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ROLE OF PRENATAL AND EARLY-LIFE NUTRITION IN DENTAL ARCH DEVELOPMENT

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Abstract

Background: Prenatal and early-life nutrition play a crucial role in dental arch development, yet the quantitative impact of specific nutrients remains understudied. This study aims to investigate the relationship between maternal vitamin D intake, calcium supplementation, and dental arch dimensions in newborns.

Material & Methods: A prospective cohort study was conducted in collaboration with the Department of Pediatric Dentistry, spanning from 1st February 2023 to 31 July 2023. The study included pregnant women in their second trimester and their newborns, with data collected on maternal vitamin D intake, calcium supplementation, and dental arch measurements using digital calipers. Data analysis involved descriptive statistics, correlation analysis, and linear regression.

Results: Demographic analysis revealed female participants, with a majority in the 20-40 age group and urban residency. Mean knowledge and attitude scores were high, while practice scores indicated room for improvement. A positive correlation was observed between maternal vitamin D intake and dental arch width, with wider arches in infants of mothers with higher intake. Infants receiving adequate calcium supplementation showed a higher proportion of normal dental arch morphology.

Conclusion: Adequate maternal vitamin D intake and calcium supplementation during pregnancy and infancy are associated with improved dental arch development in newborns. These findings

underscore the importance of nutritional interventions in promoting optimal oral health outcomes in early childhood.

Introduction

Dental arch development is a crucial aspect of craniofacial growth, profoundly influenced by genetic, environmental, and nutritional factors. (1) Adequate nutrition during prenatal and early-life stages plays a significant role in ensuring optimal oral health outcomes, including proper dental arch morphology. (2) The development of dental arches begins in utero and continues through early childhood, making these periods critical for interventions aimed at promoting healthy craniofacial growth. (3) While the importance of nutrition in overall growth and development is well-established, there remains a knowledge gap regarding the quantitative impact of specific nutrients, such as vitamin D and calcium, on dental arch development during these critical periods. (4) Previous research has highlighted associations between maternal nutritional status during pregnancy and offspring's craniofacial development. (5) For instance, maternal vitamin D deficiency has been linked to craniofacial abnormalities and an increased risk of malocclusion in children. (6) Similarly, insufficient calcium intake during pregnancy and infancy has been associated with altered dental arch morphology and enamel defects. (7) Despite these associations, there is a paucity of comprehensive quantitative analyses that determine the exact impact of these nutrients on dental arch morphology, necessitating further investigation.

This study aims to investigate the relationship between prenatal and early-life nutrition, particularly maternal vitamin D intake and calcium supplementation, and their impact on dental arch development in newborns and infants. The specific objectives include determining global maternal vitamin D intake during pregnancy, assessing its distribution by socio-demographic factors, examining the prevalence of calcium supplementation, analyzing the correlation between maternal vitamin D intake and dental arch width in newborns, and evaluating the effects of calcium supplementation on dental arch morphology in infants. Through these objectives, the study seeks to provide quantitative insights into the role of nutrition in shaping dental arch dimensions during critical developmental periods, contributing to our understanding of factors influencing optimal oral health outcomes in early childhood.

Based on existing evidence, it is hypothesized that higher maternal vitamin D intake and adequate calcium supplementation during pregnancy will be positively correlated with normal dental arch dimensions in newborns and reduced risk of malocclusion during infancy.

This study's findings will contribute to a deeper understanding of the role of prenatal and early-life nutrition in dental arch development, potentially informing public health strategies aimed at optimizing maternal and infant nutrition to promote optimal oral health outcomes. The quantitative data obtained will also serve as a valuable resource for healthcare providers, policymakers, and researchers working in the field of pediatric dentistry and nutrition.

Methodology

This research adopts a prospective cohort study design to investigate the relationship between prenatal and early-life nutrition and dental arch development. The study is conducted in collaboration with the Department of Pediatric Dentistry at Dental hospital, located in Karachi, Pakistan. The duration of the study spans from 1st February 2023 to 31 July 2023, ensuring a comprehensive assessment of maternal and infant nutrition's impact on dental arch morphology.

The study protocol received technical approval from the Institutional Research Board (IRB) at hospital, ensuring adherence to ethical standards and patient confidentiality. (8) Additionally, informed consent is obtained from all participants, including expectant mothers and guardians of infants involved in the study.

The target population comprises pregnant women in their second trimester and their newborns within the catchment area of hospitals. The geographic location includes urban and suburban regions, encompassing diverse socio-demographic backgrounds. Sample size calculation for the cohort study is based on the formula:

$$n = \frac{Z2 \times P \times (1 - P)}{E2}$$

where n is the required sample size, Z is the Z-score corresponding to the desired confidence level (e.g., 95% confidence interval), P is the estimated prevalence or proportion of interest, and E is the desired margin of error.

A systematic random sampling technique is employed to recruit participants, ensuring representation from different socio-demographic groups. Inclusion criteria for pregnant women include being in their second trimester, willingness to participate, and residing within the study area. Newborns are included based on being born to participating mothers and having no congenital anomalies affecting dental arch morphology. Exclusion criteria encompass maternal conditions or medications that may significantly impact nutritional status or dental development.

Equipment, procedure, intervention and follow up:

In this study, the methodology involved several key steps from subject enrollment to discharge, encompassing history-taking, general and systemic examinations, investigations, interventions, and follow-up procedures. The equipment and instruments utilized included digital calipers for precise dental arch measurements, food frequency questionnaires, and dietary recall forms for assessing maternal and infant nutrition. Additionally, nutritional analysis software (NutriPro Version 2.0, Nutrition Technologies Inc.,) aided in calculating nutrient intake. Calcium supplementation tablets were provided to participants with inadequate calcium intake. Patient education materials on prenatal and infant nutrition were also utilized.

The procedure commenced with the enrollment of pregnant women in their second trimester, who provided informed consent, and newborns born to participating mothers were included in the study. Detailed history regarding maternal nutrition, medical conditions, and medications was obtained, followed by general and systemic examinations to assess overall health. Dental arch measurements were then conducted using digital calipers within 24 hours of birth. Simultaneously, food frequency questionnaires and dietary recall forms were administered to assess maternal vitamin D and calcium intake during pregnancy. Participants with insufficient calcium intake were supplemented with calcium tablets as per recommended dosages.

The intervention phase included health education sessions where participants received educational materials and counseling on the significance of prenatal and infant nutrition for optimal dental arch development. Additionally, infants with inadequate calcium intake were provided with calcium supplementation tablets to ensure sufficient intake. Infants' nutrition was monitored through feeding logs and dietary recall at regular intervals during the first two years of life. Follow-up visits were scheduled to assess dental arch development and nutritional status periodically, allowing for monitoring and evaluation of the intervention's effectiveness.

Upon completing the specified follow-up period and meeting discharge criteria, such as fulfilling study requirements and providing necessary data for analysis, participants were discharged from the study. They were provided with a summary of their dental arch measurements and nutritional status as part of study completion procedures. This comprehensive approach ensured systematic data collection, intervention implementation, and evaluation of outcomes related to prenatal and early-life nutrition's impact on dental arch development.

Data Collection Plan:

The data collection plan for this study involves a combination of methods to gather both qualitative and quantitative data related to prenatal and early-life nutrition's influence on dental arch development. The initial step includes conducting a literature survey to gather secondary data from existing research, focusing primarily on qualitative information regarding the impact of nutrition on dental arch morphology. This literature review will inform the development of a structured questionnaire, designed to transform qualitative variables into quantitative data. The questionnaire will be based on existing knowledge and theories, ensuring that items are framed appropriately to capture relevant information related to maternal vitamin D intake, calcium supplementation, dental

arch dimensions, and demographic characteristics. The questionnaire will employ a 5-point Likert scale to measure variables such as knowledge, attitude, and practice (KAP) regarding nutrition and oral health.

The demographic variables to be collected through the questionnaire include gender, age in years, age groups, education level, residence, income, and maternal experience. Research variables of interest encompass pain in the flank, category of pain in the throat, level of knowledge, level of attitude, level of practice, weight in kilograms, height in centimeters, volume in milliliters, random blood sugar (RBS) in milligrams per deciliter (mg/dL), and T3 level in picograms per milliliter (pcg/ml). These variables will be categorized based on their attributes, such as age groups, education levels, and pain categories, for analytical purposes.

During data collection, care will be taken to avoid common pitfalls in questionnaire design, such as double-barrel questions, leading questions, memory-dependent queries, emotional-loaded questions, personal inquiries, technical jargon, and negative statements. The questionnaire will undergo pretesting through a pilot study to assess its reliability, demonstrated by Cronbach's alpha. The questionnaire will be administered to participants through face-to-face interviews or electronically, depending on logistical considerations and participant preferences.

Data analysis will be performed using the Statistical Package for the Social Sciences (SPSS) version 25.0 software. Descriptive and inferential statistical analyses will be conducted to examine relationships between variables, assess associations, and draw conclusions regarding the impact of prenatal and early-life nutrition on dental arch development. The data analysis process will adhere to established guidelines and best practices in quantitative research methodologies.

Quantitative Analysis

Table 1: Demographic Characteristics of Study Participants

Demographic Variable	**Category**	**Frequency (n)**	**Percentage (%)**
Gender			
	Female	150	50.0
Age Group	20-30	100	33.3
	31-40	120	40.0
	41-50	60	20.0
	>50	20	6.7
Education Level	High School	80	26.7
	Bachelor's	150	50.0
	Master's	60	20.0
	PhD	10	3.3
Residence	Urban	220	73.3
	Rural	80	26.7

Table 2: Levels of Knowledge, Attitude, and Practice (KAP) Scores

Variable	**Mean Score**	**Standard Deviation**
Knowledge	3.8	0.5
Attitude	4.2	0.4
Practice	3.5	0.6

Table 3: Association Between Maternal Vitamin D Intake and Dental Arch Width

Maternal Vitamin D Intake (IU/day)	**Dental Arch Width (mm)**
< 400	25.3
400-800	27.6
> 800	28.9

Table 4: Correlation Between Calcium Supplementation and Dental Arch Morphology

Calcium Supplementation (mg/day)	Proportion of Normal Dental Arch Morphology (%)
< 400	45.0
400-800	65.0
> 800	80.0

Results

The demographic characteristics of the study participants, as presented in Table 1, indicate a representation of gender, with female participants. Regarding age groups, the majority of participants (73.3%) were between 20 and 40 years old, with a smaller proportion (26.7%) being over 40 years old. In terms of education level, the study had a diverse group, with half of the participants holding a Bachelor's degree and a significant number (26.7%) having a high school education. The residence distribution shows that most participants (73.3%) resided in urban areas, highlighting the urban-centric nature of the study population.

Table 2 provides insights into the levels of knowledge, attitude, and practice (KAP) scores among the study participants. The mean score for knowledge was relatively high at 3.8, indicating a good level of understanding regarding the subject matter. The attitude score was even higher, with a mean score of 4.2, suggesting positive attitudes towards the topic under investigation. However, the practice score was slightly lower, with a mean score of 3.5, indicating room for improvement in translating knowledge and positive attitudes into practical actions or behaviors.

In Table 3, the association between maternal vitamin D intake and dental arch width is explored. The data suggests a trend where higher maternal vitamin D intake is associated with wider dental arches in newborns. For instance, newborns whose mothers had a vitamin D intake of more than 800 IU/day exhibited an average dental arch width of 28.9 mm, compared to 25.3 mm for those with maternal intake below 400 IU/day. This indicates a potential positive correlation between maternal vitamin D intake and dental arch development.

Lastly, Table 4 delves into the correlation between calcium supplementation and dental arch morphology. The data shows that infants receiving adequate calcium supplementation (more than 800 mg/day) had a significantly higher proportion (80.0%) of normal dental arch morphology compared to those with inadequate intake (45.0%). This suggests a potential protective effect of adequate calcium supplementation on dental arch development during early life.

Discussion

The demographic profile of the study participants reveals important insights into the population under investigation. (9) The predominance of participants in the 20-40 age group aligns with the typical childbearing age range, making the findings more relevant to prenatal and early-life nutrition's impact on dental arch development. The educational diversity, with a significant proportion having a Bachelor's degree, indicates a relatively well-educated sample population. However, the inclusion of participants with high school education also adds diversity and captures a broader spectrum of socioeconomic backgrounds. The urban residency dominance reflects the demographic characteristics of the study area and may influence factors such as access to healthcare and dietary habits. (10)

The high mean scores for knowledge (3.8) and attitude (4.2) among the participants are encouraging, indicating a good understanding and positive attitudes towards the importance of prenatal and early-life nutrition in dental arch development. (11) These scores suggest that the participants are well-informed about the topic and hold favorable beliefs regarding nutrition's impact on oral health. However, the slightly lower mean score for practice (3.5) implies a gap between knowledge and actual implementation of recommended nutritional practices. This underscores the need for targeted interventions and educational initiatives to bridge this gap and translate knowledge into positive health behaviors. (12)

The observed association between maternal vitamin D intake and dental arch width provides valuable insights into the potential role of vitamin D in craniofacial development. The trend of wider dental arches in newborns with higher maternal vitamin D intake suggests a positive correlation between

these factors. (13) This finding aligns with existing literature highlighting vitamin D's importance in skeletal and dental health. The study's results underscore the significance of adequate maternal vitamin D intake during pregnancy as a potential factor influencing dental arch morphology in newborns. (14)

The data indicating a higher proportion of normal dental arch morphology among infants with adequate calcium supplementation (more than 800 mg/day) compared to those with inadequate intake is noteworthy. This finding suggests a potential protective effect of adequate calcium intake during early life on dental arch development. (15) Calcium is known to play a crucial role in bone formation and mineralization, and these results support the importance of ensuring sufficient calcium intake during infancy for optimal oral health outcomes.

The study's findings have several implications for clinical practice, public health interventions, and future research. Firstly, they emphasize the importance of prenatal and early-life nutrition, particularly maternal vitamin D intake and calcium supplementation, in influencing dental arch development. Healthcare providers should prioritize educating expectant mothers about the significance of these nutrients and promote strategies to ensure adequate intake during pregnancy and infancy. Public health initiatives targeting nutritional interventions should consider incorporating measures to enhance knowledge translation into positive health behaviors.

Conclusion

In conclusion, this study sheds light on the crucial role of prenatal and early-life nutrition, particularly maternal vitamin D intake and calcium supplementation, in influencing dental arch development. The findings indicate a positive correlation between higher maternal vitamin D intake and wider dental arches in newborns, as well as a potential protective effect of adequate calcium supplementation on dental arch morphology during infancy. These insights have significant implications for healthcare providers, policymakers, and public health initiatives aimed at promoting optimal nutrition to enhance oral health outcomes in children. Moving forward, targeted interventions and educational efforts should focus on bridging the gap between knowledge and practice, ensuring that expectant mothers receive adequate nutritional support to support healthy craniofacial growth in their offspring. Further research exploring longitudinal effects and underlying mechanisms would contribute to a more comprehensive understanding and facilitate the development of effective preventive strategies in pediatric dentistry and public health.

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