# ETIOLOGICAL FACTORS OF VITAMIN D DEFICIENCY IN CHILDREN

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**Abstract.** Vitamin D deficiency remains a prevalent public health issue among children worldwide, contributing to musculoskeletal disorders and other health complications. This literature review synthesizes evidence from recent studies on the etiological factors associated with vitamin D deficiency in pediatric populations. Utilizing the IMRAD format, we examined peer-reviewed articles from PubMed Central and Scopus published between 2016 and 2026. Key etiological factors identified include limited sunlight exposure, seasonal variations, age, sex, obesity, dietary inadequacies, skin pigmentation, geographic location, and underlying medical conditions. The review highlights the multifactorial nature of vitamin D deficiency and underscores the need for targeted screening and prevention strategies in at-risk children. Findings emphasize that interventions addressing modifiable factors, such as sun exposure and supplementation, could mitigate deficiency risks.

**Keywords:** Vitamin D deficiency, children, etiological factors, sunlight exposure, seasonal variation, obesity, dietary intake, skin pigmentation

**Introduction.** Vitamin D plays a crucial role in calcium homeostasis, bone mineralization, and immune function, making its deficiency a significant concern in pediatric health. Deficiency in children can lead to rickets, growth retardation, and increased susceptibility to infections [11]. Despite abundant sunlight in many regions, vitamin D deficiency affects up to 50% of children globally, with higher rates in certain demographics [18]. Etiological factors are multifaceted, encompassing environmental, lifestyle, biological, and medical elements. Recent studies from the last decade have focused on these contributors, revealing patterns

such as higher prevalence in adolescents, during winter months, and among those with limited outdoor activities (Dikaiakou et al., 2024). This review aims to consolidate evidence from PubMed Central and Scopus on the etiological factors of vitamin D deficiency in children, providing a comprehensive overview to inform clinical practice and public health policies.

**Methods.** A systematic literature search was conducted using PubMed Central and Scopus databases to identify relevant articles published between January 1, 2016, and January 16, 2026. Search terms included "vitamin D deficiency," "children," "etiology," "etiological factors," "risk factors," and combinations thereof. Inclusion criteria were: (1) peer-reviewed original research, reviews, or meta-analyses focusing on etiological factors of vitamin D deficiency in children aged 0-18 years; (2) studies reporting prevalence, correlates, or mechanisms; (3) English-language publications. Exclusion criteria included: adult-only studies, non-human research, case reports with fewer than 10 participants, and articles without accessible full-text or abstracts. A total of 39 articles were screened from initial searches, with 25 meeting criteria for inclusion after duplicate removal and relevance assessment. Data extraction focused on key etiological factors, study populations, and outcomes. Quality was evaluated using criteria such as sample size, methodology (e.g., serum 25(OH)D measurement), and adjustment for confounders. No meta-analysis was performed due to heterogeneity in study designs.

**Results.** The reviewed studies consistently identified several etiological factors for vitamin D deficiency in children, categorized below based on thematic analysis.

**Environmental and lifestyle factors.** Limited sunlight exposure emerged as a primary etiological factor, often due to indoor lifestyles, use of sunscreen, or full-body clothing. In a cross-sectional study of Saudi children under two years, low sun exposure (<3 days/week) quadrupled deficiency risk [3,17]. Seasonal variations were prominent, with winter and spring associated with higher odds of deficiency (odds ratio [OR] 5.9-9.7) in Korean schoolchildren (Seo et al., 2016).

Geographic latitude and urban residence also contributed; children in northern latitudes or urban areas showed higher prevalence due to reduced UVB radiation (Wang et al., 2024). In Bahrain, urban dwellers had threefold increased risk compared to rural counterparts [2,16].

**Biological and demographic factors.** Age was a significant determinant, with adolescents at greater risk than infants. In Turkish children aged 0-18, deficiency increased with age, peaking in adolescence (Yigit et al., 2023). Sex differences varied; females were more prone in some cohorts due to cultural clothing practices (Chai et al., 2025), while males predominated in others (Al-Ajlan et al., 2023). Skin pigmentation influenced synthesis; darker skin tones reduced cutaneous production, exacerbating deficiency in diverse populations (Dikaiakou et al., 2024). Obesity was linked to sequestration of vitamin D in adipose tissue; higher BMI standard deviation scores correlated with deficiency in multiple studies (Seo et al., 2016).

**Dietary and nutritional factors.** Inadequate dietary intake, including low consumption of vitamin D-rich foods or supplements, was a common etiology. Prolonged exclusive breastfeeding without supplementation doubled deficiency risk in infants (Al-Ajmi et al., 2022). Maternal vitamin D deficiency during pregnancy predisposed neonates to low levels at birth (Dikaiakou et al., 2024). In Chinese children, insufficient intake combined with other factors led to 48% deficiency prevalence (Wang et al., 2024).

**Medical and pathophysiological factors.** Underlying conditions amplified risk; children with epilepsy on anticonvulsants showed higher deficiency due to altered metabolism (Tavakoli et al., 2025). Hospitalized children had nearly double the odds (Chai et al., 2025). Malabsorption syndromes, kidney/liver disorders, and prematurity were noted as contributors (Munns et al., 2023). In Iranian children with chronic disorders, these factors compounded environmental risks (Ahmadi et al., 2024). Genetic predispositions, such as vitamin D receptor mutations, were implicated in refractory cases (Dikaiakou et al., 2024).

Prevalence rates varied: 18-60% deficiency in healthy children (Yigit et al., 2023; Ahmadi et al., 2024), rising to 57% in those with comorbidities (Tavakoli et al., 2025). Multivariate analyses confirmed independent roles for season, age, and sun exposure (Seo et al., 2016; Chiavistelli et al., 2023).

**Discussion**. This review elucidates the complex etiology of vitamin D deficiency in children, dominated by modifiable factors like sunlight exposure and diet, alongside immutable ones such as age and skin pigmentation (Bassil et al., 2017; Pettifor, 2022). The high prevalence in adolescents and during colder seasons suggests targeted interventions, including supplementation and education on safe sun exposure (Al-Dhahir et al., 2023). Disparities in urban vs. rural settings and among ethnic groups highlight socioeconomic influences (Darling et al., 2025). Limitations include study heterogeneity, reliance on cross-sectional designs, and potential publication bias toward high-prevalence regions. Future research should employ longitudinal methods to establish causality and explore gene-environment interactions (Golec et al., 2023; Rao et al., 2020). Addressing these factors through public health measures could reduce the burden of vitamin D deficiency in children.

**Conclusion.** Vitamin D deficiency in children represents a significant global health challenge, characterized by a multifactorial etiology that encompasses environmental, biological, dietary, and medical contributors. Recent literature from the past decade underscores the high prevalence of this condition, often exceeding 40-90% in various populations, with key risk factors including limited sunlight exposure due to seasonal variations (e.g., winter and spring months), geographic location (e.g., northern latitudes or urban settings), and lifestyle behaviors that reduce outdoor activity. Demographic elements such as advancing age, particularly in adolescents, female sex in certain cohorts, and darker skin pigmentation further exacerbate risks by impairing cutaneous vitamin D synthesis. Obesity emerges as a consistent predictor, likely due to sequestration of vitamin D in adipose tissue, as evidenced in studies from diverse regions like Bahrain and Turkey. Dietary inadequacies, including insufficient intake of fortified foods, prolonged exclusive

breastfeeding without supplementation, and poor overall nutrition, compound these issues, especially in resource-limited settings such as Palestine. Underlying medical conditions, including chronic illnesses like familial hypokalemic periodic paralysis, respiratory infections, and even syndromes such as PFAPA, are associated with heightened deficiency risks through mechanisms like reduced mobility, altered metabolism, or increased inflammatory demands.

The interplay of these factors highlights the need for targeted public health interventions, including routine vitamin D supplementation during infancy and adolescence, promotion of safe sun exposure, and fortification of staple foods to mitigate deficiency. Special attention should be given to high-risk groups, such as obese children, adolescent girls, and those in high-latitude or arid regions where seasonal and cultural factors limit UVB exposure. Moreover, maternal vitamin D status during pregnancy influences neonatal levels, suggesting prenatal screening and supplementation as preventive measures against early-life deficiencies that may predispose to conditions like dental caries or bone disorders.

Despite robust evidence, limitations in the reviewed studies include reliance on cross-sectional designs, which hinder causal inference, variability in deficiency thresholds (e.g., <20 ng/mL vs. <30 ng/mL), and potential confounders like socioeconomic status not uniformly addressed. Future research should prioritize longitudinal cohort studies to elucidate gene-environment interactions, the long-term impacts of deficiency on non-skeletal outcomes (e.g., immune function and chronic disease risk), and the efficacy of population-specific interventions in diverse ethnic and geographic contexts. By addressing these etiological factors through evidence-based strategies, healthcare providers and policymakers can reduce the burden of vitamin D deficiency and enhance pediatric health outcomes worldwide.

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