

Prevalence of Tree Nut Allergies Related to Sociodemographic and Environmental Factors: A Global Review

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ABSTRACT

The prevalence of tree nut (TN) allergies has been on the rise worldwide. Estimated values for TN prevalence vary and differ according to age, region, and the diagnostic method used, which is primarily determined by both genetic and environmental factors. This paper examined the association between TN allergy prevalence and several other factors, including socioeconomic level, urban environment, certain racial or ethnic groups, including Asian and Black populations, early allergen exposure, and rural settings. Understanding the contribution of sociodemographic and environmental factors to TN allergy is essential for guiding prevention approaches and enhancing the management of allergies globally.

Keywords: Allergology; tree nut allergy; nut allergy prevalence; sociodemographic; environmental

INTRODUCTION

The prevalence of food allergies is increasing globally.¹ A true food allergy, not to be confused with a food sensitivity, is detected by the presence of Immunoglobulin E (IgE), indicating the immune system's response to an allergen.² Tree nuts (TNs) and peanuts are both common IgE-mediated food allergens, with increasing prevalence globally over the last 30 years, with some of the highest rates seen in the United States (U.S.) and the United Kingdom (U.K.).^{2,3,4} TN allergies are among the major allergenic foods and can cause serious allergic reactions ranging from hives over the body to fatal anaphylaxis.^{5,6} Anaphylaxis is a life-threatening reaction most commonly mediated by IgE and occurs within minutes after exposure to an allergy-causing agent.⁷ Although literature suggests that TN allergy prevalence ranges from 1-3% worldwide and varies by age, region, and food allergy definition,² anaphylaxis affects an estimated 46 people per 100,000 population annually worldwide, and although fatalities are rare, severe reactions can be life-threatening without prompt treatment.⁸

The development of TN allergies can happen at any time, and symptoms of allergic reactions differ on an individual level. A five-year telephone survey in the U.S. found that TN allergies can begin in early childhood.³ A review in 2019 on food allergy prevalence and severity revealed that adults can also

develop food allergies.⁹ Additional literature indicates that TN allergies often persist throughout the life course.² Individual TN allergies vary by nut type, age group, and region.¹⁰ Although genetics contributes to the development of TN allergies, the striking increase in prevalence suggests that other factors, such as the environment, may be involved.¹ Environmental factors like urban living, dietary patterns, and sanitation have been associated with differences in TN allergy prevalence, although current evidence does not establish that these factors directly cause allergy development.¹¹ For example, young children in rural areas, with siblings, in daycare, or exposed to pets tend to have lower rates of food allergies than those in more urban environments. Young children in rural areas are exposed to more microbes and environmental biodiversity that train and regulate their immune systems.¹ Sociodemographic factors have also been shown to be associated with the prevalence of TN allergies. For example, a study that investigated TN and peanut allergy prevalence in Australia found that children born to Asian mothers had an increased risk of nut allergy compared to non-Asian children.¹² In contrast, those born in Asia and who later moved to Australia had a reduced risk of TN allergy compared to those born in Australia.¹² Overall, both environmental and sociodemographic factors have been associated with differences in TN allergy prevalence, although most available evidence is observational and cannot establish causal relationships.

Comparing TN allergy prevalence globally can be complex. The identification of “tree nut” varies depending on how studies classify the nuts. In the existing literature, peanut (which is actually part of the legume food group) and TN allergies are usually combined and examined as a whole, when they are different allergies that deserve to be investigated independently. Alternatively, in studies that do not combine peanuts and TNs, most research focuses on peanuts and neglects tree nuts. Additionally, the method of diagnosing TN allergy can vary from self-reporting to IgE testing methods.² Many studies fail to examine the impact of environmental and sociodemographic factors that could increase the prevalence and cause TN allergies. Thus, this paper aims to compare the prevalence of TN allergies globally and explore how sociodemographic and environmental factors may contribute to regional differences in TN allergy development and severity. Understanding the prevalence of TN allergies is essential because they have been shown to be risk factors for other atopic diseases, such as asthma and atopic dermatitis (also known as eczema).¹³ Furthermore, by understanding the social demographic and environmental risk factors for TN allergies, interventions can be in place to reduce the prevalence of TN allergies, which ultimately will reduce the prevalence of other atopic diseases.

METHODS

<i>Inclusion Criteria</i>	<i>Exclusion Criteria</i>
Peer-reviewed journal articles	Case reports
Published in English	Editorials, letters, news articles, magazine articles
Examined tree nut allergy prevalence or	Studies focused exclusively on peanut allergy

epidemiology	without tree nut data
Evaluated sociodemographic or environmental risk factors	Animal studies
Included children and/or adults	Conference abstracts without full text
Worldwide populations	Non-English publications

Table 1: Inclusion and exclusion criteria for studies in the systematic review.

This literature review used a structured search strategy guided by PRISMA principles for identifying and selecting relevant studies. Because this was a single-author narrative review rather than a formal systematic review, the review was not preregistered, and no formal risk-of-bias assessment was performed.

Literature searches were conducted using PubMed (MEDLINE), Google Scholar, and Web of Science between June 2025 and March 2026. Search terms included combinations of:

- "tree nut allergy"
- "food allergy prevalence"
- "tree nut prevalence"
- "tree nut allergy epidemiology"
- "socioeconomic status"
- "race"
- "ethnicity"
- "sex"
- "age"
- "urban"
- "rural"
- "environmental factors"
- "pollen"
- "early allergen exposure"

Boolean operators (AND, OR) were used to combine search terms. Reference lists from relevant review articles were also screened to identify other eligible studies.

Studies were eligible if they were peer-reviewed articles published in English that evaluated the prevalence of TN allergy or examined sociodemographic or environmental factors associated with TN allergy in children or adults. Studies from all countries and study designs were considered. Articles focused exclusively on peanut allergy without reporting TN allergy data, case reports, conference abstracts, editorials, magazine or news articles, and non-English publications were excluded (Table 1).

Titles and abstracts were screened independently by one reviewer (A.T.). Full-text articles were then assessed for eligibility according to the inclusion and exclusion criteria. A total of 27 articles went through full-text review, and 12 studies met the inclusion criteria and were included in this review.

Data extracted from each study included study location, study design, study population, method of allergy diagnosis, prevalence estimates, and reported sociodemographic and environmental risk factors. Findings were synthesized into the following categories: socioeconomic status, race and ethnicity, biological sex, age, living environment, pollen exposure, and early allergen exposure.

DISCUSSION

Geographic and Identification Differences

Allergic responses can vary between individuals, with some reacting to a single nut and others experiencing cross-reactivity to multiple nuts.¹⁰ Regional dietary patterns and exposure influence which nut allergies are more widespread in different areas.¹⁴ For example, in Europe, hazelnut had the highest lifetime and point prevalence rates for self-reported allergy and sensitization, while pistachio had the lowest rates.¹⁰ Although self-reported allergies are important to note, this information is considered subjective rather than objective and requires further testing to confirm a true allergy. In the U.S., peanut allergy is the most frequent overall, but walnut allergy is the most common TN allergy.¹⁴ A 2023 survey in the U.S. confirmed that TN allergies often occur alongside peanut allergies.¹⁵ Given the above, it can be concluded that the prevalence of TN allergies differs between regions.

Global studies have found different TN allergy prevalence estimates because of differences in study populations and diagnostic methods.² Self-reported data are mostly consistently higher than data collected through Oral Food Challenges (OFC) or specific IgE testing.² Overall, studies using objective diagnostic methods, like OFCs or IgE testing, generally provide stronger evidence than studies relying on self-reported allergies, although these methods are less commonly used because of their higher cost and complexity. In a population-based survey of 40,443 U.S. adults, an estimated 10.8% had food allergies at the time of the survey, whereas nearly 19% of adults believed that they had food allergies.⁹ This highlights the need for more easily available allergy testing and enhanced education on allergy symptoms.⁹

These methodological differences make direct comparisons between studies challenging. Studies relying on self-reported food allergies generally report higher prevalence estimates than those using objective diagnostic methods such as serum-specific IgE testing or OFCs, which are considered the clinical gold standard. Additionally, variation in study populations, including differences in age distribution, geographic region, and healthcare access, likely contributes to the heterogeneity observed across prevalence estimates. Therefore, differences between studies should be interpreted cautiously, as they may reflect methodological variation rather than true differences in disease prevalence.

Sociodemographic Factors

Socioeconomic Status (SES)

Evidence indicates there is a potential correlation between socioeconomic status (SES) and the prevalence of TN allergies.¹⁶ In a 2023 study that used data from the Food Allergy Outcomes Related to White and African American Racial Differences (FORWARD) study, which is “a longitudinal, multi-center observational cohort of pediatric patients,” authors found higher prevalences of TN allergies in children from high-income households than in children from low-income households.¹⁶ In this study, high-income households were defined as making more than \$150,000 per year and low-income households were defined as making less than \$50,000 per year.¹⁶ Authors suggested that the higher rate of TN allergies in high-income families may be due to these households having more diverse diets, meaning infants in these households were more likely to come into contact with tree nuts early in life, compared to low-income families.¹⁶ One proposed explanation is that infants exposed primarily through the skin without sufficient oral exposure may become sensitized, although this mechanism requires further investigation.¹⁶ In an Australian study that examined nut allergy prevalence, the authors found that higher nut allergy rates were linked to higher levels of maternal education and higher SES.¹² The authors attributed these findings to the fact that these families may be more likely to seek medical attention and get a diagnosis than families with lower levels of maternal education and lower SES.

Racial and Ethnic Background

There have been multiple studies that found a correlation between the racial background of an individual and the prevalence of TN allergies.^{11,12,15} For example, a 2016 Australian study found that “Children born to Asian mothers were less likely to have TN or peanut allergy if they were born in Asia and subsequently migrated to Australia.”¹² The available literature suggests that being born in Asia may protect against nut allergy, possibly due to different environmental exposures in early life.¹² Whereas a 2023 study in the U.S. entitled “Racial, Ethnic, and Socioeconomic Differences in Food Allergies” revealed that Asian children reported the highest rates of TN allergy among other children from other racial and ethnic backgrounds, but it was not clear whether the Asian children were born in the U.S. or in Asia.¹⁵ Researchers also found that Black individuals had significantly higher odds of reporting TN allergies compared to White individuals.¹⁵ Hispanic individuals also showed increased odds of TN allergy, though to a lesser extent than Asian and Black individuals.¹⁵ Lastly, a Canadian study in 2011 found that immigrants had lower rates of all food allergies, including peanut and TN allergies, than Canadian-born individuals.¹¹ The lower allergy rates among immigrants may be attributed to differences in diet, early-life exposures to a diverse microbial environment, or reduced access to medical care, resulting in fewer diagnoses.¹¹ Thus, race and ethnicity appear to be associated with differences in reported TN allergy prevalence, although these associations may reflect complex interactions among genetics, early-life environment, healthcare access, and other social determinants rather than direct causal effects.

Biological Sex

Researchers have found there to be patterns and trends associated with the prevalence of biological sex and TN allergies. A U.S. telephone survey found that peanut and TN allergies are more common in male children and female adults than in other groups.³ The reason for this age-sex pattern is unknown, but similar trends were seen in earlier studies from Great Britain and in past research on anaphylaxis and food allergies.³ Furthermore, a Canadian study found that TN allergy was significantly less common in male adults.¹¹ The lower rates of TN and shellfish allergies in males may be due to the fact that men are less likely to see a doctor regularly and get diagnosed.¹¹ This study also mentioned that food allergies are more common in females after puberty, which may corroborate what other literature has found regarding females having higher rates of severe allergic reactions than males.¹¹ Given that hormones affect the immune system, and estrogen can exacerbate allergic responses, while progesterone reduces histamine release but increases IgE levels, this may contribute to the higher rates of severe allergic reactions in females than males.¹¹ Additional research is needed to determine whether hormonal differences directly contribute to observed differences in TN allergy prevalence.

Age

Though there is also a lack of evidence on the association between age and TN allergies, there are a few strong studies that support this relationship. For example, in the late 1990s and early 2000s, there was concern that food allergy rates were increasing, especially in children.³ There was also a common understanding that peanut and TN allergies were more common in children than in adults.¹¹ An Asian population-based questionnaire found that TN allergy usually began between the ages of six and ten.¹⁷ Additionally, a European study found that children often develop one nut allergy early in life and may acquire additional nut or seed allergies over time.⁴ The results of this European study also found that 60.7% of children had more than one nut or seed allergy, which was significantly higher than shown in previous studies.⁴ Although adults can also develop new-onset TN allergies, this occurs less frequently than in children.⁹ It is plausible that the changes in the immune system as individuals age and long-term exposures to certain environmental factors may trigger these new-onset TN allergies in adults. Interestingly, TN allergies often persist into adulthood, unlike other common food allergies, such as milk or egg allergies, that subside after childhood.² TN allergies persisting throughout adulthood highlight the long-term impact that TN allergies have on individuals' quality of life as well as risk for developing adult-onset of other atopic diseases.

Environmental Factors

Urban Versus Rural Living

Environmental factors like urban and rural living and sanitation may play a role in nut (TN and peanut) allergy development.¹¹ Children in rural areas, with siblings, and those who attended daycare tend to have lower rates of food allergies than those in urban environments.¹ In contrast, suburban families tend to delay introducing allergenic foods and prolong breastfeeding, which may increase allergy risk.¹⁸ Additionally, a 2016 Australian study found that children living in urban areas (like Melbourne) had higher allergy rates than those in rural areas or regional Victoria.¹² Furthermore, in 2011, authors of a demographic predictor study found that westernized environments with processed foods, less microbial exposure, and lifestyle changes (including omega-3 fatty acid deficiency, reduced intake of fresh fruits and vegetables, too much or too little vitamin D, variations in food processing, delayed introduction of certain foods, mild skin exposure to peanuts, and higher sanitation levels) were associated with an increase in nut allergy risk.¹¹

Pollen

Pollen plays a complex role in TN allergy development. Pollen sensitization can lead to false positives in nut (TN and peanut) allergy testing due to cross-reactivity.⁴ Green spaces (i.e., trees, grass, parks) might help to lower the risk of developing a TN allergy by promoting microbial exposure and outdoor activity; however, they can also increase pollen exposure, which might raise nut allergy risk.⁴ Additionally, green areas may reduce pollution, but also increase exposure to pollen allergens.⁴ Some pollens share proteins with foods, like peanuts, which can manipulate the immune system into responding incorrectly, and this can lead to cross-reactive allergies.⁴ Pollen might also weaken the respiratory lining, making it easier for food allergens to enter through the air, and leading to TN allergy development.⁴

Early Allergen Exposure

The timing and environment of allergen introduction can influence the development of the allergen. The 2016 Australian study suggests that being born in Asia may protect against combined peanut and TN allergy, possibly due to different environmental exposures in early life.¹² The study's findings provide support for theories like the hygiene hypothesis, where reduced exposure to germs early in life may increase allergy risk.¹² The study also provides strong evidence to support the idea that early life environment (especially migration timing and region of birth) plays a significant role in nut allergy development in children.¹² Authors of a Canadian study found that lower allergy rates in immigrants may be due to different diets, early-life exposures, or reduced access to medical care, leading to fewer diagnoses.¹¹ There was also a Polish Learning Early About Peanut (LEAP) study done that supports the finding that early introduction to allergens would decrease the risk of PA (peanut allergy).¹⁹ The LEAP strategy of introducing the allergen early in life has been implemented in the United Kingdom, North America, and Australia.¹⁹

Interconnected Environmental Influences

Food allergies are complex, involving genetics, timing of food exposure, and multiple environmental influences.¹ These environmental factors—vitamin D, pollution, greenness, and pollen—are all connected. For example, trees provide shade, which blocks sunlight (and thus vitamin D), but also produce pollen.¹ Green areas may reduce pollution, but also increase exposure to airborne allergens. A 2001 Canadian study on demographic predictors for food allergies found that westernized environments with processed foods, reduced microbial exposure, and lifestyle changes may increase the risk of nut (TN and peanut) allergy.¹¹ Other possible environmental factors that impact nut allergy development include low sun exposure, vitamin D deficiency, diet changes, and low microbial diversity (as seen in Western settings).¹²

Summary of Patterns for Increased Risk of Tree Nut Allergies

Although consistent patterns emerged across many studies, interpretation should consider the substantial heterogeneity among the included literature. Differences in study design, diagnostic criteria, geographic location, and participant characteristics are likely to contribute to variation in reported prevalence estimates.

Across the 12 studies included in this review, Table 2 summarizes the key sociodemographic and environmental factors associated with a higher reported prevalence of TN allergies. Among the seven different studies that examined sociodemographic risk factors, findings were relatively consistent.^{2,3,11,12,15–17} For example, higher rates of TN allergy were found in high-income (compared to low-income) households,^{12,16} as well as Asian, followed by Black and Hispanic (compared to non-Hispanic White) individuals,^{11,12,15} female adults (compared to males) and children (compared to adults).^{3,10} Thus, this evidence suggests that the lack of diversity of microbial exposure driven by higher SES, early-life exposure, and/or hormonal status may contribute to an increased risk of TN allergies. Among the seven articles, 45% of studies have found that TN allergies start in childhood and persist into adulthood, and show a long-term burden because they are rarely outgrown.^{3,4,9,11,17}

Environmental factors were also consistently associated with the prevalence of TN allergy, as illustrated in Table 2. Across the six studies that examined environmental influences, individuals living in urban or highly westernized environments generally had higher rates of TN allergies than those living in rural settings.^{1,4,11,12,18,19} Several studies identified reduced microbial exposure, high sanitation levels, pollen sensitization, and delayed allergen introduction as factors associated with increased TN allergy risk.^{1,4,11,12,18,19} Findings from migration studies and early allergen exposure research suggest that early-life environmental conditions may play an important role in shaping immune responses and influencing allergy development later in life.^{11,12,19} These findings can serve as a call to action for more studies that explore the connection between early-life environment and prevalence of TN allergies.

Across both sociodemographic and environmental categories, a common pattern emerged: populations with delayed introduction of oral allergens and reduced exposure to diverse environmental microbes tended to have higher rates of TN allergies. Consistent patterns emerged that environmental conditions during early childhood may be an important contributor to TN allergy risk and may represent a key target for prevention strategies.

Table 2: Summary of Populations at Increased Risk for Tree Nut Allergies

Risk Factor	Representative Evidence	Summary of Findings	Population Most at Risk
<i>Sociodemographic Factors</i>			
*SES	- US study (Jones et al., 2023) - Australia (Panjari et al., 2016)	Higher socioeconomic status was associated with increased prevalence of TN allergies. This relationship may reflect differences in early-life allergen exposure, dietary patterns, healthcare access, and likelihood of receiving a formal diagnosis.	High-income.
Low-income <\$50,000			
High-income >\$150,000			
Race/Ethnicity	- Australia (Panjari et al., 2016) - United States (Jiang et al., 2023) - Canada (Ben-Shoshan et al., 2012)	Studies consistently found differences in TN allergy prevalence across racial and ethnic groups. Asian, Black, and Hispanic populations generally exhibited greater prevalence than White populations, while immigrant populations often demonstrated lower prevalence, suggesting that both race/ethnicity and environmental exposures are associated with TN allergy risk.	Racial and ethnic minorities (Asian, Black, and Hispanic).
**NH-White			
**NH-Black			
Hispanic			
Asian			
Biological Sex	- United States (Sicherer et al., 2003) - Great Britain (Sicherer et al., 2003) - Canada (Ben-Shoshan et al., 2012)	Studies suggest that biological sex influences the prevalence of TN allergy. TN allergies appear to be more common in male children, but shift toward a higher prevalence in females after puberty and in adulthood, possibly due to hormonal influences on the immune system.	Female (adults) and male (children).
Male			
Female			

Age	● United States (Sicherer et al., 2003) ● Asia (Shek et al., 2010) ● Europe (Brough et al., 2020) ● United States (Gupta et al., 2019) ● Global findings (McWilliam et al., 2015)	Evidence suggests that children are at the greatest risk for developing TN allergies, with onset typically occurring during childhood. Although adults can develop new TN allergies, childhood onset is more common, and many TN allergies persist throughout adulthood.	Children (particularly ages 6–10 years).
Children (<18 years)			
Adults (18+ years)			
Environmental Factors			
Living Environment	● Global findings (Peters et al., 2022) ● Australia (Panjari et al., 2016) ● Canada (Ben-Shoshan et al., 2012): ● Suburban populations (Hannaway et al., 2005).	Studies consistently found that urban and westernized environments are associated with a higher risk of TN allergies, whereas rural environments appear protective. Reduced microbial exposure, lifestyle factors, and differences in early-life environmental exposures may contribute to the increased prevalence of allergies observed in urban populations.	Individuals living in urban/westernized environments.
Urban			
Rural			
Pollen Exposure	● Europe (Brough et al., 2020)	The relationship between pollen exposure and TN allergy is complex. While green environments may provide protective benefits, increased pollen exposure may contribute to the development of TN allergy through cross-reactivity and immune sensitization. Overall, higher pollen exposure appears to be associated with an increased risk of TN allergy.	Individuals with high pollen exposure or pollen sensitization.
Early Allergen Exposure	● Australia (Panjari et al., 2016) ● Canada (Ben-Shoshan et al., 2012)	Studies suggest that early-life environmental exposures (including migration) and early introduction of oral allergens may reduce the risk of developing allergies. Delayed allergen exposure and reduced microbial exposure in	Children with delayed allergen exposure.

	- Poland (Ryczaj et al., 2023) - United Kingdom, North America, and Australia (Ryczaj et al., 2023)	early childhood have been observed to increase TN and other food allergies.	
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*SES (Socioeconomic Status)

**NH (Non-Hispanic)

Strengths and Limitations

There are several strengths to this review paper. First, this paper covers a wide range of studies globally and provides a comprehensive understanding of TN allergy and associated risk factors. It also explores an understudied research topic that focuses on sociodemographic and environmental factors and highlights their impact on TN allergy development. Another strength is differentiating between peanuts and tree nuts, which is rarely done in the existing literature, where many studies combine them. This is important because many individuals can have allergies to just tree nuts rather than both tree nuts and peanuts because the protein that triggers the allergic response is different. Finally, this review includes multiple types of data, including surveys, IgE testing, and OFCs.

There are a few limitations of this review paper. First, there is a dearth of evidence available on this topic. Given the lack of available data, this paper was limited to including studies that do not track data on nut allergy prevalence over long periods of time, which can lead to inconsistent prevalence estimates of TN allergies. Although the review synthesizes available literature on risk factors for TN allergy development, research on causal relationships between environmental factors and TN allergies remains limited, and studies often exclude underrepresented populations. Most studies included in this review were observational in design. Meaning, while consistent associations between sociodemographic and environmental factors and TN allergy prevalence were identified, causal relationships cannot be established from the existing evidence. Secondly, there is wide heterogeneity among the included studies. Studies differed in diagnostic methods (including self-report, physician diagnosis, serum-specific IgE testing, and OFCs), study populations, geographic regions, and definitions of TN allergy. Some studies combined peanut and TN allergies, whereas others examined tree nuts separately. These methodological differences likely contributed to the wide range of reported prevalence estimates and limited direct comparison across studies. Consequently, findings should be interpreted as overall patterns across the literature rather than precise estimates of TN allergy prevalence. Additionally, several included studies relied on self-reported allergies rather than objective diagnostic methods such as oral food challenges or serum-specific IgE testing, which may have reduced diagnostic accuracy and contributed to variability in prevalence estimates. To minimize the impact of sparse data on this topic, multiple databases were utilized to gather as much available data as possible to include in the review, and this paper compares findings across multiple studies to highlight patterns and trends throughout the world regions.

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Future Directions

The connection between TN allergies and other food allergies, such as peanut or shellfish, has yet to be thoroughly explored and analyzed. Future research should focus on collecting more global data over longer periods of time to track trends in prevalence and establish causality. Gathering more information on TN allergies will allow future researchers to work towards solutions and allergy prevention as well as provide insights into other atopic diseases such as asthma and eczema.

CONCLUSION

Despite methodological differences among the included studies, including variation in diagnostic methods, study populations, and definitions of TN allergy, several consistent associations emerged across the literature. Overall, this review suggests that the prevalence of TN allergies varies across regions and populations and is associated with several sociodemographic (SES, race, biological sex, age) and environmental factors (living environments including migration, pollen exposure, and early allergen exposure). This paper highlights patterns and trends that together allow us to better understand the global prevalence of TN allergies, including those at increased risk, such as Asian populations and females and young children who are not exposed to a diverse microbial environment and/or early exposure to TN and peanuts. Understanding these trends in TN allergy prevalence can help identify the most at-risk populations and enable interventions early in a child's life to reduce environmental factors associated with TN allergies. Because most of the available evidence is observational, these findings should be interpreted as associations rather than causal relationships. Future longitudinal studies and intervention trials are needed to better understand the mechanisms underlying these observed patterns.

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