The Impact of Food Allergies on Nutrient Intake During Children's Growth and Development Stage and Possible Interventions

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Abstract. The prevalence of food allergies in children has been rising globally, with varying rates and common allergens across different countries. Common intervention strategies include elimination diets, allergy immunotherapy, and medications, all aimed at managing allergic reactions and reducing associated risks. In the United States, multiple public health strategies have been implemented by governments, health organizations, schools, and communities to support children with food allergies. However, no single treatment or policy is universally effective, and none can fully guarantee the elimination of food allergies. This study is an important reference for researching childhood food allergies, especially in the context of public health policies and community support. Although existing strategies can help manage food allergies to a certain extent, there are still problems of large individual differences and inconsistent treatment effects. Future research can focus more on the development of personalized treatment plans, such as the combination of genetic testing and environmental factors to improve the accuracy of intervention. At the same time, in-depth exploration of allergy mechanisms and verification of long-term effectiveness are also key scopes for future research.

Keywords: Food allergies; children's growth; interventions.

1. Introduction

As one of the most essential components of human life, food provides the required nutrients to grow, develop, and maintain overall well-being. As children are still at the crucial stage of growing, it is important to provide adequate nutrition to support their rapid growth and cognitive development. However, it is challenging for some children who have food allergies to maintain a balanced diet during their crucial stages of growth. Nutritionally speaking, comparing the height and weight of children with food allergies and those without food allergies, those with food allergies grow slower in height and weight. In particular, the kind of food that is omitted from the diet, the quantity of foods that are excluded, and the length of the elimination diet all have a direct impact on slowing their growth rate [1].

Food allergy occurs when the body's immune system overreacts to a specific substance, mistakenly identifying it as a harmful invader and releasing chemicals to protect against it. It usually happens soon after eating certain foods. It can be mild discomfort to severe, life-threatening reactions, triggered by even a small amount of the allergenic food [2].

The prevalence of food allergies in children has been rising globally, with different rates and common allergens across different countries. It has become considered an unforeseen “second wave” of an allergy epidemic, significantly raising the prevalence of allergy-related illnesses in young children and newborns [3]. Food allergies can occur anywhere globally, and their frequency and patterns vary greatly. For example, The UK has the highest incidence of milk and egg allergies in early childhood, while southwestern European countries like Greece and Italy have the lowest rates of milk allergies, despite being on the same continent. Another example would be children less than 5 years of age in the UK, US, and Australia are commonly allergic to peanuts but wheat, walnuts, and shellfish are the common allergens for kids in some countries of Asia [4].

This paper aims to explore the specific nutrients affected by common food allergies, the mechanisms behind these allergic reactions, and the potential consequences for children's growth and

development. Additionally, this paper will discuss intervention strategies, including elimination diet, and pharmacological treatments to reduce the nutritional risks associated with food allergies in children. Food allergy risk is influenced by genetic diversity, environment, climate, and baby feeding and dietary habits. It is also possible that these factors influence the effectiveness of therapies meant to prevent the development of food allergies. Thus, food allergy prevention, diagnosis, and treatment plans should be personalized for each different individual. In a broader societal scope, public health strategies will also be discussed to address food allergies in children.

2. Allergens and Mechanisms

Among the food allergens, nuts, seafood, eggs, and dairy are some of the most common triggers. They are nutrient-dense and important for growth and development in children.

2.1. Nuts

Nuts are high in energy and naturally include a variety of beneficial nutrients, such as fiber, non-sodium minerals, tocopherols, phytosterols, and antioxidant phenolics, as well as mono- and polyunsaturated and polyunsaturated fatty acids [5]. There is a study has found the health benefits of nut consumption in children. Data were collected from three randomized controlled trials (RCTs) involving 106 participants aged 18 years or younger. It found that nuts provide multiple health benefits for children, including improved diet quality and potential cardiometabolic advantages. In addition, nuts may support gastrointestinal health, although more research is necessary to fully understand their impact on gut microbiota. Overall, incorporating a variety of nuts into children's diets can be a valuable strategy for enhancing overall health and nutrition [6]. However, nut allergy is prevalent in children as well. Peanut allergy is especially typical in nuts allergy, which has become much more common in many Western countries in the last several decades. According to current estimates, 1% to 3% of kids suffer from a peanut allergy. This illness has a severe daily burden and is frequently lifelong, which lowers the quality of life (QoL).

Different factors can cause peanut allergy. A combination of hereditary and environmental variables contribute to the development of peanut allergy mechanisms. Heritability estimates for peanut allergies up to 81.6% put children who have a family history of the condition at increased risk. Environmental factors that might change immune responses, such as a lack of vitamin D and better cleanliness, also matter. According to the dual-allergen exposure theory, eating peanuts increases tolerance whereas skin contact—particularly in children with atopic dermatitis—is a common cause of peanut allergy. Increased risk of allergies is associated with mutations in the FLG gene that impact skin integrity. Furthermore, contextual variables, such as avoiding peanuts in the home, may contribute to the higher risk in siblings of allergic children rather than just genetics [7]. A type I IgE-mediated hypersensitivity response is what food allergies are. Peanut-specific IgE antibodies are generated during the earliest stages of sensitization to peanuts. These antibodies mostly detect AraH1, H2, and H3 as peanut antigens. When these particular IgE antibodies bind to IgE receptors on mast cells and basophils, they can cause sensitized individuals to become inflamed and produce a variety of cytokines and chemokines, including histamine. The inflammatory cells that are drawn in by this discharge intensify the allergic reaction. Low molecular weight proteins that are resistant to heat, proteases, and denaturants are the source of peanut allergy. There are now eleven known peanut allergens (Ara h 1-11) [8]. The symptoms of a peanut allergy can appear as early as 4 months of age and commonly appear within the first 2 years of life in children. Twenty percent of kids will eventually grow out of their peanut allergy and be able to live with them. Edema, erythema, and urticaria are examples of skin responses that are frequently associated with peanut allergies. Dyspnea, lip edema, and tingling in the mouth and throat are more severe symptoms. Anaphylaxis will commonly develop from these symptoms [8].

Thus, although nuts offer substantial health benefits for children, peanut allergies pose significant risks. It requires careful management and both genetic and environmental factors should be considered.

2.2. Seafood

Seafood is another common type of allergen among children. Generally speaking, seafood is an excellent source of low-fat proteins. They are rich in many vital vitamins and minerals and, in some cases, the nutrients omega-3 long-chain polyunsaturated fatty acids (n-3 LCPUFAs) [9]. A study has found that there is moderate and consistent evidence suggesting that consuming more than 4 oz per week, and likely over 12 oz per week, of various commercially available seafood from childhood through adolescence is associated with improved neurocognitive outcomes compared to not consuming seafood at all [9]. All edible aquatic animals, mainly finfish and shellfish, are considered seafood. Mollusks and crustaceans, such as shrimp and crabs, are included in the category of shellfish, whereas finfish are divided into bony fish and cartilaginous fish. While cross-reactivity between shellfish and finfish is rare, cross-reactivity within each category is prevalent. One of the biggest types of allergens generated from animals is parvalbumin, which is the main allergen in fin fish, and tropomyosin, which is the main allergy in shellfish. Additional allergens include shellfish's myosin light chain and arginine kinase, as well as collagen and gelatin found in fin fish [10].

2.3. Eggs and Diary

The third type of common allergens are eggs and dairy. Both of them are high in protein but very essential for children’s growth and development. Dairy products are nutrient-dense, providing energy, high-quality protein, and essential micronutrients like calcium, magnesium, potassium, zinc, and phosphorus, which are easily absorbed by the body. These nutrients are vital to human health, particularly in childhood development and bone health. Adequate calcium intake is essential for achieving peak bone mass during growth and helps prevent bone loss and osteoporosis in older adults. Dairy products also prevent periodontal disease and may reduce cholesterol absorption, aid in weight control, and help regulate blood pressure [11]. However, more than 20 distinct protein fractions may be detected in cow's milk, with casein (beta, kappa, and s1-s2) and whey (beta-lactalbumin and beta-lactoglobulin) proteins containing the majority of allergens. The majority of individuals who have allergies to cow's milk are also sensitive to whey proteins. Although unpleasant responses can be categorized as either IgE-mediated or non-IgE-mediated, cow's milk allergy is usually caused by a non-IgE-mediated immunological response [12].

Similarly, eggs are a rich source of nutrients for brain development, including choline, riboflavin, vitamins B-6 and B-12, folate, zinc, protein, and DHA. Other nutrients such as iron, calcium, and phosphorus make them a valuable, affordable source of high-quality animal protein [13]. Egg allergy is mediated by IgE, with healthy individuals producing antigen-specific IgE when exposed to egg allergens. A genetic link is thought to contribute to egg allergy, as children of atopic individuals are more prone to developing allergies. It is widely accepted that MHC-linked genes control IgE responses on chromosome six, while the IgE Fc receptor on chromosome eleven may also be associated with atopy and allergies [14].

3. Intervention Strategies

3.1. Elimination Diet

The primary strategy for managing food allergies is to take out the allergy food from the diet. This is a cost-effective and noninvasive strategy to avoid allergic reactions and ensure safety. However, when common allergens like milk, eggs, or nuts are excluded, it can impact nutritional intake, making ongoing nutrition counseling vital to meet dietary needs. It can also induce emotional burden [15]. Thus, a multidisciplinary approach is important. At first, it is crucial to diagnose the allergic level. Second, a well-balanced elimination diet should account for not only macro and micronutrient intake

but also food variety, processing methods, potential eating challenges, and any coexisting health conditions. In addition, allergic status should be reassessed to prevent unnecessary dietary restrictions when possible [16].

3.2. Allergy Immunotherapy

When strict allergen avoidance is not possible, desensitization therapies like oral and sublingual immunotherapy offer a potential alternative. These treatments aim to build tolerance to allergens such as peanuts, eggs, and milk by gradually exposing patients to small, controlled doses [15]. Immunotherapy works by decreasing allergic responses through controlled allergen exposure via oral immunotherapy (OIT), sublingual immunotherapy (SLIT), or epicutaneous immunotherapy (EPIT). OIT gradually increases food doses but requires continuous treatment and may cause side effects. SLIT delivers allergens under the tongue, resulting in fewer side effects but with lower efficacy than OIT. EPIT, delivered through a patch on the skin, shows promise in reducing allergic reactions, especially for peanut allergies [17].

While oral immunotherapy can help improve tolerance to specific allergens, it carries a higher risk of adverse effects and is not generally recommended for cross-reactive allergens or as a universal treatment for all food allergies. Some individuals may experience reduced sensitivity during food challenges, but the risk of gastrointestinal or systemic reactions, including anaphylaxis, may require epinephrine treatment [15].

3.3. Medications for Anaphylaxis Management

Epinephrine is the primary treatment for severe allergic reactions, including food-induced anaphylaxis. Administered through an auto-injector, it rapidly alleviates the life-threatening symptoms of anaphylaxis. However, because its effects are short-lived, a second dose may be required if symptoms persist or recur. While medications such as antihistamines, glucocorticoids, and inhaled beta2 agonists can help manage milder symptoms, they should never replace epinephrine in an emergency. It's crucial for parents and caregivers to be trained in administering epinephrine, and immediate medical evaluation in an emergency room is often necessary to address potential complications after the initial reaction [15].

The NIAID is also investigating lab-created antibodies to halt allergic reactions. One strategy involves blocking molecules linked to immune overactivity, such as tezepelumab, which has shown promise in reducing cat allergy symptoms and is currently being tested for peanut allergies. Another approach uses omalizumab, an antibody that binds to IgE, the antibody responsible for allergic reactions, preventing them from being triggered. Omalizumab has enabled children with multiple food allergies to safely consume more allergenic foods and is FDA-approved to prevent allergic reactions from accidental food exposure [16].

4. Public Health Strategies for Managing Childhood Allergies

4.1. Policy and Education

There are different policies and education programs done to ensure effective management of childhood food allergies and increase public awareness. Government agencies and health organizations often implement regulations to require clear allergen labeling on food products, allowing consumers and caregivers to make informed decisions. In the U.S., the Food Allergen Labeling and Consumer Protection Act (FALCPA) mandates that food manufacturers identify major allergens on product labels to reduce the risk of accidental exposure. Public health campaigns, such as those led by FARE (Food Allergy Research & Education), aim to educate food service workers, parents, and educators on recognizing and managing allergic reactions, including the correct use of epinephrine auto-injectors. School programs can also emphasize allergen avoidance, helping create safer environments for children with food allergies. Additionally, families need guidance on reading food labels to avoid hidden allergens.

4.2. School and Community Programs

Programs in the community and schools alson play a crucial role in managing food allergies in children. A lot of schools have implemented thorough allergy control programs that teach staff how to identify allergic response signs and how to provide emergency treatment when needed. To reduce the chance of exposure, several schools incorporate nut-free zones or allergen-free lunch alternatives. Furthermore, 504 Plans and Individual Health Care Plans (IHCPs) guarantee that kids with severe allergies get the accommodations they require, including special seating or supervised dining places [17].

Creating an Individualized Health Care Plan (IHCP) for students with food allergies is vital to their safety in school environments. This plan was developed by the school nurse using medical guidance from the child's pediatrician to outline steps for daily allergy management and emergency responses. The IHCP is personalized based on the student's age and developmental needs and is formed through collaboration between the child's family, healthcare providers, and school personnel to ensure it remains effective and up-to-date [17].

In addition, schools can designate a team to oversee allergy management, focusing on avoidance strategies and emergency preparedness. They should also have protocols to store and monitor epinephrine in easily accessible locations and train staff to administer it if necessary. Adolescents, being at higher risk for severe reactions, require additional education on avoiding risky behaviors and the importance of carrying emergency medication [17].

Furthermore, students with food allergies are legally protected by laws such as the Individuals with Disabilities Education Act (IDEA), Section 504 of the Rehabilitation Act, and the Americans with Disabilities Act (ADA). These regulations ensure that students receive appropriate accommodations and protections. Schools must also address bullying related to food allergies promptly and thoroughly, and any allergic incidents should lead to a review and improvement of the school's health care protocols [17].

Through seminars and open gatherings, community initiatives frequently aim to increase awareness about food allergies and provide a platform for families to learn about them, exchange stories, and get support. Collaborations among educational institutions, medical professionals, and community-based groups can improve allergy education and response capacities in public and academic contexts [17].

5. Conclusion

Food allergies have become increasingly common in both children and adults, with common allergens including nuts, seafood, eggs, and dairy. These allergic reactions are driven by a variety of mechanisms, and their potential impact on children's growth, height, and emotional well-being can be significant. Intervention strategies such as elimination diets, allergy immunotherapy, and medications are commonly used to mitigate the nutritional and developmental risks associated with food allergies in children. However, no single approach is universally effective, and each treatment comes with its own set of limitations and potential risks.

The risk of developing food allergies is influenced by genetic factors as well as environmental conditions. Elements such as climate, infant feeding practices, and dietary habits can also play a crucial role in shaping food allergy outcomes. Fortunately, there are existing public health strategies aimed at managing childhood food allergies. Policies such as the U.S. Food Allergen Labeling and Consumer Protection Act (FALCPA) and organizations like Food Allergy Research & Education (FARE) provide vital resources to help families navigate food safety. These regulations help ensure that allergenic foods are clearly labeled, empowering parents to make informed dietary choices for their children.

Schools and community settings also play a critical role in supporting children with food allergies through individualized health care plans like 504 Plans and Individualized Health Care Plans (IHCPs). These programs ensure that children with allergies receive accommodations and care tailored to their

needs, creating safer environments for them to thrive. By fostering collaboration between policymakers, healthcare providers, and educational institutions, these initiatives contribute to reducing risks and improving the quality of life for children and families affected by food allergies.

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