	c	b	ab**	c	a*	**** (4)
Piovesan *et al*., 2012[6]	a*	c	a*	ab**	b*	a*	****** (6)
Seirawan *et al*., 2012[7]	a*	b	a*	a*	b*	a*	***** (5)
Krisdapong *et al*., 2013[25]	a*	b	a*	ab**	c	a*	***** (5)
Agaku *et al*., 2015[29]	a*	c	b	ab**	c	a*	**** (4)
Neves *et al*., 2016[30]	a*	b	a*	ab**	c	a*	***** (5)
Shaikh *et al*., 2016[31]	a*	b	c	c	b*	b	** (2)
Naavaal *et al*., 2018[32]	a*	c	b	ab**	c	a*	**** (4)

Selection: (Maximum 4 stars)

1) Representativeness of the sample: a) Truly representative of the average in the target population* (all subjects or random sampling), b) Somewhat representative of the average in the target population (non-random sampling)*, c) Selected group of users, d) No description of the sampling strategy.

2) Non-respondents: a) Comparability between respondents and non-respondents characteristics is established, and the response rate is satisfactory*, b) The response rate is unsatisfactory, or the comparability between respondents and non-respondents is unsatisfactory, c) No description of the response rate or the characteristics of the responders and the non-responders.

3) Ascertainment of oral health status: a) Validated measurement tool (eg Independent blind assessment using clinical indices by calibrated examiners)*, b) Non-validated measurement tool, but the tool is available or described, c) No description of the measurement tool

Comparability: (Maximum 2 stars)

1) Confounding factors are controlled. a) The study controls for socioeconomic status*, b) The study control for any additional factor*, c) No description related to the adjustment analysis for confounding factors.

Outcome: (Maximum 1 star)

1) Assessment of school performance/absenteeism: a) Independent blind assessment *, b) Record linkage (eg school register)*, c) Self report, d) No description.

2) Statistical test: a) The statistical test used to analyze the data is clearly described and appropriate, and the measurement of the association is presented, including confidence intervals and the probability level (p value)*, b) The statistical test is not appropriate, not described or incomplete.