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Are oral health conditions associated with schoolchildren's performance and school attendance in the Kingdom of Bahrain? A life-course perspective

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Abstract

Background: The link between oral diseases and school performance and school attendance remains unclear among Middle Eastern children.

Aim: To investigate the relationship of oral conditions with schoolchildren's school performance and attendance using the life-course approach.

Design: A cross-sectional study was conducted with 466 schoolchildren aged 7-8 years from Kingdom of Bahrain (KoB) and their parents. Questionnaire data on children's current and at-birth environmental characteristics were completed by their parents. Children's oral health measures, including ICDAS (International Caries Detection and Assessment System), PUFA (pulp, ulcer, fistula, abscess), and DDE (developmental defects of enamel) indices, were the exposure variables. School performance and school attendance data obtained from the school register were the outcome variables. The data were analysed using multivariate ordinal logistic regression.

Results: The odds of excellent school performance were significantly lower for children with untreated dentinal caries (OR = 0.98; 95% CI: 0.96-0.99). Children with caries-treated teeth showed greater odds of excellent school performance (OR = 1.41; 95% CI: 1.15-1.74). Disease Control and Prevention None of the dental conditions were significantly associated with children's school attendance. A permissive parental style was associated with poor school attendance (OR = 2.63; 95% CI: 1.08-6.42).

Conclusion: Dental caries was associated with poor school performance but not with school attendance. Treated caries was associated with good school performance.

KEYWORDS

caries, children, life course, oral health, school attendance, school performance

1 | INTRODUCTION

In September 2015, the United Nations (UN) General Assembly adopted Agenda 2030, which agreed 17 Global

Sustainable Development Goals (GSDGs) to tackle poverty and reduce health inequalities. Education was the stepping stone for the GSDGs, and the specific goal related to education was to 'ensure inclusive and equitable

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quality education and promote lifelong learning opportunities for all'.¹

It has been suggested that poor oral health can influence children's educational performance and attendance. A review of 21 observational studies showed an association between oral health and school performance and attendance.² Two meta-analyses have concluded that poor oral health status can impact school performance and attendance in children and adolescents.^{3,4} Nevertheless, several methodological limitations have been reported in previous studies. For example, around 42% of studies have assessed oral health using self-reported measures.^{5,6} In the remaining studies, a clinical examination was included, but many relied solely on the DMFT/dmft index to assess dental caries.⁷ The use of the DMFT/dmft index has been criticised since only cavitated lesions in the dentine are considered.⁸ Furthermore, the DMFT/dmft index does not consider the status of restorations, sealants, disease progression, and activity. The index also attributes equal values to missing, untreated, and restored teeth, which makes it very difficult to evaluate changes in the condition of teeth in longitudinal studies.⁹

The International Caries Detection and Assessment System (ICDAS) has high validity and reliability and has been used in epidemiological studies.¹⁰ The system enables early detection of dental caries and longitudinal assessment by categorising the stage of disease from initial enamel caries to advanced cavitated dentinal lesions.⁸ The PUFA index assesses the clinical consequences of dental caries according to the presence of four presentations of odontogenic infections, including pulpal involvement, ulceration, fistula, and abscess.¹¹ The number of teeth presenting with these lesions is recorded as no lesion, one lesion, or more than one lesion (UKCDHS, 2013). There have been two studies that have reported the association of ICDAS and the PUFA index with poor school performance and attendance.^{12,13}

Previous systematic reviews, however, acknowledged that important risk factors such as socioeconomic status and family structure were not properly addressed in most of the primary studies. A systematic review by Ribeiro et al,¹⁴ which analysed only two papers of good quality, concluded that association between oral health and academic performance only occurs when mediated by socioeconomic and psychosocial factors. This lack of inclusion of possible risk factors that may act as confounders is perhaps due to the absence of an appropriate theoretical framework.

As such, this study adopted the life-course framework to examine the association between oral disease and children's school performance and attendance. The life-course model is a useful approach to investigate the interactions between social context, biological characteristics, and psychological factors in different life stages and how this influences individual well-being later in life.¹⁵ The model highlights the

importance of exposures during a critical period of development, such as at gestational stage, on developmental outcomes.¹⁵ The use of the life-course framework in this study brings a new theoretical perspective on the role of early and current environmental factors, as well as individual characteristics in terms of a possible link with children's oral health and school performance and attendance.

According to previous systematic reviews, only one study has been carried out in the Middle East, namely in Saudi Arabia,¹⁶ to measure the relation between toothache and school attendance. This means we know very little at present about oral health and school performance in Middle Eastern countries, where the burden of oral diseases is significantly high.¹⁷ This study was carried out in the Kingdom of Bahrain (KoB), which is a Middle Eastern country located in the Arabian Gulf, with a population of 1 501 611 in 2019. The Human Development Index for Bahrain was 0.838 in 2019, ranking the country 45th of 189 countries. Muharraq is the largest city in Bahrain. Children aged 7-8 years made up 12 087 of the population (0.8%) in 2019.

The aim of this study was to investigate the association of oral health conditions with school performance and attendance in 7- to 8-year-old schoolchildren in KoB using the life-course approach, including child's current and at-birth (critical period) environmental factors, as well as individual characteristics. This study tested the hypothesis that children with dental caries and developmental defects of enamel were more likely to experience poor school performance and lower school attendance. It was also hypothesised that current and early environmental factors (birth-critical period) were associated with child's current school performance and attendance.

2 | MATERIALS AND METHODS

2.1 | Ethical aspects

This study was approved by the research ethics committees of the University of Sheffield (May 2019) and the Ministry of Education in KoB (16 May 2019). Signed informed consent to participate in this study was obtained from the children's parents before data collection.

2.2 | Study power calculation

A post hoc analysis resulted in a study power of 84% considering the final sample size of 466 schoolchildren and their parents/caregivers, and a 95% confidence interval (95% CI) for detecting effect size of 0.05 in the multiple regression model with 20 independent variables.

2.3 | Study design, setting, and participants

A cross-sectional study was conducted in Muharraq Governorate (KoB) between 2019 and 2020. The participants were Grade 2 schoolchildren aged 7-8 years, enrolled in government primary schools in Muharraq governorate that were rated 'good' by the Ministry of Education, and their parents. This age group was selected since middle childhood is considered a relevant period of children's development when the biological and environmental factors at birth and current life circumstances might have a significant influence on children's behaviours, oral health status, and school performance.¹⁸ Moreover, by the age of six years, children in the KoB have received a visit from dental hygienists to prepare them for dental clinic visits when they are 7 years old and to teach them oral hygiene practices. Thus, at this age, children are familiar with the dental team and expected to accept oral health examination.

The government school system in Bahrain segregates boys and girls into separate schools. Each school in Bahrain is evaluated by the Ministry of Education's quality and qualification assurance (QQA) committee and receives a school-specific quality score: 'outstanding', 'good', 'satisfactory', or 'inadequate'. These QQA school evaluations are based on three components: quality of outcomes (students' academic achievement and their personal development), quality of processes (teaching and learning and students' support and guidance), and quality assurance of outcomes and processes (leadership, management, and governance). Private schools were not included in the study as they have different curricula compared with public schools, which in turn may influence students' academic achievements.

Of the 23 government primary schools in Muharraq, nine were rated 'outstanding', six were rated 'good', six were rated 'satisfactory', and two were rated 'inadequate'. Only schools rated as 'good' were included since sampling students from all 23 schools was not feasible. In addition, selecting students from 'good' schools would reduce the possible influence of the school environment on individual participants' school performance and school attendance.

Of the six good-rated schools in Muharraq, three were boys' schools and three were girls' schools. Of these, one boys' school was excluded from the study because it had no Grade 2 classes, and one girls' school was also excluded because it was a mixed primary and intermediate school. Following these exclusions, there were 510 children potentially eligible for the study. The study adopted a non-probability sampling technique, so all 510 Grade 2 schoolchildren and their parents/guardians were invited to participate.

2.4 | Data collection

The study was carried out between September and November 2019. At that time, children had just started their Grade 2

academic year. Informed consent and parents' questionnaires were distributed by class head teachers to parents through their children during school enrolment days to ensure their responses. Parents who were willing to participate along with their children were asked to sign the informed consent and fill in the accompanied questionnaire and return both to the head teacher. The head teacher received the completed questionnaires and submitted them to the researcher. The researcher then checked them for any missing data. If any data were missing, the parents were requested to supply it. A pilot study was conducted in September 2019.

The oral examination was conducted with the child in a supine position on a teacher's desk by one of two examiners using a mouth mirror (No. 4) and CPITN periodontal probe, both of which were sterilised, and head light. The teeth were dried with cotton rolls and gauze and then examined in the following order: upper right, upper left, lower right, and lower left. EDD was examined, followed by ICDAS and PUFA.

2.5 | School performance and attendance

School performance was assessed according to the final cumulative grade of each schoolchild at the end of the 2019 school year (June 2020). Due to the COVID-19 pandemic, schools in KoB operated online from March 2019. All the eligible children's parents were contacted by phone and requested to send a photograph of their child's 2020 Grade 2 school report to the principal researcher. Children in government primary schools in KoB are graded according to six levels: 'excellent', 'very good', 'good', 'average', 'acceptable', and 'failed'. This study will consider an 'excellent' grade as high school performance, 'very good' and 'good' grades as moderate school performance, and 'average' and 'acceptable' grades as low school performance, and finally, the 'failed' grade will remain the same.

Data on children's attendance in Grade 2 (2019-2020) were collected from school records by days of absence during the academic year for the period from September 2019 to February 2020. The children's attendance was grouped into: no absences, absent for 1-5 days, and absent for six or more days.

2.6 | Clinical dental measures

The ICDAS, PUFA, and DDE indices were used to assess children's clinical status. The dental examination was performed in accordance with the ICDAS collaborative team guidelines.⁹ ICDAS is a two-digit coding system, the first digit code (ranging from 0 to 9) represents the condition of the surface regarding restoration, sealants, and missing. The second digit (ranging from 0 to 6) refers to carious lesion

progression (enamel and dentine). ICDAS caries score 1 (The first visual change in enamel: opacity or discoloration (white or brown) is visible at the entrance to the pit or fissure seen after prolonged air drying), however, was not recorded. This is because air drying was not possible during the children's examination. The ICDAS caries codes for each child were combined as follows: ICDAS codes 2 and 3 were considered enamel caries, and ICDAS caries codes of 4, 5, and 6 were considered as dentinal caries. The PUFA index was used to determine the clinical consequences of dental caries.¹¹ The EDD was measured using the FDI-modified EDD¹⁹ guidelines designating only the buccal or labial surfaces of each tooth. At child level, it was registered as the totality of EDD for the mixed dentition.

2.7 | Covariates

The measurement and categorisation of all covariates can be seen in Table 1. The parent's questionnaire collected data including life-course variables that might impact school performance and/or attendance. The measures included early childhood life (at birth) factors (eg, biological, socioeconomic, and family structure), current child environmental characteristics (eg, socioeconomic status, family, and psychosocial factors), and child's characteristics, including gender, systemic health conditions, and Grade 1 school grades and attendance.

Biological factors included birthweight (low birthweight, ie, <2500 g vs. normal, ie, equal to or more than 2500 g) and gestational age (preterm birth <37 weeks vs. normal birth \geq 37 weeks), both of which were categorised according to WHO criteria.²⁰ Socioeconomic data included household income categorised by Bahraini Dinar (\leq 399 BD, 400-799 BD, and \geq 800 BD) and mother's and father's level of education (\leq 9 years vs. >9 years/not educated at all). Family structure data included family type (single, extended, or nuclear) and total number of people living in the same house. Psychosocial data included parenting style²¹ (permissive, authoritarian, or authoritative) and parental academic involvement scales²² for both mother and father, all of which were previously validated. Parents were asked to state whether their child had any chronic health conditions (yes, no). Finally, the children's Grade 1 academic performance (excellent, very good, good, average, acceptable, or failed) and attendance (no absences, absent 1-5 days, or absent \geq 6 days) were subjectively reported by parents in the questionnaire.

The children's questionnaires were administered in school on the same day as the clinical examination by two dental hygiene students using individual interviews. They were designed to collect social support data along with the paediatric oral health-related quality of life (POQL).²³ Social support is defined as behaviours, which, directly or indirectly, communicate to an individual that she or he is valued and cared for

by others.²⁴ This includes children's support at school by their teachers and peers. The POQL is a 10-item scale with four functional dimensions: physical, role, social and emotional. The POQL also has questions regarding pain.

The children's anthropometric measurements, including height and weight, were obtained to estimate their body mass index (BMI) based on the U.S. Centers for Disease Control and Prevention (CDC 2000) guidelines and calculator.²⁵ This was carried out by a nursing student using a high-quality balance beam. The BMI index was among the measures used to evaluate characteristics that might affect the children's school performance and/or attendance.

2.8 | Calibration study

Both examiners were calibrated. An unweighted kappa coefficient was used to estimate the reliability for the nominal ICDAS first digit (restorations). The ICDAS second digit (caries) is ordinal; hence, a weighted kappa coefficient was used to estimate its reliability.²⁶ Substantial agreement of 0.65 and above of the weighted kappa was targeted for both intra- and inter-rater calibration. The ICDAS second digit (caries) scoring with weighted kappa for inter-rater reliability was 0.77, whereas the intra-rater reliability scores were 0.87 and 0.88 for Examiner 1 and Examiner 2, respectively.

2.9 | Analytical framework and analysis

Figure 1 shows the theoretical model used in this study to explore the association between the three sets of risk factors (covariates). The three levels are categorised as follows: the first level records the child's environment at the time of their birth; the second level shows their current environment (at age 7-8 years); and the third level comprises the child's characteristics, including oral health and health status and previous school performance and attendance (Grade 1).

The association of a child's early life environment, current environment, and characteristics with their school performance and attendance was tested using ordinal logistic regression in order to estimate cumulative odds ratios at a 95% confidence interval (CI). Independent factors with a *P*-value of 0.20 or less were retained for the multivariable regression analyses; in the final regression model, the factors with *P* \leq .05 were retained (see Tables 3 and 4). All statistical tests were performed using the IBM SPSS statistics software version 25.

3 | RESULTS

Initially, 510 children and their parents were invited to participate in the study. Of these, 13 students refused to

TABLE 1 Measurement and categorisation of clinical and non-clinical risk factors

Characteristics	Measures	Analysis
<i>Dependent/Outcome</i>		
Academic performance (Grade 2)	Final cumulative scale as reported in child transcript	Excellent/ very good or good/average or acceptable
Absent days (Grade 2)	School absence from school record	No absences/absent 1-5 d/absent ≥ 6 d
<i>Independent/Demographic</i>		
Gender		Parent's questionnaire Female/Male
<i>Independent/Biology at birth</i>		
Birthweight	WHO 2004 ¹	Low birthweight (ie, <2500 g)/normal (ie, equal to or more than 2500 g)
Gestational age	WHO 2004	Preterm birth <37 wk/normal birth ≥ 37 wk
<i>Independent/Family structure</i>		
Family	Family type	Single/extended/nuclear
Number of people per house at birth	Scale	
Current number of people per house	Scale	
<i>Independent/socioeconomic status</i>		
Level of education	Schooling in Bahrain is compulsory from age 6 to age 14	≤ 9 y/>9 y/not educated at all
Household Income	Categorised according to Social Insurance Organisation (2018) in Bahrain BD (Bahraini Dinar)	≤ 399 BD/400-799 BD/ ≥ 800 BD
<i>Independent/support</i>		
Parenting style	Parenting Style Questionnaire ²	Permissive/authoritarian/authoritative
Parent's academic involvement	Parent-child's support scale (Ames et al, 1993) ³ Seven items with Likert scale 'never' (1) to 'always' (5)	Total score of all seven items, ranging from 0 to 28. Higher scores reflect greater involvement
Social support	Teacher and peer support (Torsheim et al, 2000) ⁴ Three items for each with Likert scale no, yes, sometimes	Total score of all six items, ranging from 0 to 12. The higher the score, the greater the social support
Mother smoking at current time		Yes/No
<i>Independent/Child's characteristics</i>		
Dental caries	International Caries Detection and Assessment System d/D(code 2-3)= enamel caries Id/D(code 4-6) =dentine caries	Total counts of tooth surfaces with enamel caries with code 2-3 Total counts of tooth surfaces with dentine caries with code 4-6
Treated teeth (extracted-filled)	ICDAS first digit's code Filled teeth with codes (3-4-5-6) Missed due to caries code (97)	Total count of filled and missed teeth due to caries
Clinical consequences of untreated dental caries	The PUFA (pulp, ulcer, fistula, abscess) index (Monse et al, 2010)	No/Yes
Enamel development defects	EDD, FDI-modified index	No/Yes
Oral health related quality of life	The paediatric oral health related quality of life POQL (Huntington et al 2011)	
Body mass index (BMI)	BMI percentile calculated (U.S Centers for Disease Control and Prevention)	Percentile
Chronic health conditions		No/Yes
Early learning activity	Kindergarten	Yes/No

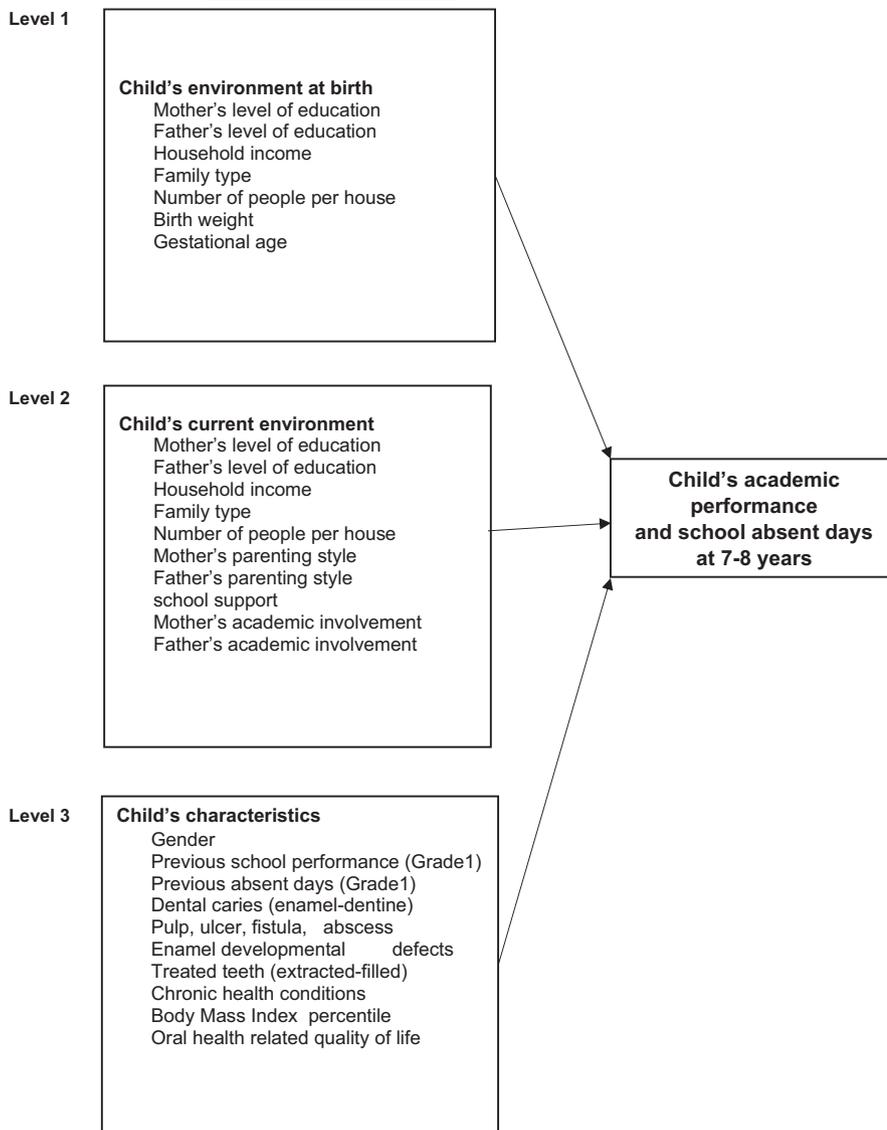


FIGURE 1 Study theoretical framework: the association between family environmental characteristics at child's birth, current family environmental characteristics, and child characteristics including OH with children's academic performance and school absent days

participate, and 11 did not return the parent's questionnaire. Thus, the final sample comprised 466 schoolchildren aged 7-8 years (287 girls and 179 boys) and their parents (response rate = 91.3%). In 25 cases, the parents' questionnaires had 0.5% missing values and were replaced by the mean and median in the sample.

The prevalence of dental caries (ICDAS code >1) was 93%, and the mean of the enamel caries ($d_{(2-3)}/D_{(2-3)}$) was 2.7, whereas for dentinal caries ($d_{(4-6)}/D_{(4-6)}$), it was 16.77. The prevalence of clinical consequences of untreated dental caries (PUFA ≥ 1) was 24.7%. More than half of the teeth with PUFA were affected by pulpal involvement (13.09%).

Regarding children's school performance, the proportions of children classified as having excellent, good, or very good (moderate), and average or acceptable (low) grades were 79%, 16%, and 5%, respectively. There were no academic failures reported. Meanwhile, 38% of the children had not missed any school days, 57% had missed between one and five days, and 5% had missed six or more days. The descriptive data for

the participants' characteristics in relation to school performances and school attendance are summarized in Table 2.

3.1 | What are the risk factors associated with low school performance?

Five ordinal regression models were used to identify the risk factors associated with low school performance. The first model included all the factors reported at Level 1, at childbirth, including mother's and father's level of education, household income, family type, gestational age, birth weight, number of people living in the same house and dental developmental defects along with gender. Factors showing a significant level ≤ 0.2 were included in the next model. Model 2 included socioeconomic and family structure factors in Level 2 (current child environment) along with the significant factors from Level 1. Model 3 included Level 2 psychosocial factors, Level 3 (child characteristics) child health and BMI,

TABLE 2 Children's and families' characteristics according to children's academic performance and school absent days

Variables	Children's academic performance N (%)				Children's school attendance N (%)			Total N (%)
	Total N (%)	Acceptable/ average	Very good/ good	Excellent	No absences	Absent 1-5 d	Absent 6 d or more	
Child's gender								
Female	287 (61.6)	15 (62.5)	45 (61.6)	227 (61.5)	101 (57.7)	174 (65.2)	12 (50)	287 (61.6)
Male	179 (38.4)	9 (37.5)	28 (38.4)	142 (38.5)	74 (42.3)	93 (34.8)	12 (50)	179 (38.4)
Family structure at child's birth								
Single parent	5 (1.1)	0 (0)	3 (4.1)	2 (0.5)	1 (0.6)	3 (1.1)	1 (4.2)	5 (1.1)
Extended	70 (15)	2 (8.3)	13 (17.8)	55 (14.9)	25 (14.3)	43 (16.1)	2 (8.3)	70 (15)
Nuclear	391 (83.9)	22 (91.7)	75 (78.1)	312 (84.6)	149 (85.1)	221 (82.2)	21 (87.5)	391 (83.9)
Mother's level of education at child's birth								
Not educated	42 (9.0)	5 (20.8)	10 (13.7)	27 (7.3)	18 (10.3)	23 (8.6)	1 (4.2)	42 (9)
≤9 y	118 (25.3)	6 (25)	26 (35.6)	86 (23.3)	48 (27.4)	60 (22.5)	10 (41.7)	118 (25.3)
>9 y	306 (65.7)	13 (54)	37 (50.7)	256 (69.4)	109 (62.3)	184 (68.9)	13 (54.2)	306 (65.7)
Father's level of education at child's birth								
Not educated	12 (2.6)	1 (4.2)	3 (4.1)	8 (2.2)	3 (1.7)	8 (3)	1 (4.2)	12 (2.6)
≤9 y	94 (20.2)	10 (41.7)	17 (23.3)	67 (18.2)	37 (21.1)	51 (19.1)	6 (25)	94 (20.2)
>9 y	360 (77.3)	13 (54.2)	53 (72.6)	294 (79.7)	135 (77.1)	208 (77.9)	17 (70.8)	360 (77.3)
Family income at child's birth								
BD ≤399	106 (22.7)	8 (33.3)	23 (31.5)	75 (20.3)	40 (22.9)	63 (23.2)	3 (12.5)	106 (22.7)
BD 400- 799	264 (56.7)	13 (54.2)	42 (57.5)	209 (56.6)	102 (58.3)	142 (53.2)	20 (83.3)	264 (56.7)
BD ≥800	96 (20.6)	3 (12.5)	8 (11)	85 (23)	33 (18.9)	62 (23.2)	1 (4.2)	96 (20.6)
Child's birthweight								
Low birthweight (<2500 g)	52 (11.2)	2 (8.3)	8 (11)	42 (11.4)	23 (13.1)	26 (9.7)	3 (12.5)	52 (11.2)
Normal (≥2500 g)	414 (88.8)	22 (91.7)	65 (89)	327 (88.6)	152 (86.9)	241 (90.3)	21 (87.5)	414 (88.8)
Child's gestational age								
Preterm birth (<37 wk)	51 (10.9)	3 (12.5)	8 (11)	40 (10.8)	19 (10.9)	30 (11.2)	2 (8.3)	51 (10.9)
Normal (≥37 wk)	415 (89.1)	21 (87.5)	65 (89)	329 (89.2)	156 (89.1)	237 (88.8)	22 (91.7)	415 (89.1)
Current mother's level of education								
Not educated	38 (8.2)	5 (20.8)	3 (4.1)	8 (2.2)	18 (10.3)	20 (7.5)	0 (0)	38 (8.2)
≤9 years	117 (25.1)	5 (20.8)	17 (24.7)	67 (18.2)	45 (25.7)	61 (22.8)	11 (45.8)	117 (25.1)
>9 years	311 (66.7)	14 (58.3)	53 (71.2)	294 (79.7)	112 (64)	186 (69.7)	13 (54.2)	311 (66.7)
Current father's level of education								
Not educated	8 (1.7)	1 (4.2)	3 (4.1)	4 (1.1)	3 (1.7)	5 (1.9)	0 (0)	8 (1.7)
≤9 years	90 (19.3)	8 (33.3)	18 (23.3)	64 (17.3)	33 (18.9)	52 (19.5)	5 (20.8)	90 (19.3)
>9 years	368 (79)	15 (62.5)	52 (72.6)	301 (81.6)	139 (79.4)	210 (78.7)	9 (79.2)	368 (79)
Current family structure								
Single parent	21 (4.5)	1 (4.2)	4 (5.5)	16 (4.3)	9 (5.1)	10 (3.7)	2 (8.3)	21 (4.5)
Extended	49 (10.5)	1 (4.2)	9 (12.3)	39 (10.6)	14 (8)	33 (12.4)	2 (8.3)	49 (10.5)

(Continues)

TABLE 2 (Continued)

Variables	Children's academic performance N (%)				Children's school attendance N (%)			
	Total N (%)	Acceptable/ average	Very good/ good	Excellent	No absences	Absent 1-5 d	Absent 6 d or more	Total N (%)
Nuclear	396 (85)	22 (91.7)	60 (82.2)	314 (85.1)	152 (86.9)	224 (83.9)	20 (83.3)	396 (85)
Current family income								
BD ≤399	81 (17.4)	4 (16.7)	16 (21.9)	61 (16.5)	9 (5.1)	10 (3.7)	2 (8.3)	21 (4.5)
BD 400- 799	254 (54.5)	16 (66.7)	43 (58.9)	195 (52.8)	14 (8)	33 (12.4)	2 (8.3)	49 (10.5)
BD ≥800	131 (28.1)	4 (16.7)	14 (19.2)	113 (30.6)	152 (86.9)	224 (83.9)	20 (83.3)	396 (85)
Mother's parenting style								
Permissive	15 (3.2)	2 (8.3)	6 (8.2)	7 (1.9)	3 (1.7)	11 (4.1)	1 (4.2)	15 (3.2)
Authoritarian	12 (2.6)	0 (0)	4 (5.5)	8 (2.2)	5 (2.9)	6 (2.3)	1 (4.2)	12 (2.6)
Authoritative	429 (92.1)	22 (91.7)	63 (86.3)	353 (95.9)	167 (95.4)	249 (93.6)	22 (91.7)	438 (94.2)
Father's parenting style								
Permissive	15 (3.2)	2 (20)	8 (9.0)	5 (1.4)	5 (2.3)	18 (6.7)	2 (8.3)	24 (5.2)
Authoritarian	12 (2.6)	0 (0)	8 (9.0)	4 (1.1)	7 (4)	8 (3)	0	15 (3.2)
Authoritative	429 (92.1)	8 (80)	73 (82.0)	348 (97.5)	164 (93.7)	241 (90.3)	22 (91.7)	427 (91.6)
Child chronic health conditions								
No	422 (90.6)	23 (95.8)	63 (86.3)	336 (91.1)	156 (89.1)	245 (91.8)	21 (87.5)	422 (90.6)
Yes	44 (9.4)	1 (4.2)	10 (13.7)	33 (8.9)	19 (10.9)	22 (8.2)	3 (12.5)	44 (9.4)
Child Grade 1								
Acceptable/ average	29 (6.2)	5 (20.8)	12 (16.4)	12 (3.3)				
Very good/ good	74 (15.9)	11 (45.8)	33 (45.2)	30 (8.1)				
Excellent	363 (77.9)	8 (33.3)	28 (38.4)	327 (88.6)				
Absent days Grade 1								
No absences					71 (40.6)	76 (28.5)	8 (33.3)	155 (33.3)
1-5 absences					92 (52.6)	154 (57.7)	11 (45.8)	257 (55.2)
≥6 absences					12 (6.9)	37 (13.9)	5 (20.8)	54 (11.6)
Child's BMI percentile, Mean N, (SD)	59.92 466 31.45	61.1 24 31.7	54.7 73 34.3	60.9 369 30.8	61.10 175 32.16	59.72 267 30.24	53.50 24 39.25	59.92 466 31.45
Mother's academic involvement, Mean, N,(SD)	20.69 466 5.28	21.5 24 4.9	18.2 73 5.8	21.1 369 5.0	21.31 175 5.07	20.41 267 5.33	19.21 24 5.80	20.69 466 5.28
School social support, Mean N, (SD)	11.38 466 1.27	11.7 24 0.75	11.4 73 1.26	11.3 369 1.30	11.32 175 1.33	11.40 267 1.24	11.46 24 1.25	11.38 466 1.27
Number of people per house at child's birth, Mean, N, (SD)	4.00 466 1.90	4.3 24 2.45	4.3 73 2.36	3.9 369 1.75	3.95 175 1.72	4.03 267 2.03	3.96 24 1.83	4.00 466 1.90

(Continues)

TABLE 2 (Continued)

Variables	Children's academic performance				Children's school attendance			
	Total N (%)	Acceptable/ average	Very good/ good	Excellent	No absences	Absent 1-5 d	Absent 6 d or more	Total N (%)
Current number	6.42	6.3	6.8	6.3	6.39	6.46	6.25	6.42
of people per	466	24	73	369	175	267	24	466
house, Mean	2.35	2.51	2.64	2.28	2.31	2.45	1.42	2.35
(SD)								
DDE, Mean	0.55	0.38	0.23	0.62	0.52	0.55	0.71	0.55
(SD)	466	24	73	369	175	267	24	466
	1.568	1.837	0.717	1.66	1.611	1.56	1.37	1.57
PUFA, Mean	0.47	0.67	0.78	0.39	0.47	0.46	0.50	0.47
(SD)	466	24	73	369	175	267	24	466
	0.997	0.86	1.47	0.86	1.08	0.96	0.72	0.99
$d_{(2-3)}/D_{(2-3)}$	2.74	2.54	2.95	2.71	2.73	2.74	2.79	2.74
Mean, N,	466	24	73	369	175	267	24	466
(SD)	2.79	2.50	3.077	2.76	2.71	2.87	2.72	2.79
$d_{(4-6)}/D_{(4-6)}$	16.77	21.71	21.07	15.60	17.0	16.21	20.83	16.77
Mean, N,	466	24	73	369	175	267	24	466
(SD)	13.06	15.01	15.65	12.12	13.73	12.74	11.19	13.06
Treated teeth	1.28	0.71	0.79	1.41	1.41	1.22	1.00	1.28
(extracted-	466	24	73	369	175	267	24	466
filled), Mean,	1.67	1.12	1.27	1.75	1.76	1.65	1.25	1.67
N, (SD)								

BD, Bahraini Dinar.

and the significant factors in model 2. Model 4 included the remainder of Level 3 (Grade 1 school performance and attendance, oral health in the form of enamel and dental caries, PUFA, treated teeth, and POQL) and the significant factors at Level 3. Only factors with 0.05 or less significance were retained in the final model. The results of the analysis of school performance are reported in Table 3.

In terms of Level 1 (early life) and Level 2 (current environment), none of the risk factors were significant in the final model. Level 3 (child characteristics), however, showed 3 factors to be associated with school performance. Children with dentinal caries had lower odds of high school performance ($d_{(4-6)}/D_{(4-6)}$) (OR = 0.98; 95% CI: 0.96-0.99). Interestingly, children who presented with treated caries (extracted or filled) showed 1.40 (95% CI: 1.15-1.71) higher odds of having high school performance. Also, low (OR = 0.09; 95% CI: 0.04-0.20) and moderate (OR = 0.08; 95% CI: 0.05-0.15) scores at Grade 1 were associated with current poor school performance.

Other dental conditions, including DDE and PUFA, showed no significant associations with children's school performance. Similarly, children's reported quality of life (POQL scores) was not associated with their school performance.

3.2 | What are the risk factors associated with high school absenteeism?

Five ordinal regression models were used to examine the risk factors associated with high school absenteeism. Model 1 included all Level 1 (childbirth) factors along with gender. Factors with significance level ≤ 0.2 were added to the next model. Model 2 included all factors in Level 2 (current child environment), Level 3 (child characteristics) child health and BMI, and the significant factors in model 1. Model 3 included the remaining factors of Level 3 along with the significant factors in model 2. Model 4 shows all the factors from the previous models with ≤ 0.2 significance level. The final model shows all the factors with 0.05 significance level. The results of the analysis of school attendance are reported in Table 4.

From Level 1, none of the independent variables remained significant. From Level 3, children who reported no absenteeism or < 5 days of absence in Grade 1, however, had lower odds of high absenteeism (≥ 6 days) in Grade 2 (OR = 0.36; 95% CI: 0.19-0.69, OR = 0.52; 95% CI: 0.28-0.96), whereas from Level 2, the odds of being frequently absent from school were significantly higher for children

TABLE 3 Ordinal regression of the association of family environmental characteristics at child's birth, current family environmental characteristics and child characteristics including OH with children's academic performance

Risk factors	OR (95%)	OR (95%)	OR (95%)	OR (95%)	OR (95%)
	Model 1	Model 2	Model 3	Model 4	Model 5
Gender		-	-	-	-
Female	1.161 (0.710, 1.898)				
Male	1				
Mother level of education at child's birth					-
Not educated	0.457 (0.209, 0.999)	0.150 (0.007, 3.136)	0.508 (0.239, 1.080)	1.026 (0.437, 2.407)	
≤9	0.616 (0.348, 1.092)	0.209 (0.039, 1.133)	0.618 (0.357, 1.070)	1.103 (0.587, 2.071)	
>9	1	1	1	1	
Father education level at child's birth			-	-	-
Not educated	1.002 (0.261, 3.849)*	2.771 (0.234, 32.819)			
≤9	0.688 (0.395, 1.199)	1.249 (0.327, 4.768)			
>9	1	1			
Family household income at child's birth					-
BD ≤399	0.392 (0.177, 0.867)*	0.346 (0.112, 1.070)	0.505 (0.226, 1.131)	0.531 (0.218, 1.289)	
BD 400-799	0.621 (0.299, 1.291)	0.755 (0.293, 1.946)	0.700 (0.337, 1.454)	0.597 (0.265, 1.349)	
BD ≥800	1	1	1	1	
Family type at child's birth					-
Single	0.223 (0.038, 1.290)	0.168 (0.019, 1.461)	0.235 (0.042, 1.314)	0.341 (0.049, 2.352)	
Extended	0.883 (0.458, 1.704)	0.766 (0.326, 1.802)	1.022 (0.525, 1.991)	1.670 (0.784, 3.556)	
Nuclear	1	1	1	1	
Child gestational age		-	-	-	-
Preterm birth (ie, less than 37 wk)	0.627 (0.257, 1.534)				
Normal (ie, equal to or more than 37 wk)	1				
Child birthweight		-	-	-	-
Low birthweight (ie, less than 2500 g)	1.455 (0.582, 3.641)				
Normal (ie, equal to or more than 2500 g)	1				
Number of people lived in the same house at child's birth	0.939 (0.833, 1.059)		-	-	
Dental developmental defects	1.305 (1.030, 1.653)*	1.311 (1.027, 1.674)*	1.288 (1.012, 1.640)*	1.206 (0.922, 1.576)	-
Current mother level of education	-		-	-	-
Not educated		2.953 (0.136, 64.327)			
≤9		3.231 (0.593, 17.604)			
>9		1			

(Continues)

TABLE 3 (Continued)

Risk factors	OR (95%)	OR (95%)	OR (95%)	OR (95%)	OR (95%)
	Model 1	Model 2	Model 3	Model 4	Model 5
Current father level of education	-		-	-	-
Not educated		0.195 (0.015, 2.593)			
≤9		0.505 (0.131, 1.942)			
>9		1			
Current household income	-		-	-	-
BD ≤399		1.447 (0.475, 4.410)			
BD 400- 799		0.785 (0.352, 1.748)			
BD ≥800		1			
Current family type	-		-	-	-
Single		1.302 (0.324, 5.227)			
Extended		1.395 (0.494, 3.943)			
Nuclear		1			
Current number of people living in the same house	-	0.968 (0.873, 1.073)	-	-	-
Father parenting style	-	-		-	-
Permissive			1.088 (0.362, 3.270)		
Authoritarian			0.506 (0.160, 1.597)		
Authoritative			1		
Mother parenting style	-	-			-
Permissive			0.390 (0.117, 1.296)	0.857 (0.266, 2.768)	
Authoritarian			0.904 (0.222, 3.686)	1.897 (0.397, 9.057)	
Authoritative			1	1	
Current child chronic health conditions	-	-	-	-	-
No					
Yes					
Father academic involvement	-	-	0.985 (0.953, 1.018)	-	-
Mother academic involvement	-	-	1.035 (0.988, 1.084)	1.000 (0.950, 1.053)	-
School social support	-	-	0.948 (0.776, 1.158)	-	-
Child BMI	-	-	1.001 (0.994, 1.009)	-	-
Grade 1 academic performance	-	-	-		
Low				0.097 (0.042, 0.225)**	0.090 (0.041, 0.197)**
Medium				0.073 (0.038, 0.139)**	0.083 (0.046, 0.148)**
High				1	1
Absence days for Grade 2	-	-	-		-
No absences				1.985 (0.692, 5.695)	

(Continues)

TABLE 3 (Continued)

Risk factors	OR (95%)		OR (95%)		OR (95%)
	Model 1	Model 2	Model 3	Model 4	Model 5
Absent days from 1-5 d				2.053 (0.737, 5.719)	
Absent days ≥ 6				1	
Enamel caries ($d_{(2-3)}/D_{(2-3)}$)	-	-	-	0.990 (0.899, 1.091)	-
Dentine caries ($d_{(4-6)}/D_{(4-6)}$)	-	-	-	0.978 (0.955, 1.001)	0.978 (0.961, 0.996)*
PUFA	-	-	-	1.081 (0.825, 1.418)	
Treated teeth (extracted-filled)	-	-	-	1.411 (1.144, 1.741)**	1.401 (1.150, 1.706)**
Number of POQL events reported by child	-	-	-	1.002 (0.897, 1.119)	-

* $P < .05$; ** $P < .01$.

with permissive fathers (OR = 2.56; 95% CI: 1.06-6.16) than those whose parents were merely authoritative. None of the dental conditions were significantly associated with children's school attendance.

4 | DISCUSSION

In this study, we evaluated the association between oral conditions and children's school performance and attendance, within a life-course framework.

This study found an association between dentinal caries and poor school performance. The association between treated dental caries and better school performance was also significant. No association was found between oral health measures and school absenteeism. In addition, there was a negative association between children with moderate-to-low preceding grades and their future chances of securing high school performance. Permissive parental style was associated with children's poor school attendance, and children who did not miss any school days in Grade 1 showed lower odds of missing more than 6 school days in Grade 2.

The finding that children with more dentinal caries (D/d_{4-6}) had greater odds of poor school performance is consistent with past studies (23). A cross-sectional study involving 600 3- to 5-year-old Indian children showed, for example, that high dental caries had an impact in lowering school performance, according to the overall marks obtained from school-teachers.²⁷ In this study, such a relation was not necessarily because of dental pain, measured by POQL, or other early or current characteristics since they were not significantly associated with the outcomes in the final models. One explanation may be because POQL was measured only once,

at the beginning of Grade 2. As such, future studies need to examine these relationships longitudinally.

Interestingly, enamel caries was not found to be associated with school performance and attendance. Assessment using ICDAS in this study identified no effect of enamel caries. This may be due to the enamel caries being asymptomatic.

Unlike this study, past studies have found treated dental caries to be associated with better school performance.²⁸ A cross-sectional study that examined Greek students aged 12-17 years found that better school performance was associated with better dental health. Similarly, a case-control study with 1149 8- to 10-year-old Brazilian children concluded that caries lesions, even if treated, were risk indicators of poor school performance.²⁹

In an ecological study involving 109 603 children aged 2 years and above in the USA, Gift et al³⁰ reported an annual loss among children of more than 51 million school hours. These lost hours tended to increase with children's age and were more frequent among girls, underprivileged persons, and those from an Hispanic background. Yet, such findings were not reported in this study. The present findings are in accordance with El-Sayed et al¹⁶ who found, in a cross-sectional study with 385 Sudanese, 5- to 15-year-old students, that unlike with school performance, there was no significant association between absenteeism and dental caries.

Neither PUFA/pufa nor EDD were associated with school performance or school attendance. Gradella et al¹³ reported that prevalence of pufa as a measure of severe dental caries of 5% among preschool children was significantly related to toothache and eating certain foods. The prevalence of pufa/PUFA in this study was comparatively higher (24.7%), but it was not related to the two school outcomes. This somewhat unexpected finding may be due to some dental caries

TABLE 4 Ordinal regression of the association of family environmental characteristics at child's birth, current family environmental characteristics and child characteristics including OH with children's school absent days

Risk factors	OR (95%)	OR (95%)	OR (95%)	OR (95%)	OR (95%)
	Model 1	Model 2	Model 3	Model 4	Model 5
Gender		-	-	-	-
Female	1.174 (0.800, 1.723)				
Male	1				
Mother level of education at child's birth			-	-	-
Not educated	0.598 (0.290, 1.232)	2.546 (0.182, 35.600)			
≤9	0.815 (0.509, 1.303)	0.416 (0.085, 2.029)			
>9	1	1			
Father education level at child's birth		-	-	-	-
Not educated	2.090 (0.579, 7.549)				
≤9	1.047 (0.648, 1.690)				
>9	1				
Family household income at child's birth		-	-	-	-
BD ≤399	0.959 (0.541, 1.702)				
BD 400-799	1.093 (0.669, 1.787)				
BD ≥800	1				
Family type at child's birth		-	-	-	-
Single	3.028 (0.449, 20.436)				
Extended	1.008 (0.598, 1.698)				
Nuclear	1				
Child gestational age	-	-	-	-	-
Preterm birth (ie, less than 37 wk)					
Normal (ie, equal to or more than 37 wk)					
Child birthweight	-	-	-	-	-
Low birthweight (ie, <2500 g)					
Normal (ie, equal to or more than 2500 g)					
Number of people lived in the same house at child's birth	1.041 (0.938, 1.154)	-			
Dental developmental defects	1.033 (0.918, 1.162)	-			
Current mother level of education	-		-		-
Not educated		0.165 (0.011, 2.458)	0.471 (0.230, 0.965)*	0.473 (0.231, 0.968)*	
≤9		1.799 (0.360, 8.985)	0.928 (0.582, 1.480)	0.936 (0.591, 1.483)	
>9		1	1	1	
Current father level of education	-		-	-	-
Not educated		0.980 (0.221, 4.354)			
≤9		1.000 (0.602, 1.660)			

(Continues)

TABLE 4 (Continued)

Risk factors	OR (95%)		OR (95%)		OR (95%)	
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 5
>9		1				
Current household income	-					
BD \leq 399		1.630 (0.887, 2.993)	1.708 (0.943, 3.095)	1.706 (0.946, 3.077)		
BD 400-799		1.365 (0.874, 2.131)	1.385 (0.891, 2.154)	1.379 (0.888, 2.139)		
BD \geq 800		1	1	1		
Current family type	-					
Single		0.828 (0.338, 2.029)				
Extended		1.305 (0.680, 2.505)				
Nuclear		1				
Current number of people living in the same house	-	1.005 (0.920, 1.098)	-	-	-	
Father parenting style	-					
Permissive		2.414 (0.897, 6.499)	2.450 (0.990, 6.064)*	2.439 (0.987, 6.029)*	2.558 (1.062, 6.160)*	
Authoritarian		0.644 (0.222, 1.867)	0.740 (0.261, 2.099)	0.743 (0.262, 2.105)	0.746 (0.265, 2.097)	
Authoritative		1	1	1	1	
Mother parenting style	-					
Permissive		1.345 (0.399, 4.535)				
Authoritarian		0.548 (0.159, 1.891)				
Authoritative		1				
Current child chronic health conditions	-					
No		1.303 (0.689, 2.464)				
Yes		1				
Father academic involvement	-	1.002 (0.976, 1.029)				
Mother academic involvement	-	0.967 (0.930, 1.005)	0.972 (0.935, 1.010)	0.973 (0.936, 1.010)		
School social support	-	1.039 (0.897, 1.202)	-	-	-	
Child BMI	-	0.998 (0.992, 1.004)	-	-	-	
Absence days for Grade 1	-	-				
No absences			0.408 (0.208, 0.798)*	0.407 (0.208, 0.797)*	0.360 (0.188, 0.691)**	
Absent days from 1-5			0.602 (0.320, 1.133)	0.603 (0.321, 1.134)	0.515 (0.278, 0.955)*	
Absent days \geq 6			1	1	1	
Enamel caries ($d_{(2-3)}/D_{(2-3)}$)	-	-	1.012 (0.945, 1.083)	-	-	
Dentinal caries ($d_{(4-6)}/D_{(4-6)}$)	-	-	1.001 (0.984, 1.019)	-	-	

(Continues)

TABLE 4 (Continued)

Risk factors	OR (95%)	OR (95%)	OR (95%)	OR (95%)	OR (95%)
	Model 1	Model 2	Model 3	Model 4	Model 5
PUFA	-	-	0.956 (0.768, 1.189)	-	-
Treated teeth (extracted-filled)	-	-	0.917 (0.819, 1.027)	0.920 (0.823, 1.028)	-
Number of POQL events reported by child	-	-	1.010 (0.933, 1.092)	-	-

* $P < .05$; ** $P < .01$.

sequelae such as ulcer, fistula, and even open pulp that is fully necrotic not resulting in dental symptoms.

In this study, socioeconomic factors, both in early and current life, did not have a significant impact on children's school performance and attendance. This contrasted with findings from two cross-sectional studies conducted with 12-year-old students in Brazil. The first reported that socioenvironmental factors, measured by number of people living in the household and over-crowding, along with others have an important impact on school performance.²⁹ The second showed that low household income was a determinant for lower school performance.³¹ These differences in findings may be due to marked differences in the health services and macro-economic policies between Brazil and Bahrain. The gross domestic product (GDP) per capita for Bahrain was about 49,057 compared with Brazil's 14 563 ('World Economic Outlook—GDP per capita'. International Monetary Fund. October 2020. Retrieved 13 October 2020). Also, the percentage of people living in extreme poverty (daily income of less than \$1.90) in Brazil was 7.4% in 2017 compared with Bahrain's 0% in 2018. In addition, all the health services provided by the government of Bahrain are free of charge for citizens. This includes the primary, secondary, and tertiary dental care services. It may be that these structural factors at national level mean that socioeconomic factors at the individual and/or family level have a less important role in school outcomes in Bahrain compared with other countries, such as Brazil.

This study did not find an association between early child environmental factors and school attendance. Permissive father parenting style, previous grade, and no absenteeism, however, were associated with missing school days. Permissive parenting style is characterised by high responsiveness and lack of control. Previous findings have found that children of permissive parents are usually very social but perform less well academically than other children.³² Unsurprisingly, previous poor school performance grades were found to be associated with current poor academic performance. Children's previous academic achievement and attendance are therefore important predictors for their future school outcomes.

5 | LIMITATIONS

The main limitation of this study is the cross-sectional design. Although the life course framework guided the selection of variables, measures, and the analytic approach, all data was collected at one point in time. Thus, no causal relationships can be assumed.³³ The selection of schools by using a non-probabilistic sample is another possible limitation. In addition, only students from 'good' rated schools were selected in order to decrease the heterogeneity of the schools' environmental characteristics and reduce the possible influence of contextual confounders on the relationship of oral diseases with school performance and attendance. This potentially limits the applicability of the study's findings to schools rated as either very low (inadequate) or very high (outstanding) on the quality continuum. Lastly, Grade 1 school performance and attendance were self-reported measures obtained from parents. It is possible therefore that parents under- or overestimated their child's attendance due to recall bias.

6 | CONCLUSION

This study was the first to examine the association between oral disease and school performance and attendance by incorporating self-reported individual risk factors alongside clinical dental measures within a life-course framework. The findings indicate that among 7- to 8-year-old children in Bahrain, more dentinal caries is associated with lower academic performance, whereas treated caries is associated with higher performance. Dental caries was not significantly associated with student's school attendance in this study. EDD and clinical consequences of untreated dental caries, together with child early environmental factors, were not associated with children's school performance or attendance. Those children whose parents had a more permissive parenting style were more likely to miss school days. Having untreated dental decay negatively affects school performance. This is further evidence of the need to prevent the development of dental caries and for it to be treated when it occurs.

WHY IS THIS PAPER IMPORTANT TO PAEDIATRIC DENTISTRY?

- Exploring the relationship of poor oral health with school performance and school attendance using the life course approach can help identify important child and family characteristics that could be common risk factors between both oral health and school performance and attendance.
 - Severe dental caries was found to be negatively associated with children's school performance in Bahrain even when variations in family characteristics were considered.
 - Treated dental caries was positively associated with children's school performance.
 - Oral conditions were not found to be associated with school attendance when considering other family and social factors.
- This paper provides further evidence of the effect of dental disease on children's general well-being and the need to prevent dental disease where possible and treat it when it does occur.

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CONFLICT OF INTEREST

The authors declared that there are no possible conflicts of interest.

AUTHORS' CONTRIBUTIONS

Mohamed, S. was the principal author of the paper who was responsible for study design, data collection, and analysis. Vettore, M. was the student's PhD supervisor who developed the research question, guided the analysis, and revised the manuscript. Baker, S. was the student's PhD supervisor who guided analysis and revised the manuscript. Deery, C. was the student's PhD supervisor who provided clinical training and calibration and revised the manuscript.

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