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## Relationship between occurrence of caries and calcium, phosphorus and vitamin D levels in children in Al-Muthanna province (Iraq)

**Abstract.** Dental caries is a multifactorial chronic disease affecting children worldwide. Calcium, phosphorus, and vitamin D play an important role in the prevention of dental caries. **Objectives:** To explore the relationship between the occurrence of dental caries and serum levels of Ca, P, and vitamin D3 in children in the Al-Muthanna province of Iraq. **Materials and methods.** The study included 100 children, categorized as either having caries or being caries-free according to the DMFT (Decayed, Missing, Filled Teeth) index. Demographic data included age, gender, nutritional status, and dietary habits, while socioeconomic status was assessed based on parents' education, occupation, and geographic distribution. Ca, P, and vitamin D levels were estimated in the serum of all participants. **Results.** Poor dietary habits, insufficient brushing frequency, lack of parental supervision, and an absence of dental visits were strongly associated with a high risk of caries. Distribution by DMFT components showed that 26% of patients had D $\geq$ 6 and M=1–3, 32% had D=4–5 and M=1–4, and 42% had D $\leq$ 3 and M=1–3. In caries-free children compared to those with caries, the mean levels of Ca were 8.4 and 6.6 mg/dl, phosphorus concentrations were 5.5 and 4.1 mg/dl, and 25(OH)D levels were 45.8 and 27.6 ng/ml, respectively ( $p<0.05$ ). **Conclusion.** A strong correlation was found between poor dietary habits, insufficient brushing frequency, lack of parental supervision, infrequent dental visits, and a high risk of caries. A significant positive correlation was observed between decreased levels of Ca, P, and 25(OH)D and a higher occurrence of caries in the study population. The authors recommend future longitudinal studies in other Iraqi provinces to support the development of a national caries prevention program.

**Key words:** caries, calcium, children, Al-Muthanna, Iraq, 25(OH)D[P.A. Ашур](#)<sup>1</sup>,

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AAshour R.A., Abdulhussein D.N., Alhaboby A.A., Al-Salihi K.A. Relationship between occurrence of caries and calcium, phosphorus and vitamin D levels in children in Al-Muthanna province (Iraq). — *Клиническая стоматология*. — 2026; 29 (1): 119—125. DOI: 10.37988/1811-153X\_2026\_1\_119

## Взаимосвязь между возникновением кариеса и уровнем кальция, фосфора и витамина D у детей в провинции Аль-Мутанна (Ирак)

**Реферат.** Кариес зубов — это многофакторное хроническое заболевание, поражающее детей во всем мире. Кальций, фосфор и витамин D играют важную роль в профилактике кариеса. **Цель исследования** — изучить взаимосвязь между возникновением кариеса зубов и уровнями кальция (Ca), фосфора (P) и витамина D3 у детей в иракской провинции Аль-Мутанна. **Материалы и методы.** В исследование было включено 100 детей, распределенных на группы (с кариесом и без кариеса) в соответствии с индексом КПУ. Демографические данные включали возраст, пол, статус питания и пищевые привычки; социально-экономический статус оценивали на основе образования родителей, рода их занятий и географического распределения. Также измеряли содержание Ca, P и витамина D в крови. **Результаты.** Неправильные пищевые привычки, недостаточная частота чистки зубов, отсутствие контроля со стороны родителей и отсутствие визитов к стоматологу были тесно связаны с высоким риском развития кариеса. Распределение детей с кариесом по КПУ составило: 26% с «К»  $\geq$ 6 и «У»=1–3, 32% с «К»=4–5 и «У»=1–4, 42% с «К»  $\leq$ 3 и «У»=1–3. У детей без кариеса по сравнению с детьми с кариесом среднее содержание Ca составило 8,4 и 6,6 мг/дл, концентрация фосфора — 5,5 и 4,1 мг/дл, а 25(OH)D — 45,8 и 27,6 нг/мл соответственно ( $p<0,05$ ). **Заключение.** Выявлена сильная корреляция между неправильными пищевыми привычками, недостаточной частотой чистки зубов, отсутствием родительского контроля, редкими визитами к стоматологу и высоким риском развития кариеса. Наблюдалась значимая положительная корреляция между снижением уровней Ca, P и 25(OH)D и более высокой частотой возникновения кариеса у исследуемой группы детей. Авторы рекомендуют проведение дальнейших исследований в других провинциях Ирака для поддержки разработки национальной программы профилактики кариеса.

**Ключевые слова:** кариес, кальций, дети, Аль-Мутанна, Ирак, 25(OH)D

## INTRODUCTION

Dental caries, commonly known as tooth decay, is a multifactorial chronic disease. It affects populations worldwide, with childhood caries affecting nearly 50% of children internationally [1]. Persistent socioeconomic disparities impacting caries prevalence, the limited availability of effective silver diamine fluoride treatments, and the complex role of the oral microbiome remain key challenges [2, 3]. Prevalence rates vary significantly, from 27–64% in India [4] to 16.7% in Sweden [5], and 18.6% for early childhood caries in the United States [6]. According to WHO reports, there is notable heterogeneity across studies and data from nine countries regarding dental caries prevalence. The prevalence for deciduous dentition in 5-year-old children was 65% (45–85%), 61% (50–72%) for permanent dentition in 12-year-olds, 70% (64–75%) for 15-year-olds, and 66% (59–73%) for children aged 6–15 years [7].

Despite health advancements, significant inequality in disease burden persists, particularly in low- and middle-income countries. This highlights the need to translate caries research into practice and promote targeted interventions [8]. Caries results from the demineralization of tooth enamel and dentin by acids produced through the bacterial fermentation of dietary carbohydrates. Tooth decay in children can present in various forms, including early childhood caries, smooth surface caries, and pit and fissure caries, each varying in location and progression [9, 10].

The pathogenesis and progression of dental caries are influenced not only by bacterial activity and dietary habits but also by the status of essential minerals and vitamins. The “bone mineralization triangle”, which includes calcium, phosphorus, and vitamin D, consists of elements essential to the tooth mineral matrix that play a vital role in maintaining enamel strength and resistance to acid attack. Vitamin D acts through several mechanisms as a protective factor against the development of caries. It contributes to tooth mineralization by maintaining calcium and phosphorus homeostasis, which is necessary for the formation, calcification, and mineralization of teeth [11]. Disturbances in this homeostasis can lead to hypocalcemia and hypophosphatemia, causing enamel and dentin defects. Another mechanism involves

the active form of vitamin D, 1,25-dihydroxyvitamin D<sub>3</sub>, which acts directly on ameloblasts and odontoblasts [12]. Consequently, hypoplasia and hypomineralization resulting from vitamin D deficiency during tooth development leave teeth susceptible to caries [13]. Moreover, vitamin D may stimulate antimicrobial peptides that prevent the colonization of pathogens [14, 15]. A deficiency in these nutrients can compromise dental integrity; thus, the correlation between caries and the levels of these essential elements must be thoroughly understood to effectively control caries in children. Furthermore, studies have suggested that the efficacy of treatment for chronic apical periodontitis is significantly influenced by systemic osteopenia and vitamin D deficiency [16].

Data regarding caries in Eastern Mediterranean countries remain scarce. A meta-analysis of deciduous teeth caries in Gulf countries showed a prevalence of 80.9% [17]. A literature review concerning the relationship between caries and Ca, P and vitamin D<sub>3</sub> concentrations revealed a lack of publications from Iraq in general, and the Al-Muthanna Governorate specifically. Consequently, this study aims to investigate the relationship between the occurrence of dental caries and the levels of calcium, phosphorus, and vitamin D<sub>3</sub> in children in Al-Muthanna province.

## MATERIALS AND METHODS

The study was conducted in private pediatric dentistry clinic in Al-Muthanna province on 100 children. Based on DMFT index (Decayed, Missing, and Filled Teeth) according to the WHO description [18] the enrolled children were divided into 2 groups:

- I — 50 caries-free children (DMFT=0) — control group (healthy);
- II — 50 children showing various degree of caries as follows:
  - mild caries (DMFT 1—3, early stage of caries activity), few teeth affected, with limited decay, possibly one or two small restorations or cavities;
  - moderate Caries (DMFT 4—6, active dental caries), more teeth affected, multiple cavities or restorations and management was needed;
  - severe Caries (DMFT > 6, active caries including missing teeth due to caries with poor oral hygiene and limited dental care access).

The inclusion criteria were a child between the age group of 4–9 years, parent and child cooperation, a systemic healthy children, and caries-free (dmft=0) for Group I. Exclusion criteria were: metabolic disease, long-term medication use, and current chemotherapy or radiotherapy.

A demographical data including the age, gender, nutritional status (good or poor) and food habit (non-alcoholic beverages like Coca cola, Sprite, and juice; cookies and sweets including lollipops, fruit drops, and candy canes). In addition the socioeconomical status including parent's education degree and occupation (professional, clerical, etc.), and geographic distribution (urban or rural) were also collected for each participant before dental clinical examination. The study was extended for a period of 8 months, from February to October 2024.

Dentist examined each participant to categorize the participant according to caries index (fig. 1).



Fig. 1. Intraoral view of one participant of the study showing mouth preparation prior to dental treatment. It demonstrates the isolation and retraction with a dental mirror and probe, providing visibility of the dentition and gingival tissue

All participants were sent for clinical pathology laboratory. A 2 ml blood sample was collected by a technician from each child with a sterile disposable plastic syringe without anticoagulant, and used for estimating the calcium, phosphorus, and vitamin D levels.

Calcium concentration in serum was measured using a photometric test through using atomic absorption spectrophotometry at 570 nm, using a commercial kit (Liquicolor Human, Germany) and according to the instruction of the manufacturer.

Phosphorus concentration was measured by ultraviolet colorimetry using the UV-visible colorimetric method and a commercial kit (Liquicolor Human, Germany) according to the manufacturer's instructions. The absorbance of the complex at 340 nm is proportional to the inorganic phosphorus concentration in the sample [19].

Vitamin D level was estimated by using a commercial 25-OH vitamin D ELISA kit (Creative Diagnostics, USA). There are no international standard for 25-OH vitamin D, therefore, gravimetrically was used to calibrate the kit's standard and controls. Briefly, the standards, controls, and samples were added to the antibody-containing wells specifically coated with 25-hydroxyvitamin D3 and incubated to allow binding. Later, unbound substance was washed away. Then enzyme-linked secondary antibody added to bind to the vitamin D complex. The sample incubated and substrate solution was added to start the color reaction. The optical density (OD) was measured at the specified wavelength using a microplate reader. The standard curve was generated by plotting known standard concentration against their equivalent OD (ELISA), then vitamin D concentration from each sample signal measurement were interpolated in standard curve. The level of vitamin D was reported as ng/ml or nmol/L.

### Statistical analysis

The Pearson correlation was calculated and, a level of significance at a  $p < 0.05$  was identified by unpaired t-test, and chi-square test for comparing between the two groups.

## RESULTS

The results of this study compared the sociodemographic factors of caries-free children and children with caries. The mean age of caries-free children and those with caries was  $6.5 \pm 1.7$  and  $6.8 \pm 1.7$  years, respectively. The gender distribution was 44% (male/female) and 56% for the caries-free group, compared to 48 and 52% for the group with caries. Regarding paternal education, for caries-free children, 8% were illiterate, 26% had primary education, 38% middle, and 28% higher education, compared to 2, 18, 44, and 36%, respectively, for fathers of children with caries. Maternal education for caries-free children was 10% illiterate, 36% primary, 34% middle, and 20% higher education, while for children with caries, the figures were 12, 32, 36, and 20%, respectively. Paternal occupation among caries-free children was 36% laborer, 36% clerical, and 28% professional, compared to 32, 44, and 24% for the caries group. Maternal occupation in the caries-free group was 30% laborer, 22% clerical, 18% professional, and

30% housewife. In contrast, for children with caries, 48% of mothers were housewives, 12% were professionals, and 20% each were laborers or clerical workers. Both groups showed 100% good nutritional status. Geographical distribution showed that 54% of caries-free children were from urban areas, while 60% of children with caries were from rural regions (Table 1).

**Table 1. Sociodemographic factors of children caries free and children with caries**

Criteria	Caries-free children	Children with caries
Age (year)	$6.5 \pm 1.7$	$6.8 \pm 1.7$
Gender (%)		
Male	44	48
Female	56	52
Father education (%)		
Illiterate	8	2
Primary	26	18
Middle	38	44
High	28	36
Mother education (%)		
Illiterate	10	12
Primary	36	32
Middle	34	36
High	20	20
Father occupation (%)		
Laborer	36	32
Clerical	36	44
Professional	28	24
Mother occupation (%)		
Laborer	30	20
Clerical	22	20
Professional	18	12
Housewife	30	48
Geographical distribution (%)		
Urban	54	40
Rural	46	60

All children in caries-free group experienced good dietary habits (100%), while the percentages of children with caries were 52% for good dietary habits. The results of previous dental visits, 76% of caries-free children had visited a dentist, compared to 56% in children with caries. The percentages of brushing in the caries-free children, and children with caries were 78% and 56% respectively. While the percentages of brushing frequency showed obvious contrast, in the caries-free group, 42% brushed twice daily, 36% once daily and only 22% did not brush. However, 44% of the caries group children did not brushing, and 28% brushed once or twice daily. Moreover, the parental supervision of brushing was reported 70% and 56% for caries free children and with caries respectively. The results of the DMFT showed various percentages for degrees in children with caries. The distribution of children with caries according to DMFT scores was as follows:  $D \geq 6$  and

M=1-3 – 26% of patients, D=4-5 and M=1-4 – 32% of patients, D≤3 and M=1-3 – 42% of patients (Table 2).

**Table 2. Food habit & oral hygiene and DMFT in children**

Criteria	Caries-free children	Children with caries
Food habit — drinks, cookies and sweet (%)		
Good	100	52
Poor	0	48
Previous dentistry visit (%)		
Yes	76	56
No	24	44
Brushing (%)		
Yes	78	56
No	22	44
Brushing frequency (%)		
No	22	44
Once a day	36	28
Twice a day	42	28
Parents supervision of brushing (%)		
Yes	70	56
No	30	44
DMFT (%)		
0	100	—
1	—	12
2	—	16
3	—	14
4	—	16
5	—	16
6	—	12
>6	—	14

The biochemical parameters comparison between caries-free children and children with caries is displayed in Table 3. A significant higher mean serum calcium levels ( $8.4 \pm 0.4$  mg/dl) found in caries-free children compared with caries children ( $6.6 \pm 0.5$  mg/dl), additionally, showing a statistically significant ( $t=2.484$ ,  $p<0.001$ ). Serum phosphorus levels also found significantly higher in caries-free children ( $5.5 \pm 0.4$  mg/dl) than caries children ( $4.1 \pm 0.2$  mg/dl;  $t=2.069$ ,  $p=0.002$ ). Likely, serum 25(OH) vitamin D concentrations were markedly higher between carries free children ( $45.8 \pm 1.4$  ng/ml) compared with those with caries ( $27.6 \pm 0.8$  ng/ml), with the difference reaching statistical significance ( $t=3.420$ ,  $p=0.007$ ). The correlation analysis proved weak negative associations between dental caries and the measured biochemical

**Table 3. Concentration of calcium, phosphorus and 25(OH)D in children caries free and children with caries**

Criteria	Caries-free children	Children with caries	t	p	r
Ca (mg/dl)	$8.4 \pm 0.4$	$6.6 \pm 0.5$	2.484	<0.001	-0.033
P (mg/dl)	$5.5 \pm 0.4$	$4.1 \pm 0.2$	2.069	0.002	-0.055
25(OH)D (ng/ml)	$45.8 \pm 1.4$	$27.6 \pm 0.8$	3.420	0.007	-0.041

parameters. A weak negative correlation with serum calcium ( $r=-0.033$ ), serum phosphorus ( $r=-0.055$ ), and serum 25(OH)D levels ( $r=-0.041$ ). These values demonstrating that lower levels of these parameters were associated caries higher occurrence.

## DISCUSSION

This study provides valuable insights into the multifactorial nature of childhood dental caries, according to the global understanding of this widespread chronic disease [20, 21].

According to the World Health Organization, dental caries affects a significant proportion of children worldwide, with variation in prevalence depending on the age group [7]. The observed prevalence rates vary widely worldwide, for example, from 27–64% in India [4], 11.4% in Sweden [22], and 11% in the United States [23], and 54% of 3-year-olds and 37% of 6-year-olds in Serbia [24]. Despite of advances in healthcare, significant differences in disease load persist, particularly in low- and middle-income countries, highlighting the urgent need to translate research into practical, targeted interventions [1].

The results of demographic factors of the current study showed a difference between children caries-free and those with caries. The means of age and gender revealed no differences; however the parental education and occupation displayed varying patterns that contribute to consider these factors for health prevention program. For example, the higher education father was 36% in children with caries compared to 28% for children caries free. This observation appeared to be contrary with general concept where higher education often linked with better health outcomes, emphasizing the impacts of socioeconomic factors on oral health and its significant effect caries prevalence [25]. Conversely, father illiteracy was less common in the caries group (2%) compared to the caries-free group (8%). Similarly, mothers' educational levels showed similar proportions of higher education in both groups. However, a slightly higher proportion of illiterate mothers was observed among children with caries. These results are compatible with previously published observations from other researchers [26].

In terms of parental occupation, mothers who identified as housewives were significantly more common in the caries group of children (48%) compared to the caries-free group (30%). This observation, combined with the lower proportion of working mothers in the caries group, suggests potential influences of maternal availability of time or focus on hygiene routines in the household [27]. The higher proportion of children with caries living in rural areas (60%) compared to caries-free children (46%) is consistent with the broader challenge of persistent inequalities in disease burden, particularly in areas that may have less access to effective treatments [28]. However, both groups reported 100% good nutritional status, an interesting finding given on the known role of diet in caries development.

Additionally, the impact of dietary habits and oral hygiene practices was also highlighted in the current study and its relation on caries prevention.

All children in the caries-free group demonstrated good dietary habits, while 48% of the children with caries were

revealed poor dietary habits, and these results are compatible with previously published study [29] that display the direct association between poor dietary habits specifically drinks, cakes, and sweets [30]. The presence of caries indicates the multifactorial nature of the disease, with diet being a major contributing factor [31].

Furthermore, the study clearly demonstrates the role of reliable oral hygiene practices and parent's supervision in caries prevention. The results of the current study showed a significant difference in tooth brushing rates. There were 42% of children caries-free brushed twice daily, while only 28% from children with caries. However, 44% of children with caries reported not brushing at all. This result agrees with previously published research, that highlights a direct relationship between poor brushing and caries incidence [32].

The percentage of parent's supervision of tooth brushing was more common in children without caries (70%) than in children with caries (56%). And these are compatible with previously published observations of other researchers [33]. WHO demonstrated the role of parental supervision and reliable oral hygiene practices in caries prevention. The current observations displayed the role of parent's supervision and reliable oral hygiene practices in preventing caries, moreover it promotes to the maternal preventive behavior, which has been shown to have long-term effects on children's dental health [34].

The current study also focused on the findings of the previous dental visits, which strengthen the importance of access to dental care and preventive measures. A current study results showed higher proportion of caries-free children (76%) with a previous dental visit compared to children with caries (56%). This suggests that regular professional dental care, combined with home preventive practices can contributed significantly to maintaining a caries-free status. This finding is consistent with previously published results that challenge from lack of access to effective treatments, as a major factor affecting caries incidence globally [35].

The most important minerals required for the formation of hydroxyapatite  $\text{Ca}_{10}(\text{PO}_4)_6(\text{OH})_2$ , are the calcium and phosphorus, which are the primary minerals composition of tooth enamel and dentin. The sufficient availability of these minerals during stages of teeth development secure the ideal enamel hardness, crystal density, mineralization of dental matrix and resistance to acid demineralization. Nonetheless, deficiencies during this stage resulted in enamel hypoplasia, and susceptibility of teeth to bacterial invasion and decay [36, 37]. Moreover, after demineralization from acid exposure due to dietary sugars or bacterial metabolism, remineralization occurs by redepositing calcium and phosphate ions, particularly in the presence of fluoride [38].

Likewise, vitamin D plays a regulatory role in dental development and mineralization process. It increases the intestinal absorption of both Calcium and phosphorus [39], and considered as an essential factor for maintaining adequate serum levels enforced for enamel and dentin formation [40]. Vitamin D also plays another important role in expression of antimicrobial peptides like oral tissue cathelicidin help in decrease the oral bacterial load and decreasing the caries risk [41, 42].

Other additional reported teeth abnormalities due to vitamin D deficiencies were hypomineralization, enamel defects and delayed eruption [43], and increased incidence of early children caries and enamel abnormalities [18]. Nevertheless, previous published studies showed a positive correlation between insufficiency of vitamin D level and a significant prevalence of dental caries [44]. The results of other published studies related to the deficiency of vitamin D showed the impaired immune responses leading to delayed eruption and defects of enamel developmental [45]. Other published study correlated vitamin D levels, and early children caries with limited exposure or poor dietary intake [46, 47].

The results of the current study approved a significant correlation between occurrence of caries and the levels of calcium, phosphorus, and vitamin D among children in Al-Muthanna governorate. The current results showed that children caries-free had significantly higher serum calcium levels (8.4 mg/dl) compared to the children with caries (6.6 mg/dl). These observations agree with previously published stud [48, 49], who reported a correlation between the deficiency of salivary calcium levels and vitamin D and potential risk of teeth caries occurrence. Likewise, another researcher approved the development of enamel hypoplasia due to hypocalcemia that make the teeth more susceptible to tooth decay and caries [10].

However, another study reported a significant correlation between calcium, phosphorus levels and dental caries. With respect to serum phosphorus level, the results showed a statistically significant difference between caries-free children (5.5 mg/dl) and children with caries (4.1 mg/dl), with a negative Pearson correlation. These results are compatible with previously published research that confirmed the importance of pH during stages of teeth development, mineralization of dental matrix and resistance to acid demineralization [50].

Additionally, the current study showed a higher mean level of 25(OH)D in children caries-free (45.8 ng/mL) compared to children with caries (27.6 ng/mL). These results agree with previously published studies [11]. These previously published studies focused on the dual roles of vitamin D in enhancing calcium and phosphate absorption and synthesis of antimicrobial peptides like cathelicidin [41]. Furthermore, the previous researcher predicated that sufficient sun exposure and vitamin D intake contribute significantly in decreasing the dental caries risk in children [11]. Nonetheless, other study revealed a statistically significant association between serum level of vitamin D and dental caries in older children and this contribute to the potential variations in sun exposure, diet and genetic differences in vitamin D metabolism [50].

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## CONCLUSION

In conclusion, the current study showed a strong correlation between poor dietary habits, insufficient brushing frequency, and lack of parent supervision on brushing, fewer dental visits with high risk of caries. Moreover, the current findings provide a valuable perception about the biochemical risk factors that influencing the dental caries, especially

in population at risk for caries in areas with limited available data. The authors recommend further longitudinal and interventional studies in various Iraqi governorates, where sunlight and nutritional status are commonly different.

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