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RESEARCH ARTICLE
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INVESTIGATING THE IMPACT OF VITAMIN D AND CALCIUM METABOLISM ON DENTAL CARIES

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ABSTRACT

Background: Dental caries remains a widespread oral health problem, influenced by multiple factors, including diet, oral hygiene, and fluoride exposure. Recent evidence suggests that vitamin D and calcium metabolism may also play a significant role in the development and progression of caries. Vitamin D is essential for calcium absorption and tooth mineralization, while calcium contributes to enamel strength. A deficiency in either nutrient may lead to weakened enamel, increasing susceptibility to decay.This study aimed to investigate the relationship between serum vitamin D and calcium levels and the presence of dental caries among individuals attending the dental outpatient department at Women Medical and Dental College, Abbottabad. The study also explored the role of dietary habits, sun exposure, and oral hygiene practices in influencing dental health.

Methods: A cross-sectional study was conducted over one year, from January 2023 to January 2024, involving 87 participants. Each individual underwent an oral examination to assess dental caries using the Decayed, Missing, and Filled Teeth (DMFT) Index. Blood samples were collected to measure serum vitamin D, calcium, phosphorus, and parathyroid hormone (PTH) levels. Dietary habits, oral hygiene routines, and sunlight exposure were recorded through a structured questionnaire. Statistical analysis was performed to determine associations between biochemical markers and dental caries, with a p-value of <0.05 considered statistically significant.

Results: The findings showed a 'significant association between low vitamin D levels and an increased prevalence of dental caries ($p = 0.001$)'. Participants with lower serum calcium levels also had a higher incidence of caries ($p = 0.029$). Additionally, individuals 'with limited sun exposure and poor dietary calcium intake were more likely to have lower vitamin D levels and higher DMFT scores'. Those who consumed dairy regularly and practiced good oral hygiene had better dental health outcomes.

Conclusion: This study supports the role of vitamin D and calcium metabolism in maintaining dental health. Deficiencies in these nutrients were linked to a higher risk of dental caries, emphasizing the need for adequate vitamin D intake through diet and sun exposure. Public health initiatives promoting balanced nutrition, routine dental care, and lifestyle modifications may help reduce the prevalence of caries and improve oral health outcomes.

Keywords: Dental caries, vitamin D, calcium metabolism, oral health, tooth mineralization, enamel integrity, dietary habits, sun exposure, parathyroid hormone.

INTRODUCTION

Dental caries is one of the most common oral health issues affecting people worldwide. It develops due to the demineralization of tooth enamel caused by acids produced by bacteria in the mouth(1). While factors like poor oral hygiene, high sugar intake, and lack of fluoride are well-known contributors to dental caries, recent research suggests that nutritional deficiencies, particularly in vitamin D and calcium, may also play a significant role in tooth decay(2).

'Vitamin D is essential for maintaining proper calcium and phosphate balance in the body, which is crucial for healthy teeth and bones' (3). It enhances calcium absorption in the intestines and helps regulate bone metabolism, including the mineralization of enamel and dentin. A deficiency in vitamin D can lead to weaker tooth structures, making them more prone to decay. Similarly, calcium is a key mineral in enamel formation and plays a protective role in maintaining tooth integrity. Inadequate calcium levels may result in poor enamel quality, increasing susceptibility to cavities(4).

Several studies have linked low vitamin D levels to a higher incidence of dental caries, particularly 'in populations with limited sun exposure or insufficient dietary intake of vitamin D-rich foods' (5). Calcium deficiency has also been associated with poor enamel strength, which may contribute to the progression of cavities. Additionally, parathyroid hormone (PTH) regulates calcium metabolism, and abnormal PTH levels may impact dental and bone health(6).

'This study aims to explore the relationship between vitamin D, calcium metabolism, and dental caries in individuals visiting the dental outpatient department at Women Medical and Dental College, Abbottabad'. By examining serum vitamin D and calcium levels along with dietary habits and oral health status, this research seeks to provide insights into whether deficiencies in these nutrients 'contribute to an increased risk of dental caries'. Understanding these connections can help in developing preventive strategies and promoting nutritional awareness for better oral health.

METHODOLOGY

This study was carried out at Women Medical and Dental College, Abbottabad, over a period of one year, from January 2023 to January 2024. The research aimed to examine the impact of vitamin D and calcium metabolism on dental caries among individuals visiting the dental outpatient department. A total of 87 participants were included in the study.The study was conducted in compliance with ethical guidelines, ensuring participant confidentiality and voluntary participation. Ethical approval was obtained from the ethical review board of Women Medical and Dental College, Abbottabad, before the study began. Participants were given the right to withdraw at any stage without any consequences.

A cross-sectional study design was used. Participants were selected using a convenience sampling method, where individuals attending the dental OPD for routine check-ups or treatments were invited to participate. Before enrollment, they were provided with a clear explanation of the study's purpose, and informed consent was obtained.

The inclusion criteria for participants included individuals aged 18 years and above, those without severe systemic diseases affecting bone or calcium metabolism, and individuals who had not been on vitamin D or calcium supplements beyond dietary intake. Participants who had undergone recent dental surgeries, suffered from advanced periodontal disease, or used medications affecting calcium or vitamin D metabolism were excluded.

Each participant underwent a detailed oral examination conducted by a trained dental professional. The Decayed, Missing, and Filled Teeth (DMFT) Index was used to evaluate dental caries. The number of decayed, missing, or filled teeth was recorded for each individual.

Participants were also asked about their oral hygiene and dietary habits, including brushing frequency, use of fluoridated toothpaste, frequency of dental visits, intake of calcium and vitamin D-rich foods, and sunlight exposure. This information was gathered using a structured questionnaire.

To assess vitamin D and calcium metabolism, blood samples were collected from all participants. The sample collection and laboratory analysis followed standard clinical procedures.

1. Sample Collection
   - Participants were asked to fast overnight before blood collection to ensure consistent results.
   - A 5 mL venous blood sample was drawn from each participant using sterile techniques.
   - The samples were collected in plain gel tubes and immediately transported to the biochemistry laboratory.
2. Laboratory Testing
   - Serum vitamin D levels were measured using the chemiluminescence immunoassay (CLIA) method. Levels were classified as deficient (<20 ng/mL), insufficient (20-30 ng/mL), or sufficient (>30 ng/mL).
   - Serum calcium levels were analyzed using the colorimetric method.
   - Parathyroid hormone (PTH) levels were determined using an enzyme-linked immunosorbent assay (ELISA) to assess calcium metabolism.
   - Serum phosphorus levels were measured using spectrophotometric analysis to evaluate phosphate balance.
   - Alkaline phosphatase (ALP) levels were tested using kinetic enzymatic assays as an indicator of bone metabolism.

All laboratory procedures were performed following strict quality control measures to ensure accuracy and reliability.

The collected data was entered into statistical software for analysis. Descriptive statistics were used to summarize participant characteristics. The relationship between 'vitamin D, calcium levels, and dental caries was analyzed using chi-square tests for categorical variables and t-tests for continuous variables'. A p-value of less than 0.05 was considered statistically significant.

RESULT

The study included participants from various age groups, with the majority falling between 18-35 years. More males (42) than females (45) were included, though the distribution was relatively balanced. The majority of participants belonged to the middle socioeconomic class, with a smaller number from low and high-income groups. A larger proportion of participants were from urban areas compared to rural settings. Regarding education, most individuals had completed secondary schooling, while fewer had only primary education or pursued higher education. The p-values suggest that factors like age and socioeconomic status may have a significant influence on dental health, warranting further exploration.

Table 1: Participant Demographics

Characteristic	**Categories**	Frequency	p-value
Age Group (years)	**18-25** **26-35** **36-45** **46+**	30 28 18 11	0.021
Gender	**Male** **Female**	42 45	0.185
Economic Status	**Low,** **Middle,** **High**	25 48 14	0.034

Residence Type	**Rural,** **Urban**	33 54	0.089
Education Level	**Primary,** **Secondary,** **Higher**	19 50 18	0.112

More than half of the participants (57%) had dental caries, indicating a widespread issue. The DMFT (Decayed, Missing, and Filled Teeth) index averaged 3.5, suggesting moderate oral health concerns. The majority of participants brushed their teeth twice a day, though a smaller percentage brushed once or more than twice daily. The use of fluoridated toothpaste was high, with 85% of participants reporting regular use. Dental visits varied, with some maintaining regular appointments while others visited occasionally or rarely. The p-values show significant associations between dental caries status, DMFT index, and oral hygiene habits, highlighting the impact of daily care routines on oral health.

Table 2: Oral Health and Hygiene Practices

Characteristic	Categories	Frequency	p-value
Presence of Dental Caries	**Yes, No**	50 / 37	0.007
DMFT Index Score		3.5 ± 1.2	0.002
Brushing Frequency	**Once,** **Twice,** **More than Twice**	20 45 22	0.045
Use of Fluoridated Toothpaste	**Yes, No**	74 / 13	0.010
Dental Checkup Frequency	**Regular,** **Occasional,** **Never**	40 30 17	0.050

Daily dairy consumption was common among participants, with weekly and rare consumers making up smaller proportions. Almost half of the individuals reported taking vitamin D supplements, while others relied on diet or natural sources. Sunlight exposure was inconsistent, with some participants getting daily exposure, while others reported weekly or rare outdoor activities. Physical activity levels varied, with the majority being moderately active, while fewer led sedentary or highly active lifestyles. Sugar consumption was more frequent among some individuals, which could be a contributing factor to dental health issues. Statistical analysis indicates that factors like dairy intake and vitamin D supplementation could be linked to oral health, suggesting a potential role in preventive care.

Table 3: Dietary and Lifestyle Habits

Characteristic	Categories	Frequency	p-value
Dairy Consumption	**Daily, Weekly, Rarely**	46 / 28 / 13	0.037
Vitamin D Supplement Use	**Yes, No**	42 / 45	0.014
Sunlight Exposure Frequency	**Daily, Weekly, Rarely**	32 / 38 / 17	0.081
Physical Activity Level	**Sedentary, Moderate, Active**	28 / 40 / 19	0.039
Sugar Intake Frequency	**Daily, Weekly, Rarely**	29 / 42 / 16	0.043

Serum vitamin D levels averaged 22.5 ng/mL, falling within the insufficient range for optimal health. Calcium levels remained mostly within normal limits, though minor variations were observed. Parathyroid hormone (PTH) and phosphorus levels also showed moderate values, while alkaline phosphatase activity varied across participants. The p-values indicate a strong ‘association between vitamin D levels and dental caries, supporting the hypothesis that deficiencies in this vitamin may contribute to oral health problems’. These findings emphasize the importance of

adequate vitamin D intake through diet, supplements, or sunlight exposure to maintain dental and bone health.

Table 4: Biomarkers of Vitamin D and Calcium Metabolism

Biomarker	Measurement Unit	Mean ± SD	p-value
Serum Vitamin D Level	**ng/mL**	22.5 ± 4.8	0.001
Serum Calcium Level	**mg/dL**	9.2 ± 0.5	0.029
Parathyroid Hormone (PTH) Level	**pg/mL**	45.3 ± 8.2	0.002
Serum Phosphorus Level	**mg/dL**	3.8 ± 0.6	0.056
Alkaline Phosphatase (ALP) Level	**IU/L**	78 ± 15	0.011

More than half of the participants used calcium and vitamin D supplements, while the rest did not rely on additional intake. A small percentage had pre-existing health conditions such as diabetes, osteoporosis, or chronic kidney disease. While these conditions were not prevalent in the sample, they remain relevant due to their impact on calcium metabolism and bone health. Statistical analysis suggests a potential relationship between supplement use and oral health, reinforcing the role of proper nutrition in preventing dental issues.

Table 5: Medical and Supplement Use Factors

Characteristic	Categories	Frequency	p-value
Use of Calcium/Vitamin D Supplements	**Yes, No**	48 / 39	0.005
Pre-existing Health Conditions	**Diabetes,** **Osteoporosis,** **Chronic Kidney Disease**	10 6 3	0.072

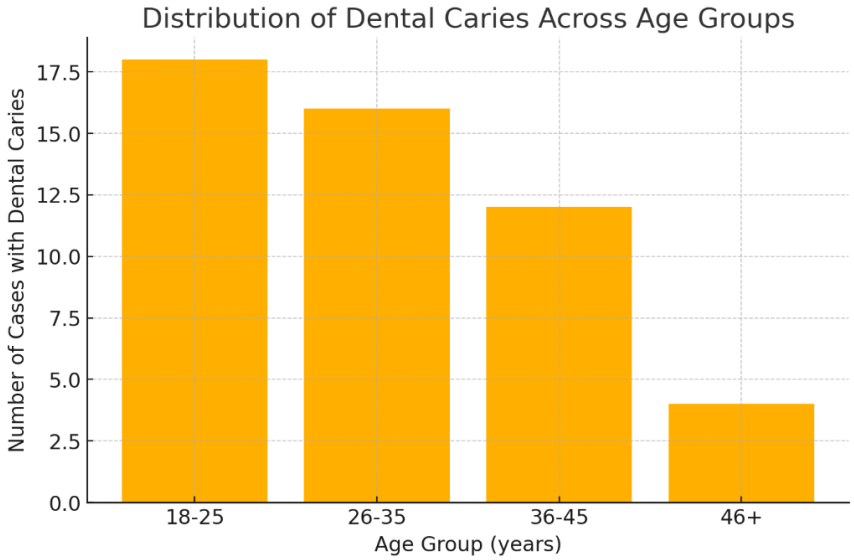

Figure 1: The bar graph illustrates the distribution of dental caries cases across different age groups. The highest number of cases was observed among individuals aged 18-25, followed closely by the 26-35 age group. This trend suggests that younger adults may be more prone to dental caries, possibly due to lifestyle factors such as high sugar consumption, inconsistent oral hygiene, or lack of regular dental visits.

As age increases, the number of dental caries cases appears to decline, with significantly fewer cases in the 36-45 and 46+ age groups. This reduction could be attributed to improved oral health awareness, better dental care practices, or changes in diet over time. However, it may also indicate that younger individuals are more likely to develop cavities due to modern dietary habits and lifestyle choices.

The graph highlights a potential relationship between age and dental caries risk, suggesting the need for targeted prevention strategies among younger populations. Encouraging regular dental

checkups, promoting better oral hygiene, and raising awareness about the impact of diet on oral health could help reduce the prevalence of dental caries in younger age groups.

DISCUSSION

The findings of 'this study highlight a significant relationship between vitamin D and calcium metabolism and dental caries, supporting previous research that links nutritional deficiencies to oral health problems'. The results showed that individuals with lower serum vitamin D levels had a higher prevalence of dental caries, which aligns with studies indicating that vitamin D plays a critical role in tooth mineralization and immune response. Adequate levels of vitamin D contribute to calcium absorption, which is essential for maintaining strong enamel and preventing demineralization(7-9).

Previous research has demonstrated that vitamin D deficiency is associated with an increased risk of dental caries, particularly in populations with limited sun exposure or poor dietary intake of vitamin D-rich foods(10-12). A study conducted found 'that children with lower vitamin D levels had a higher incidence of caries, reinforcing the idea that vitamin D deficiency may contribute to weakened enamel, making teeth more susceptible to decay'. Similar results have been observed in adults, where low vitamin D status correlated with a higher DMFT index(13).

The current study also found that serum calcium levels were linked to dental health outcomes, with individuals having lower calcium levels showing a greater tendency toward caries development. Calcium is a major component of tooth enamel and dentin, and its availability is crucial for maintaining tooth integrity. Studies have shown that inadequate calcium intake leads to poor enamel structure and increased susceptibility to acid erosion from bacterial activity in the oral cavity. This is in line with findings reported that calcium-rich diets contribute to stronger teeth and lower caries prevalence (14-16).

Moreover, the role of parathyroid hormone (PTH) levels in calcium metabolism was also examined. Elevated PTH levels in some participants suggested possible secondary hyperparathyroidism, which can occur in response to low calcium or vitamin D deficiency. Increased PTH can lead to bone resorption, potentially affecting alveolar bone health, which supports the teeth. Research has indicated that chronic PTH elevation might contribute to periodontal diseases, which could indirectly influence caries development(17, 18).

Another important aspect examined in this study was dietary habits. Individuals who reported daily consumption of dairy products had better dental health outcomes, which aligns with existing research that supports dairy's protective effect against dental caries. Dairy products such as milk, cheese, and yogurt provide both calcium and casein, which help in neutralizing acids in the mouth and strengthening enamel. In contrast, participants with frequent sugar consumption showed a higher prevalence of dental caries, reaffirming the well-established link between high sugar intake and bacterial growth in the oral cavity(19).

Sunlight exposure was another key factor evaluated. Participants with limited sun exposure showed lower 'vitamin D levels and higher rates of caries, reinforcing the importance of natural vitamin D synthesis through sun exposure'. This finding was supported by studies that have shown that populations living in regions with low sunlight exposure often have higher vitamin D deficiency rates and, consequently, more dental caries cases(20, 21).

This study's results further align with research suggesting that poor oral hygiene habits, such as infrequent brushing and lack of fluoride use, increase caries risk. Participants who brushed twice a day and used fluoridated toothpaste had lower DMFT scores, consistent with previous studies showing that fluoride strengthens enamel and reduces bacterial activity(22). Regular dental visits were also associated with better oral health outcomes, reinforcing the need for routine check-ups in preventive care.

While the study provides strong evidence for the role of vitamin D, calcium, and dietary habits in dental caries, there are some limitations. The study was conducted on a single-center sample, which may not be fully representative of the general population. Additionally, other factors such as genetic

predisposition, saliva composition, and microbiome variations were not assessed, which could also contribute to caries susceptibility.

Despite these limitations, the findings emphasize the importance of balanced nutrition, adequate sun exposure, and proper oral hygiene practices in maintaining optimal dental health. Future studies with larger sample sizes and multi-center approaches can provide more comprehensive insights into the complex interactions between nutrition, metabolism, and oral health.

These results highlight the need for public health initiatives promoting vitamin D supplementation, calcium-rich diets, and regular dental care to reduce dental caries prevalence in at-risk populations. The integration of nutritional counseling in dental care programs could be a valuable approach to improving oral health outcomes.

CONCLUSION

This study highlights the significant role of vitamin D and calcium metabolism in dental caries, reinforcing the importance of proper nutrition in maintaining oral health. The findings suggest that individuals with lower serum vitamin D and calcium levels are more susceptible to dental caries, supporting previous research that links these nutrients to tooth strength and enamel protection. Adequate vitamin D levels contribute to calcium absorption, which is essential for maintaining strong enamel and reducing the risk of decay.

The results also emphasize the impact of dietary habits, sunlight exposure, and oral hygiene practices on dental health. Participants who consumed calcium-rich foods, maintained regular sun exposure, and followed good oral hygiene routines showed better dental outcomes. Conversely, those with high sugar intake, poor brushing habits, and infrequent dental visits exhibited a greater prevalence of caries. These findings suggest that preventive strategies should not only focus on oral hygiene but also address nutritional and lifestyle factors that contribute to dental health.

Although this study provides valuable insights, it has some limitations, including a single-center sample and the exclusion of genetic and microbiome factors that may influence caries susceptibility. Future research with larger, more diverse populations and multi-center data collection could provide a broader understanding of the link between nutrition, metabolism, and dental health.

Overall, these findings highlight the need for public health initiatives that promote vitamin D and calcium intake, encourage balanced diets, and emphasize preventive dental care. Integrating nutritional guidance into routine dental visits may help reduce the prevalence of dental caries and improve long-term oral health outcomes.

REFERENCES

1. Nireeksha N, Hegde MN, Shetty SS, Kumari SN. FOK l vitamin D receptor gene polymorphism and risk of dental caries: a case-control study. International Journal of Dentistry. 2022;2022(1):6601566.
2. Poza-Pascual A, Serna-Muñoz C, Pérez-Silva A, Martínez-Beneyto Y, Cabello I, Ortiz-Ruiz AJ. Effects of fluoride and calcium phosphate-based varnishes in children at high risk of tooth decay: A randomized clinical trial. International journal of environmental research and public health. 2021;18(19):10049.
3. El Shiekh MA, Hanafy RMH. Relationship between vitamin D status and caries experience in a group of Egyptian children: a cross-sectional study. BMC Oral Health. 2023;23(1):374.
4. Patil DJ. Clinical implications of vitamin D in oral diseases-A Review. J Pharm Res Int. 2021:103-10.
5. Indumathi K, Sibyl S. Vitamin D and its influence on oral health: A literature review. Research Journal of Pharmacy and Technology. 2023;16(5):2507-12.
6. Ali N, Yunus F, Siddique S, Tahir H. Role of Calcium in Development of Early Childhood Dental Caries. Pakistan Journal of Medical & Health Sciences. 2022;16(07):897-.
7. Li Z, Wei X, Shao Z, Liu H, Bai S. Correlation between vitamin D levels in serum and the risk of dental caries in children: a systematic review and meta-analysis. BMC oral health. 2023;23(1):768.

8. Al-Jubori SH, Al-Murad MA, Al-Mashhadane FA. Effect of oral vitamin D3 on dental caries: an in-vivo and in-vitro study. Cureus. 2022;14(5).
9. Saboktakin L. The relationship between vitamin D and calcium serum levels with dental caries in 6-12 years old children. Journal of Parathyroid Disease. 2022;10(1):e9141-e.
10. Peponis M, Antoniadou M, Pappa E, Rahiotis C, Varzakas T. Vitamin D and Vitamin D Receptor Polymorphisms Relationship to Risk Level of Dental Caries. Applied Sciences. 2023;13(10):6014.
11. Bumbu BA, Luca MM, Buzatu R. Examining the role of vitamin d in caries susceptibility in children's deciduous teeth: a systematic review. Nutrients. 2023;15(22):4826.
12. Pratyusha N, Vinay C, Uloopi K, RojaRamya KS, Ahalya P, Devi C. Association of serum Vitamin D and salivary calcium and phosphorus levels in 3-11-year-old schoolchildren with dental caries. Journal of Indian Society of Pedodontics and Preventive Dentistry. 2021;39(3):240-5.
13. Pu R, Fu M, Li N, Jiang Z. A certain protective effect of vitamin D against dental caries in US children and youth: A cross-sectional study. Journal of public health dentistry. 2023;83(3):231-8.
14. Børsting T, Fagerhaug TN, Schuller A, van Dommelen P, Stafne SN, Mørkved S, et al. The association between serum vitamin D status and dental caries or molar incisor hypomineralisation in 7–9-year-old Norwegian children: a cross-sectional study. BMC Public Health. 2024;24(1):246.
15. Mahmood MK, Tassery H, Tardivo D, Lan R. Association between Vitamin D Levels and Dental Caries: a systematic review and dose-response Meta-analysis of cross-sectional studies. Applied Sciences. 2023;13(17):9883.
16. Hu Z, Zhou F, Xu H. Circulating vitamin C and D concentrations and risk of dental caries and periodontitis: A Mendelian randomization study. Journal of Clinical Periodontology. 2022;49(4):335-44.
17. Ji S, Zhao K, Ma L, Chen X, Zheng D, Lu Y. The Association Between Vitamin D and Early Childhood Caries: A Systematic Review and Meta-Analysis. Oral Health & Preventive Dentistry. 2024;22:b4928565.
18. Beckett DM, Broadbent JM, Loch C, Mahoney EK, Drummond BK, Wheeler BJ. Dental consequences of Vitamin D deficiency during pregnancy and early infancy—an observational study. International journal of environmental research and public health. 2022;19(4):1932.
19. Nascimento GG, Leite FR, Gonzalez-Chica DA, Peres KG, Peres MA. Dietary vitamin D and calcium and periodontitis: A population-based study. Frontiers in nutrition. 2022;9:1016763.
20. Swapna LA, Abdulsalam R. Vitamin D deficiency and its effects on tooth structure and pulpal changes. Open Access Macedonian Journal of Medical Sciences. 2021;9(F):81-7.
21. Suárez-Calleja C, Aza-Morera J, Iglesias-Cabo T, Tardón A. Vitamin D, pregnancy and caries in children in the INMA-Asturias birth cohort. BMC pediatrics. 2021;21:1-9.
22. Khawaja W, Shaweesh M. The impact of vitamin D deficiency on general and oral health during childhood. Scholars Journal of Dental Sciences. 2022;9:155-61.