ORIGINAL ARTICLE

UDC: 616.314-002-053.2
DOI: https://doi.org/10.2298/VSP190426039K

# Association between dental caries risk indicators and various stages of caries in newly erupted permanent teeth

## Povezanost indikatora rizika od pojave karijesa i različitih stadijuma karijesa na mladim stalnim zubima

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**Abstract**

**Background/Aim.** Identification of caries risk indicators involved in the disease development is of great importance. The aim of this study was to assess the association between distinctive risk indicators and different stages of caries disease process in children. **Methods.** The cross-sectional study was conducted on a sample (n = 327) of school children ages 7–11. A questionnaire submitted to parents was used to record the data regarding demographic characteristics, children's dietary habits, oral hygiene habits and oral health behaviors. Caries was assessed using the International Caries Detection and Assessment System (ICDAS) II and subjects were stratified according to the highest and most prevalent caries lesion stage. The data obtained were analyzed using the $\chi^2$ or Fisher`s exact test and multinomial logistic regression. **Results.** Caries lesions were detected in 56.6% of examinees observed in the study. Compared to caries-free subjects, appearance of initial caries lesions was statistically significantly influenced by maternal education level ($p = 0.021$), paternal occupational status ($p = 0.023$), toothbrushing frequency ($p < 0.001$), and caries status of deciduous teeth ($p = 0.027$). Maternal educational level ($p = 0.026$), paternal occupational status ($p = 0.003$), sweets and snacks taking frequency ($p = 0.005$), toothbrushing frequency ($p < 0.001$), and fluoridate dentifrice usage ($p = 0.027$) were associated with moderate caries lesions. Maternal educational level ($p < 0.001$), sweets and snacks taking frequency ($p = 0.022$) and toothbrushing frequency ($p < 0.001$) were associated with extensive caries lesions. Maternal educational level ($p = 0.02$) and brushing frequency ($p < 0.001$) were statistically significantly associated with the highest prevalence of initial caries lesions. Maternal educational level ($p = 0.025$), toothbrushing frequency ($p < 0.001$) and frequency of dental check-ups ($p = 0.016$) were statistically significantly associated with the highest prevalence of moderate caries lesions. **Conclusion.** Parental socioeconomic indicators and children's behavior related to oral health were involved in the changes from caries-free status to different caries stages.

**Key words:**
**child; dental caries; habits; oral health; risk factors; socioeconomic factors; surveys and questionnaires.**

**Apstrakt**

**Uvod/Cilj.** Identifikacija indikatora rizika od pojave karijesa je od velike važnosti. Cilj ove studije je bio da se proceni povezanost između određenih indikatora rizika od karijesa i različitih faza karijesnog procesa kod dece. **Metode.** Studijom preseka obuhvaćen je uzorak od 327 školske dece uzrasta 7–11 godina. Podaci o demografskim karakteristikama, navikama dece u ishrani, oralnoj higijeni i ponašanju povezanim sa oralnim zdravljem prikupljeni su putem upitnika koje su popunjavali roditelji. Detektovanje i procena karijesnih lezija sprovedeni su korišćenjem *International Caries Detection and Assessment System* (ICDAS) II metode. Ispitanici su stratifikovani prema najvećem i najćešćem stepenu karijesne lezije. Dobijeni podaci analizirani su pomoću $\chi^2$ testa, Fišerovog testa i multivarijantne nominalne logističke regresije. **Rezultati.** Karijesne lezije nađene su kod 56,6% ispitanika. Utvrđeno je da su kod ispitanika na pojavu početnih karijesnih lezija statistički značajno uticali nivo obrazovanja majke ($p = 0,021$), radni status oca ($p = 0,023$), učestalost pranja zuba ($p < 0,001$) i karijes status mlečnih zuba ($p = 0,027$). Nivo obrazovanja

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majke ($p$ = 0,026), radni status oca ($p$ = 0,003), učestalost konzumiranja slatkiša i grickalica ($p$ = 0,005), učestalost pranja zuba ($p$ < 0,001) i upotreba zubne paste sa fluorom ($p$ = 0,027) bili su povezani sa pojavom lezija srednjeg stepena. Nivo obrazovanja majke ($p$ < 0,001), učestalost konzumiranja slatkiša i grickalica ($p$ = 0,022) i učestalost pranja zuba ($p$ < 0,001) bili su povezani sa pojavom ekstenzivnih karijesnih lezija. Nivo obrazovanja majke ($p$ = 0,020) i učestalost pranja zuba ($p$ < 0,001) statistički su značajno bili povezani sa najvećom učestalošću početnih karijesnih lezija kod dece. Nivo obrazovanja majke ($p$ = 0,025), učestalost pranja zuba ($p$ < 0,001) i učestalost stomatoloških pregleda ($p$ = 0,016) značajno su bili povezani sa najvećom učestalošću karijesnih lezija srednjeg stepena. **Zaključak.** Socijalnoekonomski indikatori i ponašanje dece u vezi sa oralnim zdravljem povezani su sa pojavom karijesa i različitim stadijumima karijesnog procesa.

**Ključne reči:**
**deca; zub, karijes; navike; usta, zdravlje; faktori rizika; socijalno-ekonomski faktori; ankete i upitnici.**

## Introduction

Dental caries is a posteruptive, complex multifactorial disease process. Although preventable, it is the most common childhood disease and noncommunicable disease worldwide [1]. Between 60% and 90% of children are affected by dental caries [1].

In view of the above considerations, children need special attention, particularly in the age when permanent teeth begin to erupt. This period shows the state of the teeth which allows the food retentions to occur and makes it difficult to be cleaned [2]. In the months and years following the tooth eruption, enamel posteruptive maturation, which is thought to reduce vulnerability to caries [2], has not finished yet. This is the period with the highest risk of caries incidence [3]. Even low levels of dental caries in children, especially when observed in the permanent dentition, are of concern since dental caries is a lifelong progressive and cumulative disease that tracks to adulthood [4].

The occurrence of dental caries in children is influenced by many factors such as: caries experience in primary dentition, educational level of parents, socioeconomic status [5], oral hygiene habits, fluoride history [6], dietary habits [7], etc.

Since caries etiology is complex, there is a need to identify risk factors that are involved in the development of the disease in order to plan the appropriate public health measures to prevent it. Caries-associated variables detected in the cross-sectional study are considered to be risk indicators which might be the risk factors of the disease [8].

Caries is characterized by a gradual but cumulative dissolution and destruction of the mineralized tissues of the teeth resulting in a large clinical polymorphism, from small white spot lesions to large cavities. Caries lesions evolution requires a long period of time, usually months or years [9]. It could be assumed that different risk indicators might be involved in caries disease process and they manifest their effects in specific caries stages, playing different roles at different times. Confirmation of this assumption would contribute to a better understanding of caries initiation and progression. Furthermore, early identification of potential risk factors and subjects prone to caries would allow planning of targeted specific measures for caries prevention and increase the efficiency of preventive programs [10].

Traditionally used criteria for caries assessment, established by the World Health Organization (WHO) in 1997, does not distinguish among the different stages of the caries lesions [11, 12]. Considering the importance of assessing dental caries in all its stages, the International Caries Detection and Assessment System (ICDAS) II has been developed. The ICDAS II distinguishes 6 different stages of caries lesions (from the first visual change in enamel to an extensive cavity in dentine) [12] and aids in the collection of better-quality information to support diagnosis, prognosis and clinical management of dental caries [13].

The aim of the study was to determine whether or not specific risk indicators might affect different stages of the caries disease process in newly erupted permanent teeth. According to data available to us, no previous study has explored this issue.

## Methods

In order to investigate the association between caries risk indicators and various stages of caries in newly erupted permanent teeth, a cross-sectional study was conducted.

This study was approved by the Ethics Committee of the Faculty of Medical Sciences, University of Priština, with the headquarters in Kosovska Mitrovica, Serbia. The study was conducted in accordance with the ethical standards laid down in the Declaration of Helsinki. The informed consent form was handed out to the school authorities so as to obtain parental permissions. Only children with their parents signed consent were enrolled in the study.

The study was carried out between December 2017 and March 2018, involving children of both genders, 7–11 years olds, attending elementary schools located in the northern part of Kosovska Mitrovica, Serbia. Children who were systemically healthy, exclusively in the mixed dentition phase were recruited. The exclusion criteria, chosen because of their potential to influence the expression of caries, included antibiotic use of 30 days prior to the onset of the study, structural anomalies of the teeth, presence of fixed orthodontic appliances and the presence of pit and fissure sealants on permanent teeth.

The data collection method consisted of a structured questionnaire (Anex) and a subsequently implemented clinical oral examination. In order to test the methodology and comprehension of the questionnaire, a pilot study was done with a sample of parents (n = 30) not included in the main sample. The results revealed no misunderstanding regarding the questionnaire. Prior the questionnaires were administered, parents received explanations regarding the purpose of the questionnaires and importance of getting precise answers. The anonymity and confidentiality of their responses were emphasized, along with the important contribution that their responses would provide. Questionnaires were submitted to parents, who agreed to allow their children to participate in the study, in order to collect data on demographic and socioeconomic details including sex and age of the child, as well as the educational level and occupational status of their parents and behavioral variables related to their child such as: dietary habits, oral hygiene practices and visits to a dentist.

Clinical examinations were performed at school dental offices according to the ICDAS examination criteria [14]. To avoid inter-examiner variability, they were conducted by a single examiner, who underwent a training programme proposed by the ICDAS Committe [15]. Prior to the examination, the dentist passed through calibration procedure. Fifty children who were not part of the sample were examined twice, with a 72-hour interval between examinations. Intra-examiner consistency was assessed. Cohen's kappa [16] statistics with a subject and a tooth surface considered as the units analysis was higher than 0.8 for both. Standard infection control measures followed each examination. In the case of more than one lesion present in the same tooth, the most severe lesion was recorded as valid. Trauma related restored teeth were considered as sound. No radiographs were taken. Only caries lesions in permanent teeth were included in the analysis, while the presence of caries lesions in deciduous teeth was considered as a background variable.

All statistical analyses were performed using IBM SPSS Statistics 22 (IBM Corporation, Armonk, NY, USA). Data derived through clinical examination were grouped as follows: No caries (ICDAS 0), Initial stage (ICDAS 1-2), Moderate stage (ICDAS 3-4) and Extensive stage (ICDAS 5-6) [17]. Study subjects were stratified according to the maximum caries lesion stage (subjects were coded according to the highest ICDAS caries score recorded) and according to the most prevalent caries lesion stage (subjects were coded according to the most prevalent ICDAS caries score recorded) [18].The normally distributed continuous data were presented as mean ± standard deviations (SD) and categorical variables were expressed as a number (percentages). In the univariate analysis, the $\chi^2$ test or Fisher's test was used to compare the categorical variables. The background variables with a *p*-value less than 0.05 in the univariate analysis were included in the multinomial logit model in order to assess their associations with the caries lesion stage in subjects stratified as reported above. The first model with the highest caries lesion stage as a dependent variable included the whole sample, using the caries-free children as the base outcome, while the model with the most prevalent caries lesion stage included only caries affected children, using the subjects with the extensive caries lesions as the base outcome. The criterion for statistical significance was $p < 0.05$.

**Results**

According to data obtained from school authorities, there were 1,003 children aged 7–11 attending these schools. All of them were invited to participate in the study. A total of 761 parents signed informed consent for their children participation in the study and a questionnaire was applied to each of them. Twenty-four subjects who had returned incomplete questionnaires were excluded from the study. Thus, a total of 737 children were eligible for the clinical examination. A total of 387 children failed to meet the study criteria, 17 children were absent from school on the days scheduled for the clinical examinations and 6 children showed lack of cooperation during the examinations. All of them were excluded from the survey. In our final analyses, we used data from a total of 327 children.

The children were 7–11 years old with the mean age of 9.32 ± 1.40 years. Caries lesions were detected in 56.6% of the children, while caries experience (the sum of decayed, filled and missing teeth due to caries) was 75.2%. According to the maximum caries lesion stage stratifying procedure, initial caries lesion stage was present in 16.6%, moderate caries lesion stage was present in 22.6%, and extensive caries lesion stage was present in 17.4% of the children (Table 1). According to the most prevalent caries lesion stage stratifying procedure, a prevalence of initial caries lesion stage, moderate caries lesion stage and extensive caries lesion stage were present in 41.1%, 41.1% and 17.8% of the affected children, respectively (Table 2).

Parental educational level ($p < 0.001$ for both mother and father), paternal occupational status ($p = 0.028$), toothbrushing frequency ($p < 0.001$), sweets and snacks taking frequency ($p = 0.022$), use of fluoride containing toothpaste ($p = 0.033$), frequency of dental check-ups ($p < 0.001$) and caries status of deciduous teeth ($p = 0.043$) were statistically significantly associated with the highest caries score (Table 1).

Table 2 shows variables that were singled out as statistically significant. It was shown that parental education level ($p = 0.048$ for mother and $p = 0.033$ for father), toothbrushing frequency ($p = 0.010$) and the frequency od dental check-ups ($p = 0.021$) were statistically significantly associated with caries lesion stage prevalence (Table 2).

All variables which were statistically significantly associated with the highest caries lesion stage stratifying procedure and with the most prevalent caries stage stratifying procedure in models of univariate logistic regression were included in the model of multinominal logistic regression (Tables 3 and 4).

**Table 1**

**Distribution of the children according to the highest caries lesion stage stratifying procedure (n = 327)**

| Variables | Highest caries score (ICDAS), n (%) | | | | *p* |
|---|---|---|---|---|---|
| | healthy teeth | initial caries lesion | moderate caries lesion | extensive caries lesion | |
| | 142 (43.4) | 54 (16.6) | 74 (22.6) | 57 (17.4) | |
| Maternal educational level | | | | | |
| primary school | 1 (0.7) | 3 (5.6) | 3 (4.1) | 11 (19.3) | |
| high school | 62 (43.7) | 27 (50.0) | 50 (67.6) | 28 (49.1) | < 0.001* |
| faculty | 79 (55.6) | 24 (44.4) | 21 (28.4) | 18 (31.6) | |
| Paternal educational level | | | | | |
| primary school | 1 (0.7) | 2 (3.7) | 1 (1.4) | 2 (3.5) | |
| high school | 58 (40.8) | 19 (35.2) | 51 (68.9) | 38 (66.7) | < 0.001* |
| faculty | 83 (58.5) | 33 (61.1) | 22 (29.7) | 17 (29.8) | |
| Maternal occupational status | | | | | |
| employed | 89 (63.1) | 33 (61.1) | 46 (63.0) | 30 (53.6) | |
| unemployed | 48 (34.0) | 17 (31.5) | 24 (32.9) | 23 (41.1) | 0.728 |
| self-employed | 4 (2.8) | 4 (7.4) | 3 (4.1) | 3 (5.4) | |
| Paternal occupational status | | | | | |
| employed | 113 (80.7) | 34 (63.0) | 51 (68.9) | 43 (75.4) | |
| unemployed | 19 (13.6) | 9 (16.7) | 12 (16.2) | 11 (19.3) | 0.028* |
| self-employed | 8 (5.7) | 11 (20.4) | 11 (14.9) | 3 (5.3) | |
| Sweet beverages taking frequency | | | | | |
| never or rarely | 17 (12.0) | 12 (22.2) | 14 (18.9) | 11 (19.3) | |
| 2–5/ day | 97 (68.3) | 29 (53.7) | 44 (59.5) | 26 (45.6) | 0.072 |
| > 5/ day | 28 (19.7) | 13 (24.1) | 16 (21.6) | 20 (35.1) | |
| Sweets and snacks taking frequency | | | | | |
| never or rarely | 49 (34.5) | 11 (20.4) | 13 (17.6) | 10 (17.5) | |
| 2–5/ day | 59 (41.5) | 22 (40.7) | 32 (43.2) | 23 (40.4) | 0.022* |
| > 5/ day | 34 (23.9) | 21 (38.9) | 29 (39.2) | 24 (42.1) | |
| Toothbrushing frequency | | | | | |
| < 1/ day | 13 (9.2) | 21 (38.9) | 27 (36.5) | 39 (68.4) | |
| 1–2/ day | 63 (44.4) | 29 (53.7) | 44 (59.5) | 18 (31.6) | < 0.001* |
| > 2/ day | 66 (46.5) | 4 (7.4) | 3 (4.1) | 0 (0) | |
| Brush teeth for at least 3 minutes | | | | | |
| yes | 45 (31.7) | 20 (37.0) | 22 (29.7) | 17 (29.8) | 0.818 |
| no | 97 (68.3) | 34 (63.0) | 52 (70.3) | 40 (70.2) | |
| Use of fluoridated toothpaste | | | | | |
| yes | 115 (81.0) | 42 (77.8) | 63 (85.1) | 37 (64.9) | 0.033* |
| no | 27 (19.0) | 12 (22.2) | 11 (14.9) | 20 (35.1) | |
| Use of fluoridated mouthwash | | | | | |
| yes | 9 (6.3) | 5 (9.3) | 6 (8.1) | 2 (3.5) | 0.625 |
| no | 133 (93.7) | 49 (90.7) | 68 (91.9) | 55 (96.5) | |
| Dental check-ups frequency | | | | | |
| periodically | 74 (52.1) | 24 (44.4) | 19 (25.7) | 13 (22.8) | |
| occasionally | 62 (43.7) | 26 (48.1) | 47 (63.5) | 25 (43.9) | < 0.001* |
| visit a dentist when in pain | 6 (4.2) | 4 (7.4) | 8 (10.8) | 19 (33.3) | |
| Deciduous teeth caries | | | | | |
| yes | 89 (62.7) | 43 (79.6) | 57 (77.0) | 42 (73.7) | 0.043* |
| no | 53 (37.3) | 11 (20.4) | 17 (23.0) | 15 (26.3) | |

***Statistically significant result.**
**ICDAS – International Caries and Assessment System.**

**Table 2**

**Distribution of caries affected children according to the the most prevalent caries lesion stage (n = 185)**

| Variables | Most prevalent caries stage, n (%) | | | *p* |
|---|---|---|---|---|
| | initial | moderate | extensive | |
| | 76 (41.1) | 76 (41.1) | 33 (17.8) | |
| Maternal educational level | | | | |
| primary school | 7 (9.2) | 5 (6.6) | 5 (15.2) | |
| high school | 45 (59.2) | 49 (64.5) | 11 (33.3) | 0.048* |
| faculty | 24 (31.6) | 22 (28.9) | 18 (51.5) | |
| Paternal educational level | | | | |
| primary school | 3 (3.9) | 1 (1.3) | 1 (3.0) | |
| high school | 34 (44.7) | 53 (69.7) | 21 (63.6) | 0.033* |
| faculty | 39 (51.3) | 22 (28.9) | 11 (33.3) | |
| Toothbrushing frequency | | | | |
| < 1/ day | 33 (43.4) | 30 (39.5) | 24 (72.7) | |
| 1–2/ day | 38 (50.0) | 44 (57.9) | 9 (27.3) | 0.010* |
| > 2/ day | 5 (6.6) | 2 (2.6) | 0 (0) | |
| Dental check-ups frequency | | | | |
| periodically | 28 (36.8) | 19 (25.0) | 9 (27.3) | |
| occasionally | 37 (48.7) | 48 (63.2) | 13 (39.4) | 0.021* |
| visit a dentist when in pain | 11 (14.5) | 9 (11.8) | 11 (33.3) | |

***Statistically significant result.**

**Table 3**

**Multivariate nominal logistic regression with the highest caries lesion stage as dependent variable (n = 327)**

| Variable | B (SE) | OR (95% CI) | *p* |
|---|---|---|---|
| Caries-free (ICDAS = 0) – Base outcome | | | |
| Initial lesions (ICDAS = 1/2) | | | |
| maternal educational level (Primary school) | 3.2 (1.4) | 25.5 (1.6–397.0) | 0.021* |
| paternal educational level (High school) | -0.5 (0.5) | 0.6 (0.3–1.4) | 0.266 |
| paternal occupational status (Employed) | -1.6 (0.6) | 0.2 (0.06–0.7) | 0.009* |
| sweets and snacks taking frequency (Never or rarely) | -1.2 (0.5) | 0.3 (0.1–0.9) | 0.023* |
| toothbrushing frequency (<1/day) | 3.8 (0.7) | 45.9 (11.6–182.3) | <0.001* |
| use of fluoridated toothpaste (Yes) | 0.5 (0.5) | 1.6 (0.6–4.0) | 0.350 |
| dental check-ups frequency (Periodically) | -0.3 (0.8) | 0.7 (0.1–3.4) | 0.668 |
| deciduous teeth caries (Yes) | 1.0 (0.5) | 2.7 (1.1–6.5) | 0.027* |
| Moderate lesions (ICDAS=3/4) | | | |
| maternal educational level (Primary school) | 3.2 (1.4) | 24.4 (1.5–402.4) | 0.026* |
| paternal educational level (High school) | 1.2 (0.4) | 3.2 (1.5–6.7) | 0.003* |
| paternal occupational status (Employed) | -1.0 (0.6) | 0.4 (0.1–1.2) | 0.105 |
| sweets and snacks taking frequency (Never or rarely) | -1.4 (0.5) | 0.2 (0.09–0.7) | 0.005* |
| toothbrushing frequency (< 1/day) | 4.4 (0.8) | 84.5 (18.6–384.0) | < 0.001* |
| use of fluoridated toothpaste (Yes) | -1.0 (0.5) | 0.37 (0.11–0.62) | 0.046* |
| dental check-ups frequency (Periodically) | -1.2 (0.7) | 0.3 (0.07–1.3) | 0.102 |
| deciduous teeth caries (Yes) | 0.6 (0.4) | 1.8 (0.8–4.2) | 0.141 |
| Extensive lesions (ICDAS = 5/6) | | | |
| maternal educational level (Primary school) | 4.8 (1.5) | 120.4 (6.7–2163.4) | 0.001* |
| paternal educational level (High school) | 0.8 (0.4) | 2.2 (0.9–5.3) | 0.072 |
| paternal occupational status (Employed) | -0.1 (0.9) | 0.9 (0.2–5.0) | 0.920 |
| sweets and snacks taking frequency (Never or rarely) | -1.4 (0.6) | 0.3 (0.08–0.8) | 0.022* |
| toothbrushing frequency (< 1/day) | 22.9 (0.5) | $8 \times 10^9$ ($3 \times 10^9$–$2 \times 10^{10}$) | < 0.001* |
| use of fluoridated toothpaste (Yes) | -0.03(0.5) | 1.0 (0.4–2.6) | 0.960 |
| dental check-ups frequency (Periodically) | -1.8 (0.7) | 0.3 (0.08–1.3) | 0.017* |
| deciduous teeth caries (Yes) | 0.3 (0.5) | 1.3 (0.5–3.3) | 0.577 |

***Statistically significant result.**

**ICDAS – International Caries and Assessment System; CI – confidence interval; OR – odds ratio.**

**Table 4**

**Multivariate nominal logistic regression with the most prevalent caries lesion stage as dependent variable (n = 185)**

| Variable | B (SE) | OR (95% CI) | *p* |
|---|---|---|---|
| Initial lesions (ICDAS = 1/2) | | | |
| Maternal educational level (High school) | 1.1 (0.5) | 3.1 (1.2–8.2) | 0.020* |
| Paternal educational level (High school) | -0.6 (0.5) | 0.6 (0.2–1.5) | 0.258 |
| Toothbrushing frequency (< 1/day) | -17.3(1.0) | 0.0 (0.0–0.0) | < 0.001* |
| Dental check-ups frequency (Occasionally) | 0.8 (0.6) | 0.3 (0.08–0.8) | 0.189 |
| Moderate lesions (ICDAS=3/4) | | | |
| Maternal educational level (High school) | 1.1 (0.5) | 3.0 (1.1–7.9) | 0.025* |
| Paternal educational level (High school) | 0.7 (0.5) | 1.9 (0.7–5.2) | 0.194 |
| Toothbrushing frequency (< 1/day) | -16.4 (0.5) | 0.0 (0.0–0.0) | < 0.001* |
| Dental check-ups frequency (Occasionally) | 1.5 (0.6) | 4.3 (1.3–13.9) | 0.016* |
| Extensive lesions (ICDAS = 5/6) – Base outcome | | | |

***Statistically significant result.**
**ICDAS – International Caries and Assessment System; CI – confidence interval; OR – odds ratio.**

It was shown that in caries affected children compared to those who were caries free (considered as the base outcome), initial caries lesion stage was statistically significantly associated with maternal educational level (Primary school, $p = 0.021$), paternal occupational status (Employed, $p = 0.009$), sweet or snacks taking frequency (Never or rarely, $p = 0.023$), toothbrushing frequency (<1/day, $p = <0.001$) and deciduous teeth caries (Yes, $p = 0.027$). Maternal educational level (Primary school, $p = 0.026$), paternal educational level (High school, $p = 0.003$), sweets or snacks taking frequency (Never or rarely, $p = 0.005$), toothbrushing frequency (<1/day, $p < 0.001$), use of fluoridated toothpaste (Yes, $p = 0.046$) were associated with moderate caries lesion stage in caries affected children compared with those being caries free. On the other hand, maternal educational level (Primary school, $p = 0.001$), sweets or snacks taking frequency (Never or rarely, $p = 0.022$), toothbrushing frequency (< 1/day, $p < 0.001$) and dental check-ups frequency (Periodical, $p = 0.017$) were associated with extensive caries lesion stage in subjects with caries compared to those with no caries (Table 3).

Table 4 shows results of the multinominal logistic regression when the most prevalent caries lesion stage was used as a dependent variable in caries affected children. The children with the prevalence of extensive caries lesions were used as the base outcome. Comparing the subjects with the prevalence of initial caries lesions and the base outcome, maternal educational level (High school) and toothbrushing frequency (<1/day) were statistically significantly associated with this caries lesion stage ($p = 0.020$ and $p < 0.001$, respectively). In subjects affected by moderate caries lesions as the most prevalent figure, maternal educational level (High school, $p = 0.025$), toothbrushing frequency (<1/day, $p < 0.001$) and dental check-ups frequency (Occasionally, $p = 0.016$) were statistically significantly associated with this caries lesion stage compared to those affected by the highest prevalence of extensive caries lesions.

## Discussion

The present cross-sectional study sought to determine whether distinct caries risk indicators were associated with different stages of a caries disease process using the ICDAS II as the diagnostic criteria. According to the obtained results, a large percentage of subjects affected by caries were fairly similarly distributed through stratified groups. Parental socioeconomic and children behavioral indicators were associated with different stages of the caries disease process and interacted with the disease evolution. Considering the entire sample stratified according to the highest caries lesion stage, parental educational level, paternal occupational status, sweets or snacks taking frequency, toothbrushing frequency, dental check-ups frequency and caries status of deciduous teeth were statistically significantly associated with this stratification. A multinomial model with caries-free children being the base outcome was used to evaluate the role of risk factors in the initiation and progression of a caries disease process. In children with initial caries lesions, a low level of maternal education, paternal employed status, sweets and snacks low taking frequency, low toothbrushing frequency, and caries deciduous teeth caries were involved in changing status from caries-free. A low level of parental education, rare consumption of sweets and snacks, a low toothbrushing frequency and usage of fluoridated toothpaste were associated with moderate lesions in caries affected children with regard to the base outcome. In subjects with extensive caries stages, a low level of maternal education, rare consumption of sweets and snacks, a low level of toothbrushing frequency, and periodical dental check-ups were statistically significantly associated with this caries lesion stage. The distribution of caries affected children according to the most prevalent caries lesion stage showed statistically significant association with parental education level, the frequency of toothbrushing and frequency of dental check-ups. In multinomial model, the subjects with prevalence of the highest caries lesions were used as the base

outcome. In children with the highest prevalence of initial caries lesions, maternal educational level and low level of toothbrushing frequency were significantly assocated with this stage. In subjects with the prevalence of moderate lesions, maternal educational level, low level of toothbrushing frequency and occasional dental check-ups were embodied in this stage. All of these findings confirm that socioeconomic and causal factors act in synergy and play their respective roles in different stages of caries.

Our findings highlighted the importance of parental educational level in caries disease evolution. Insufficient parental education contributes to poor dietary habits and unhealthy lifestyles [19]. Low educational level often means lack of various social benefits and skills such as ability to process certain information, interact with health professionals and adapt to health beneficial behaviors [20]. Parental educational level has been shown to be associated with the children dental visits, toothbrushing frequency, and dental caries prevalence [21–23]. A higher educational level could help an individual acquire a better job and a higher income, which guarantees a better socioeconomic position [24] and easier access to dental services and oral hygiene products [25]. It might be possible that children whose parents have a higher level of education and more knowledge about dental health perform more regular dental visits for preventive measures which results in their having more caries-free teeth and lower degree caries lesions.

The occupational status of parents, particularly that of the father, showed significant association with different caries stages in our study. The access to dental services and oral hygiene products is partially conditioned by family income [23] which could affect the state of oral health of all family members including children. According to a French study [26] children whose parents were employed experienced less caries than those whose parents were unemployed.

According to our study, the frequency of consuming sweets and snacks is associated with the caries lesion progression. The intake of dietary sugars is considered the most important risk factor for dental caries [27, 28]. Years ago, an epidemiological study showed that the frequency of sugar intake was an important risk factor for caries development [29]. It is found that sugar consumption frequency and dental caries experience have a positive corelation [30] and that the former increases caries risk [31].

Studies have shown that the effective removal of dental biofilm by toothbrushing improves hygiene levels [32] and significantly reduces the risk of dental caries [33]. It was observed in our study that low brushing frequency increases risk of caries lesion progression regardless of fluoride content in toothpaste. Although the relationship between oral hygiene habits and caries has been widely explored, the effect of toothbrushing frequency on prevention of dental caries is unclear because evidence is inconsistent and conflicting. While David et al. [7] found no association between brushing frequency and caries prevalence and severity, there are studies on dental caries that reported an association between dental caries and toothbrushing habits [31, 34, 35]. People who brush their teeth less than once daily are in higher risk of dental caries compared to those who brush their teeth regularly [35]. Our finding are consistent with all studies but by the David et al. [7].

Fluoride is a caries defensive factor [33] and the daily use of a fluoride-containing toothpaste helps to minimize the risk of developing caries [34–38]. Our results showed that children who used to brush their teeth with fluoridated toothpaste were less likely to have caries lesions of moderate stage.

The present study showed that children who had visited a dentist periodically were less likely to have extensive caries lesions than those who had visited a dentist occasionally or when symptoms of pain existed. Regular dental visits are important as during them caries can be diagnosed, managed and even avoided on time [20, 39].

Our findings suggest that caries experience in the primary dentition seems to be associated with initial caries lesions in newly erupted permanent teeth. Other researchers have found caries experience in deciduous teeth as a risk indicator of the disease in permanent teeth, too [5, 21]. This could be associated with the presence of bad habits acquired in early childhood.

There are some methodological limitations in this study that should be considered. Firstly, the cross-sectional study design measured the cause and effect at the same point in time, thus the directionality of the associations and the time frames of the exposures were not considered. That allows us to discuss only dental caries indicators, leaving risk factors and risk predictors for future longitudinal studies. Secondly, the information on children behavior and habits collected through questionnaires given to parents might be affected by memory recalls or a social desirability bias. Before the questionnaires were administered, parents were informed about the purpose of the questions and the importance of accuracy in their reports. The anonymity and confidentiality of their responses were emphasized, along with the important contribution that their responses would provide, so we do not expect these biases to have a significant impact on the obtained results. Because it was impossible to determine the caries lesion stage that preceded the fillings and extractions of the teeth, the study analyzed only association between caries risk indicators and untreated caries lesions, while other components of caries experience (filled and missing teeth due to caries) were not considered. Regarding the strong points of the study, despite the demanding study-related criteria, this study relied on a large sample size which provided data on the effects of caries indicators on various stages of caries in the study population. The researcher, conducting the clinical examinations, was trained to perform the assessment with calibrated, standardized and sophisticated method such as the ICDAS. This study evaluated the roles of risk indicators considering the disease as a continuous process. That makes our findings novel, important and based on clinically relevant information that can help raise awareness about caries risk indicators that might be responsible for caries occurrence and lesion evolution in the study population. Our findings can also raise awareness of other populations with the same age range, as these factors are highly prevalent and globally relevant. Social-economic, behavioral and nutritional indicators are interconnected and act in synergy. Socioeconomic factors might be modified, but their modification requires time-consuming macro-level

changes. The others could be targeted for modification by directing the limited resources to prevent disease and retard caries lesion evolution as well.

## Conclusion

The results of this research, within the limitations described above, provide valuable information on the risk indicators associated with caries lesion stages in newly erupted permanent teeth. Parental educational level, paternal occupational status, sweets and snacks taking frequency, teeth brushing frequency, caries status of deciduous teeth, usage of fluoridated toothpaste, and dental check-ups frequency were involved in caries occurrence and were associated with different caries stages in newly erupted permanent teeth.

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Received on April 26, 2019
Revised on January 19, 2020
Accepted on April 3, 2020
Online First April, 2020

# Anex

## Questionnaire for parents

**Name of a child:**_____

**1. Gender of the child:** □ male; □ female

**2. How old is the child?** .....

**3. What level of education did the mother complete?**

□ Primary school

□ High school

□ Faculty

**4. What level of education did the father complete?**

□ Primary school

□ High school

□ Faculty

**5. What is mother's work status?**

□ Employed

□ Unemployed

□ Self-employed

**6. What is father's work status?**

□ Employed

□ Unemployed

□ Self-employed

**7. How many main meals does the child have during the day?**

□ Less than three

□ Three to five

□ More than five

**8. Does your child consume sweets, snacks and sweet beverages between main meals?**

□ Yes

□ No

**9. How often does the child consume sweets and snacks?**

□ Never or rarely

□ Two to five times a day

□ More than five times a day

**10. How often does the child consume sugary drinks?**

□ Never or rarely

□ Two to five times a day

□ More than five times a day

**11. Does your child brush his/her teeth?**

□ Yes

□ No

**12. How often does the child brush his/her teeth?**

□ Less than once a day

□ Once to twice a day

□ More than twice a day

**13. How long does the child brush their teeth?**

□ Less than three minutes

□ Three minutes or longer

**14. Does your child use toothpaste?**

□ Yes

□ No

**15. Does your child use fluoride toothpaste?**

□ Yes

□ No

**16. Does the child use fluoride mouthwash?**

□ Yes

□ No

**17. Has the child ever visited a dentist?**

□ Yes

□ No

**18. How often does your child visit a dentist?**

□ He/ she regularly goes to dental examinations

□ Occasionally

□ Only when there is pain

**19. Does your child suffer from a systemic disease or does the child have any health problem?**

□ Yes

□ No

Thank you for your time to fill in this questionnaire. Please submit the completed questionnaire to a member of the research team who will do the clinical examinations of the children.

If you have any comments, please write below.