

EFFECTIVENESS OF VITAMIN D SUPPLEMENTATION IN CHILDHOOD ALLERGIC DISEASES: EVIDENCE FROM A LITERATURE REVIEW

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ABSTRAK

Penyakit alergi, termasuk asma, rinitis alergi, dermatitis atopik, dan alergi makanan, merupakan salah satu penyakit kronis yang paling sering dijumpai pada anak serta menjadi beban kesehatan global yang terus meningkat. Kondisi ini umumnya dimulai sejak usia dini dan dipengaruhi oleh interaksi kompleks antara predisposisi genetik, disregulasi sistem imun, dan faktor lingkungan. Bukti yang semakin berkembang menunjukkan bahwa vitamin D, selain berperan dalam metabolisme tulang, juga memiliki fungsi imunomodulator yang penting dan dapat memengaruhi perkembangan serta tingkat keparahan penyakit alergi pada anak. Tinjauan literatur ini merangkum bukti terkini mengenai epidemiologi dan etiopatogenesis penyakit alergi pada anak, prevalensi defisiensi vitamin D pada populasi pediatrik, mekanisme imunologis yang mendasarinya, serta potensi manfaat klinis suplementasi vitamin D. Secara keseluruhan, suplementasi vitamin D tampak memberikan manfaat potensial, terutama pada asma anak dan dermatitis atopik, meskipun hasil penelitian yang tersedia masih heterogen dan belum konsisten. Oleh karena itu, diperlukan penelitian berkualitas tinggi lebih lanjut untuk memperjelas peran vitamin D serta menyusun rekomendasi berbasis bukti dalam tata laksana penyakit alergi pada anak.

Kata Kunci: Penyakit Alergi, Asma, Dermatitis Atopik, Anak-Anak, Vitamin D.

ABSTRACT

Allergic diseases—including asthma, allergic rhinitis, atopic dermatitis, and food allergies—are among the most common chronic conditions in children and represent a growing global health burden. These conditions typically manifest early in life and are influenced by complex interactions between genetic predisposition, immune system dysregulation, and environmental factors. Growing evidence indicates that vitamin D, beyond its role in bone metabolism, possesses important immunomodulatory functions that may influence the development and severity of allergic diseases in children. This literature review summarizes current evidence regarding the epidemiology and etiopathogenesis of pediatric allergic diseases, the prevalence of vitamin D deficiency in the pediatric population, underlying immunological mechanisms, and the potential clinical benefits of vitamin D supplementation. Overall, vitamin D supplementation appears to offer potential benefits—particularly for pediatric asthma and atopic dermatitis—although existing research findings remain heterogeneous and inconsistent. Therefore, further high-quality research is needed to clarify the role of vitamin D and to formulate evidence-based recommendations for the management of allergic diseases in children.

Keyword: Allergic Diseases, Asthma, Atopic Dermatitis, Children, Vitamin D.

INTRODUCTION

Allergic diseases, including asthma, allergic rhinitis, atopic dermatitis, and food allergies, are among the most prevalent chronic conditions affecting children worldwide and constitute a growing public health challenge. Over recent decades, the global prevalence of pediatric allergic diseases has increased markedly, particularly in urbanized and industrialized regions. Epidemiological studies estimate that up to 30–40% of children worldwide are affected by at least one allergic condition, often beginning in early childhood and persisting into adolescence or adulthood [1,2]. These diseases significantly impair health-related quality of life, leading to sleep disturbances, impaired physical activity,

reduced academic performance, and increased school absenteeism, as well as substantial healthcare utilization and economic burden [3].

In Indonesia and other low- and middle-income countries, pediatric allergic diseases have similarly emerged as an important health concern. Rapid urbanization, environmental pollution, changes in dietary patterns, and lifestyle transitions are thought to contribute to the rising prevalence of childhood allergies in these regions [4]. Despite advances in diagnostic and therapeutic strategies, allergic diseases in children remain difficult to manage optimally, particularly due to their chronic nature, frequent comorbidities, and potential progression along the atopic march [5].

Pediatric allergic diseases often coexist as part of a broader atopic spectrum, with conditions such as atopic dermatitis, food allergy, allergic rhinitis, and asthma frequently occurring sequentially or concurrently. This clustering of allergic conditions increases disease severity and complicates long-term management [6]. Conventional prevention and treatment strategies primarily focus on allergen avoidance, pharmacological symptom control, and immunotherapy. However, these approaches do not adequately address underlying immune dysregulation or prevent disease onset in all children.

Recently, increasing attention has been directed toward modifiable environmental and nutritional factors that may influence immune development and allergic disease progression. Among these factors, vitamin D has emerged as a nutrient of interest due to its immunomodulatory properties beyond its classical role in bone metabolism [7]. Vitamin D is involved in the regulation of innate and adaptive immune responses, maintenance of epithelial barrier integrity, and promotion of immune tolerance. Vitamin D deficiency is common in children and has been associated with increased susceptibility to allergic diseases and more severe disease manifestations [8]. Nevertheless, evidence from interventional studies evaluating the effectiveness of vitamin D supplementation in childhood allergic diseases remains inconsistent, highlighting the need for a comprehensive literature review to clarify its potential role in pediatric allergy prevention and management.

METHOD

Metode penelitian ini menggunakan studi Pustaka dengan mengambil data dan referensi dari berbagai buku dan artikel ilmiah yang valid. Artikel tersebut dicari melalui data NCBI, PubMed, GoogleScholar, dan ResearchGate yang dibatasi dari 1 juni hingga 29 juni 2026 dan mengambil literatur 10 tahun terakhir dengan menggunakan kata kunci berupa: Allergic diseases, Asthma, Atopic dermatitis, Children, Vitamin D. Sumber bacaan yang telah dikumpulkan kemudian dianalisis dengan metode systematic literature review yang mencakup aktivitas pengumpulan, evaluasi dan pengembangan penelitian dengan focus topik tertentu.

RESULTS AND DISCUSSION

The development of allergic diseases in children results from complex interactions between genetic susceptibility, immune system immaturity, and environmental exposures during critical periods of early life. Children with a family history of atopy are genetically predisposed to allergic diseases and tend to exhibit immune responses skewed toward T helper 2 (Th2) dominance. This Th2-biased immune profile is characterized by increased production of cytokines such as interleukin (IL)-4, IL-5, and IL-13, which promote immunoglobulin E (IgE) synthesis, eosinophilic inflammation, and mast cell activation following exposure to allergens [1,2].

Early immune development plays a pivotal role in allergic disease pathogenesis. In infancy and early childhood, the immune system is still maturing, with limited regulatory

T-cell (Treg) activity and an increased tendency toward exaggerated inflammatory responses. Impaired immune regulation during this critical window increases susceptibility to allergic sensitization [3]. In addition, dysfunction of epithelial barriers in the skin, respiratory tract, and gastrointestinal tract facilitates allergen penetration and enhances immune activation. This mechanism is particularly evident in atopic dermatitis, where disrupted skin barrier function allows transcutaneous allergen exposure and systemic sensitization [4].

The concept of the atopic march describes the natural progression of allergic diseases from early-life eczema and food allergy to allergic rhinitis and asthma later in childhood. This progression reflects shared underlying immunological mechanisms and highlights the importance of early-life factors in determining long-term allergic outcomes [5]. Environmental influences such as air pollution, tobacco smoke exposure, urban living, dietary changes, microbial imbalance, and reduced exposure to diverse microorganisms further modulate immune responses and contribute to the increasing prevalence of allergic diseases in children [6].

The hygiene hypothesis proposes that reduced microbial exposure in early life, particularly in highly sanitized environments, impairs the development of immune tolerance and favors Th2-mediated allergic responses [7]. In addition, nutritional factors, including vitamin D deficiency, have been implicated in allergic disease etiopathogenesis. Vitamin D influences immune cell differentiation, enhances epithelial barrier integrity, and promotes immune tolerance through modulation of dendritic cells and Treg activity, suggesting a potential role in preventing allergic sensitization during childhood [8,9].

Pediatric allergic diseases impose a substantial global burden. Large international studies have documented significant geographical variation in prevalence, with higher rates observed in urbanized regions and developed countries, although prevalence is rising rapidly in developing nations [10]. Asthma remains one of the leading causes of chronic morbidity in children, while allergic rhinitis and atopic dermatitis are major contributors to impaired daily functioning and reduced quality of life [11].

In Indonesia, population-based studies indicate that allergic diseases affect a considerable proportion of children, with increasing trends over time [4]. The burden of these conditions extends beyond physical symptoms, affecting psychosocial well-being, family dynamics, and healthcare systems. Frequent physician visits, medication use, and hospitalizations contribute to increased healthcare costs, emphasizing the importance of effective preventive strategies [3].

Vitamin D deficiency is widely recognized as a global public health problem affecting children across diverse geographic regions, including tropical countries with adequate sunlight exposure. Several studies have demonstrated that despite favorable climatic conditions, a significant proportion of children exhibit suboptimal serum vitamin D levels due to limited outdoor activity, increased indoor lifestyles, air pollution, excessive sun avoidance, inadequate dietary intake, obesity, and chronic inflammatory conditions [12,13]. Vitamin D is essential during childhood, as it plays a critical role in skeletal development and immune system maturation.

Multiple epidemiological studies have reported a high prevalence of vitamin D deficiency among children with allergic diseases. A cross-sectional study by Brehm et al. found that children with asthma had significantly lower serum 25-hydroxyvitamin D levels compared with non-asthmatic controls, and vitamin D deficiency was associated with increased asthma severity and exacerbation risk [11]. Similarly, Litonjua and Weiss reported that low vitamin D levels were linked to increased asthma prevalence and poorer disease control in pediatric populations [7].

In atopic dermatitis, observational studies have demonstrated an inverse relationship between serum vitamin D levels and disease severity. Peroni et al. showed that children with severe atopic dermatitis had significantly lower vitamin D levels compared with those with milder disease [16]. A study by Wang et al. further supported these findings, reporting that vitamin D deficiency was associated with increased disease activity and higher rates of skin infection in children with atopic dermatitis [17].

Vitamin D deficiency has also been implicated in allergic rhinitis and food allergy. Wjst and Hyppönen reported lower vitamin D levels in children with allergic rhinitis, suggesting a potential association between vitamin D status and upper airway allergic inflammation [18]. Additionally, Allen et al. demonstrated that children born during periods of reduced ultraviolet exposure had a higher risk of developing food allergies, indirectly linking vitamin D deficiency with food allergy development [15]. Collectively, these studies indicate that vitamin D deficiency is common in children with allergic diseases and may contribute to disease susceptibility and severity.

Vitamin D exerts its biological effects through the vitamin D receptor (VDR), which is expressed on various immune cells, including dendritic cells, macrophages, T lymphocytes, and regulatory T cells [9]. Activation of the vitamin D–VDR pathway modulates immune responses by promoting immune tolerance and suppressing excessive inflammation.

Vitamin D inhibits Th2-driven cytokine production and enhances Treg function, leading to reduced IgE synthesis and attenuation of allergic inflammation [9,15]. In addition, vitamin D strengthens epithelial barrier integrity and stimulates the production of antimicrobial peptides, such as cathelicidin, which protect against microbial invasion and allergen penetration [16]. These mechanisms are particularly relevant in children, whose immune and epithelial barrier systems are still developing.

An increasing body of clinical evidence has evaluated the potential benefits of vitamin D supplementation in childhood allergic diseases, with the strongest evidence observed in pediatric asthma. A large individual participant data meta-analysis by Martineau et al. demonstrated that vitamin D supplementation significantly reduced the rate of asthma exacerbations requiring systemic corticosteroids, particularly among children with baseline vitamin D deficiency [14]. These findings were supported by cohort studies showing that low vitamin D levels were associated with increased risk of severe asthma attacks and poorer lung function outcomes in children [11].

Additional randomized controlled trials have suggested that vitamin D supplementation may improve asthma control and enhance responsiveness to inhaled corticosteroids. For example, a study by Majak et al. reported fewer asthma exacerbations and improved clinical scores among children receiving vitamin D supplementation compared with placebo [20]. These results suggest that vitamin D may serve as a beneficial adjunct therapy in pediatric asthma management.

In atopic dermatitis, vitamin D supplementation has been associated with improvements in disease severity and skin barrier function. Sidbury et al. demonstrated that vitamin D supplementation during winter months significantly improved eczema severity scores in children [16]. A meta-analysis by Kim and Bae further confirmed that vitamin D supplementation resulted in modest but statistically significant reductions in disease severity, particularly in children with vitamin D deficiency [17].

Evidence regarding allergic rhinitis and food allergy is less robust but emerging. Observational studies have reported inverse associations between vitamin D levels and allergic rhinitis severity in children [18]. In food allergy, epidemiological studies suggest that adequate vitamin D status during early life may reduce the risk of allergic sensitization,

although interventional trials remain limited [15]. A systematic review by Allen and Dharmage concluded that while vitamin D shows potential as a preventive factor, current evidence is insufficient to support routine supplementation solely for food allergy prevention [8].

Overall, these studies indicate that vitamin D supplementation may provide clinical benefits in selected childhood allergic diseases, particularly asthma and atopic dermatitis. However, the magnitude of benefit appears to vary depending on baseline vitamin D status, disease phenotype, and supplementation strategy.

CONCLUSION

Vitamin D plays an important role in immune regulation and may offer potential benefits as an adjunctive strategy in the management of childhood allergic diseases, particularly asthma and atopic dermatitis. However, current evidence remains insufficient to support routine supplementation for all children with allergic diseases. Further high-quality studies are required to clarify its clinical role and to develop evidence-based recommendations.

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