ARTÍCULO ORIGINAL

Gac Méd Caracas 2026;134(3):734-746
DOI: 10.47307/GMC.2026.134.3.3

Allergic sensitization pattern in pediatric population: A cross-sectional study in Cartagena, Colombia

Patrón de sensibilización alérgica en población pediátrica: un estudio transversal en Cartagena, Colombia

Gennys Gutiérrez Ramírez[1a*], Jaime Plazas Román[2b], José Miguel Escamilla Arrieta[3c], Isabel Cristina Gil Belalcázar[4d], María Camila Niebles[5e], Arlena Llamas Cera[6f], Luisa Milena Trujillo González[7f], Julia María Jiménez Arriola[8f]

SUMMARY

Background: *Allergic diseases represent a growing public health concern in pediatric populations, particularly in tropical regions where environmental conditions influence sensitization patterns. Limited epidemiological data exist for tropical coastal communities.* **Objective**: *To characterize the prevalence of specific allergic conditions, identify the most clinically relevant allergens, and examine polysensitization patterns in a pediatric population from Cartagena, Colombia.* **Design, setting, and patients**: *Cross-sectional study conducted between December 2024 and March 2025 at a Respiratory and Allergy Clinic, Colombia, including 122 consecutive pediatric patients aged 3–17 years with clinical suspicion of allergic disease. Skin prick tests were performed using 33 standardized allergen extracts in accordance with EAACI recommendations. Clinical diagnoses were made according to the ARIA 2020, GINA 2023, Hanifin-Rajka, and EAACI/GA²LEN/EDF/WAO 2022 criteria.* **Main outcomes**: *Prevalence of allergic conditions; individual and grouped allergen sensitization rates; polysensitization distribution; inter-allergen correlations; urban versus rural comparisons.* **Results**: *Mean age was 10.2 ± 3.8 years; 54.9% were male. Allergic rhinitis was the most prevalent condition (72.9%, 95% CI 65.1–80.8%), followed by asthma/recurrent wheezing (62.3%, 95% CI 53.7–70.9%). Dust mites showed the highest sensitization rate (89.3%, 95% CI: 83.9–94.8%), with Dermatophagoides pteronyssinus predominating (71.3%). Food sensitization affected 67.2% (95% CI: 58.4–75.2%), with shrimp (27.9%) leading the list. Polysensitization (≥3 allergens) occurred in 74.6% (95% CI 66.4–81.6%) of patients, with a mean of 7.3 ± 4.2 positive allergens per patient. Inter-species dust mite correlations were exceptionally strong (r = 0.937–0.966), indicating an extensive co-sensitization pattern consistent with possible cross-reactivity; immunological confirmation via component-resolved molecular diagnostics is required to establish cross-*

ORCID:
[1] 0000-0001-8571-6750
[2] 0000-0002-5040-6899
[3] 0000-0002-9632-8582
[4] 0009-0007-4332-8806
[5] 0009-0007-6944-5859
[6] 0009-0002-4655-6250
[7] 0009-0000-9924-3368
[8] 0009-0000-5445-2684

***Corresponding author**: Gennys Gutiérrez Ramírez. E-mail: gemainvestigativa@gmail.com

Recibido: 27 de marzo 2026
Aceptado: 17 de junio 2026

a. MD. Pediatrician. Respiratory and Allergy Clinic; Serena del Mar Hospital, Cartagena, Colombia.
b. DDS, MSc. Odontologist. Specialist in Pediatric Dentistry and Maxillary Orthopedics. Master in Bioinformatics. Universidad de Cartagena; Universidad del Sinú, Cartagena, Colombia.
c. MD. Pediatric Pulmonologist. Respiratory and Allergy Clinic, Serena del Mar Hospital, Universidad de Cartagena, Cartagena, Colombia.
d. MD. Pediatric Allergologist. Respiratory and Allergy Clinic; Serena del Mar Hospital, Cartagena, Colombia.
e. MD. Pediatrician. Universidad del Sinú EBZ, Seccional Cartagena, Colombia.
f. MD. Resident, Pediatrics. Escuela de Medicina, Universidad del Sinú EBZ, Seccional Cartagena, Colombia.

reactivity definitively. Urban–rural differences were negligible, with overlapping confidence intervals across all allergen groups. **Conclusion***: This study reveals exceptionally high rates of allergic sensitization in a tropical pediatric population, with dust mites as the predominant allergen group. High polysensitization rates demand comprehensive multi-allergen diagnostic approaches and region-specific environmental control measures. These findings underscore the critical influence of the tropical climate on allergen exposure and immune sensitization.*

Keywords*: Hypersensitivity, pediatrics, skin tests, allergens, dust mites*

RESUMEN

Introducción*: Las enfermedades alérgicas representan una preocupación creciente de salud pública en la población pediátrica, especialmente en regiones tropicales, donde las condiciones ambientales influyen en los patrones de sensibilización. Los datos epidemiológicos de las comunidades costeras tropicales son escasos.* **Objetivo***: Caracterizar la prevalencia de condiciones alérgicas específicas, identificar los alérgenos clínicamente más relevantes y examinar los patrones de polisensibilización en una población pediátrica de Cartagena, Colombia.* **Diseño, escenario y pacientes***: Estudio transversal realizado entre diciembre de 2024 y marzo de 2025 en una Clínica Respiratoria y de Alergias de Colombia, que incluyó a 122 pacientes pediátricos consecutivos de 3 a 17 años con sospecha clínica de enfermedad alérgica. Se realizaron pruebas cutáneas de puntura con 33 extractos alérgicos estandarizados siguiendo las recomendaciones de la EAACI. Los diagnósticos clínicos se basaron en los criterios de ARIA 2020, GINA 2023, Hanifin-Rajka y EAACI/GA²LEN/EDF/WAO 2022. Principales desenlaces estudiados: prevalencia de condiciones alérgicas; tasas de sensibilización individuales y por grupos de alérgenos; distribución de la polisensibilización; correlaciones interalérgicas; comparaciones urbano-rurales.* **Resultados***: La edad media fue de 10,2 ± 3,8 años; el 54,9% eran del sexo masculino. La rinitis alérgica fue la condición más prevalente (72,9%; IC 95%: 65,1–80,8%), seguida de asma/sibilancias recurrentes (62,3%; IC 95%: 53,7–70,9%). Los ácaros del polvo presentaron la mayor tasa de sensibilización (89,3%; IC 95%: 83,9–94,8%), siendo Dermatophagoides pteronyssinus (71,3%) el más prevalente. La sensibilización alimentaria afectó al 67,2% (IC 95%: 58,4–75,2%), liderada por el camarón (27,9%). La polisensibilización (≥3 alérgenos) se observó en el 74,6% (IC 95%: 66,4–81,6%), con una media de 7,3 ± 4,2 alérgenos positivos por paciente. Las correlaciones interespecíficas entre ácaros fueron excepcionalmente elevadas (r = 0,937–0,966), lo que indica un patrón de co-sensibilización consistente con una posible reactividad cruzada; la confirmación inmunológica mediante diagnóstico molecular por componentes es necesaria para establecer de forma definitiva dicha reactividad. No se observaron diferencias significativas entre las poblaciones urbanas y rurales.* **Conclusión***: Este estudio revela una prevalencia excepcionalmente alta de sensibilización alérgica en una población pediátrica de un entorno tropical, con los ácaros del polvo como el principal grupo alérgico. Las altas tasas de polisensibilización exigen enfoques diagnósticos multicomponentes y medidas específicas de control ambiental en regiones tropicales. Estos hallazgos subrayan la influencia determinante de las condiciones climáticas tropicales en la exposición a alérgenos y en la sensibilización inmunitaria.*

Palabras clave: *Hipersensibilidad, pediatría, pruebas cutáneas, alérgenos, ácaros del polvo doméstico*

INTRODUCTION

Allergic diseases have become increasingly prevalent worldwide, affecting approximately 25% of children globally, with significant regional variations reflecting environmental, genetic, and socioeconomic factors (1,2). The burden has doubled over the past two decades, establishing these conditions as a major public health challenge, particularly in developing countries where healthcare resources are limited and environmental factors may exacerbate disease severity (3,4). This epidemic is one of the most significant pediatric health concerns of the 21st century, with implications that extend beyond individual patient care to encompass substantial healthcare system costs and societal impacts.

Tropical and subtropical regions present unique environmental conditions that lead to distinct sensitization patterns compared with temperate climates. High humidity, elevated temperatures, and specific allergen profiles in these areas may lead to increased prevalence of allergic disease and altered clinical presentations (5,6). The Caribbean coast of Colombia exemplifies such conditions, with year-round high humidity (70–85%), consistent temperatures (25–32°C), and minimal seasonal variation, creating optimal environments for dust mite proliferation and other tropical allergens while eliminating the natural seasonal breaks that might provide respite in

temperate regions (7,8). These environmental characteristics can lead to year-round allergen exposure, fundamentally altering the natural history and clinical expression of allergic diseases.

Understanding regional sensitization patterns is crucial for developing appropriate diagnostic and therapeutic strategies tailored to specific populations and environmental conditions. While studies in temperate climates consistently identify dust mites, pollens, and animal dander as primary sensitizers with significant seasonal variations influencing symptom patterns and treatment responses (9,10), limited data exist regarding tropical pediatric populations, creating substantial knowledge gaps that affect clinical decision-making, treatment protocol development, and public health planning initiatives (11,12).

Polysensitization, defined as sensitization to multiple unrelated allergens, has been increasingly recognized as a marker of disease severity and complexity, often requiring more intensive management strategies (15,16). This phenomenon appears particularly relevant in tropical settings, where year-round allergen exposure may promote broader patterns of immune sensitization. Recent tropical studies suggest dust mite sensitization rates may significantly exceed those in temperate climates, potentially reaching prevalence rates above 80% in some populations (17,18). This contrasts with temperate regions, where dust mite sensitization typically ranges from 15–45% (19,20).

The clinical significance of understanding regional allergen patterns extends beyond diagnosis to treatment selection and outcome prediction. Allergen-specific immunotherapy requires precise identification of clinically relevant allergens for optimal outcomes (21,22). Similarly, environmental control measures must be tailored to local allergen profiles and environmental conditions to maximize effectiveness (23,24). The economic implications in tropical developing countries may be disproportionately severe due to continuous allergen exposure patterns, leading to persistent symptoms and increased healthcare utilization (25,26).

MATERIAL AND METHODS

Study design and population

A cross-sectional descriptive study was conducted between December 2024 and March 2025 at a Respiratory and Allergy Clinic in the Colombian Caribbean. The study included 122 consecutive pediatric patients aged 3–17 years who presented with clinical suspicion of allergic disease and were treated at the institution. The institution serves as an important referral center for allergic diseases in the Colombian Caribbean region. Skin prick tests were performed using 33 standardized allergen extracts in accordance with EAACI recommendations.

Inclusion criteria: age 3–17 years; clinical suspicion of allergic disease based on standardized questionnaires; signed informed consent from parents/guardians with additional assent from participants ≥7 years; and residence in the study region for ≥2 years, ensuring adequate allergen exposure. Exclusion criteria: antihistamine use within 72 hours (levocetirizine, desloratadine, fexofenadine, bilastine) or 5 days (sedating antihistamines); systemic corticosteroids within 4 weeks; topical corticosteroids at testing sites within 7 days; immunodeficiencies; severe dermatitis preventing testing; pregnancy in adolescents; chronic diseases interfering with evaluation; and prior anaphylaxis to test allergens.

Clinical evaluation and definitions

Board-certified allergologists conducted comprehensive evaluations using standardized protocols. Allergic rhinitis was diagnosed according to the ARIA 2020 guidelines, which require characteristic symptoms (rhinorrhea, congestion, sneezing, itching) and a temporal relationship to allergen exposure. Asthma/recurrent wheezing was defined using the GINA 2023 criteria, including recurrent wheezing, breathlessness, chest tightness, and cough episodes, with documented reversible airflow obstruction when possible. The atopic dermatitis

diagnosis was made according to the Hanifin and Rajka criteria, which require characteristic morphology, distribution, and chronicity. Allergic urticaria was defined according to the EAACI/GA²LEN/EDF/WAO 2022 guidelines as recurrent wheals with a specific association with allergen exposure.

Skin prick testing methodology

The allergenic extracts used included *Dermatophagoides farinae*, *D. pteronyssinus*, *Blomia tropicalis*, house dust, environmental fungi (*Aspergillus fumigatus*, *Alternaria alternata*), animal epithelia (dog, cat), foods (milk, casein, tartrazine, egg white/yolk, bakery flour, soy flour, wheat, peanut, chocolate, octopus, shrimp, lobster, tuna, pork, pineapple, strawberry), insects (mosquito, ant, American cockroach, insect mix, bee, wasp), and others (polyester, latex). The extracts were obtained from a standardized battery of aeroallergens and food allergens from the INMUNOTEK® laboratory (Madrid, Spain), with INVIMA registration valid at the time of the study. The extracts were stored at 2°C to 8°C, in accordance with the manufacturer's recommendations and institutional protocols for the preservation of biological products. Testing was performed on both forearm volar surfaces, with application points separated by ≥2 cm, using sterile disposable 1-mm lancets (ALK-Abelló) for perpendicular puncture, with histamine 10 mg/mL (positive control) and saline (negative control). All procedures were performed in the allergy department's procedure room by trained personnel and under the supervision of certified allergists.

Test interpretation and quality control

Trained personnel blinded to clinical information interpreted reactions at 15 minutes post-application. Positive reactions were defined as ≥3 mm in diameter, larger than the negative control, measured using standardized rulers. Valid tests required positive control ≥3 mm wheal and negative control <3 mm. Quality control included daily extract expiration verification, proper cold-chain storage (2–8°C), monthly equipment calibration, quarterly procedure audits, and standardized photographic documentation. Additionally, the integrity, traceability, and regulatory validity of the allergenic extracts used during the study were periodically verified. Inter-observer agreement assessment using a random 10% sample achieved $\kappa = 0.92$.

Statistical analysis and definitions

Analysis employed SPSS 28.0 and R 4.3.2. Descriptive statistics included means, standard deviations, and proportions with 95% confidence intervals (CI) using Wilson's method for optimal small-sample coverage. Chi-square tests were used to compare categorical variables, with Fisher's exact test when expected frequencies were <5. Pearson coefficients assessed inter-allergen correlations. Polysensitization was defined as sensitization to ≥3 allergens from different groups. Severity classification: mild (≤4 allergens AND ≤1 clinical condition), moderate (5–9 allergens OR 2 conditions), severe (≥10 allergens OR ≥3 conditions). Bonferroni correction was applied for multiple comparisons. Effect sizes were reported as odds ratios (ORs) with 95% confidence intervals; the expression "statistically significant difference" was avoided, and differences were interpreted using confidence intervals.

Ethical considerations

The Institutional Ethics Committee of the Respiratory and Allergy Clinic approved this study (Resolution 2024-CEI-045) in accordance with the principles of the Declaration of Helsinki. The study was classified as minimal risk under current Colombian regulations. Written informed consent was obtained from all parents/guardians, with additional assent from participants ≥7 years. Emergency protocols were established for potential adverse reactions, including immediate availability of epinephrine and corticosteroids. Data confidentiality was ensured through coding

and anonymization, with restricted access to personal identifiers.

RESULTS

Population characteristics

The study included 122 patients with a mean age of 10.2 ± 3.8 years (range 3–17), comprising 54.9% males (67/122) and 45.1% females (55/122). Urban residence was observed in 86.1% (105/122), while 13.9% (17/122) lived in rural areas. Age distribution showed 23.0% (28/122) preschool age (3–5 years), 54.9% (67/122) school age (6–11 years), and 22.1% (27/122) adolescence (12–17 years). The detailed demographic distribution is presented in Figure 1.

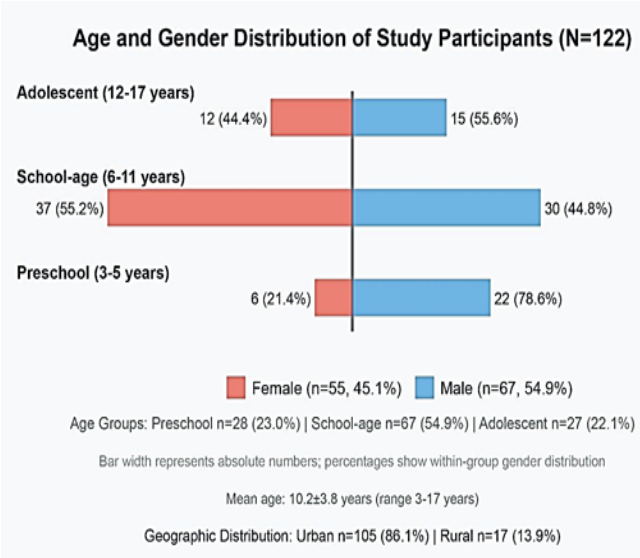

Figure 1. Age and gender distribution of study participants (N = 122). Population pyramid showing 122 pediatric patients across age groups (preschool, 3–5 years; school-age, 6–11 years; adolescent, 12–17 years), stratified by gender. Bar width represents absolute numbers; percentages show within-group gender distribution. Mean age: 10.2 ± 3.8 years

Prevalence of allergic conditions

Allergic rhinitis was the most prevalent condition, affecting 72.9% of patients (95% CI, 65.1–80.8%), followed by asthma/recurrent wheezing, affecting 62.3% (95% CI, 53.7–70.9%). Atopic dermatitis occurred in 36.9% (95% CI 28.3–45.4%) and allergic urticaria in 31.1% (95% CI 22.9–39.4%). Nearly all patients (93.4%, 95% CI 87.8–96.8%) presented with at least one allergic condition. Complete prevalence data with confidence intervals are detailed in Table 1.

Clinical manifestation frequencies indicate that allergic rhinitis is the dominant condition, affecting nearly three-quarters of patients, while respiratory allergies (rhinitis and asthma combined) affect the vast majority. Confidence intervals indicate robust prevalence estimates with acceptable precision for this clinical population size.

Allergen sensitization patterns

Dust mites had the highest group sensitization rate, at 89.3% (95% CI 83.9–94.8%), making them the predominant allergen category. Individual dust mite prevalence showed *Dermatophagoides pteronyssinus* at 71.3%, *D. farinae* at 68.9%, and *Blomia tropicalis* at 64.8%. Food allergens affected 67.2% (95% CI 58.4–75.2%), with shrimp being the leading individual food allergen at 27.9%, followed by milk (23.0%) and egg white (19.7%). Insect sensitization occurred in 58.2% (95% CI 49.3–66.7%), led by mosquitoes (36.9%), American cockroaches (31.1%), and ants (23.8%). Fungal sensitization affected 45.1% (95% CI 36.4–54.0%), predominantly *Alternaria alternata* (34.4%) and *Aspergillus fumigatus* (25.4%). Animal epithelium sensitization was present in 41.0%, with dog epithelium (28.7%) exceeding cat epithelium (23.0%). The comprehensive allergen group analysis is shown in Table 2 and Figure 2.

Allergen group analysis reveals environmental aeroallergens (dust mites) as the predominant sensitizing agents, consistent with tropical climate conditions. Food sensitization patterns reflect both regional dietary preferences (e.g., seafood prevalence) and known cross-reactivity involving shared tropomyosin proteins.

Table 1. Prevalence of allergic conditions in the study population (N = 122)

Allergic Condition	Cases (n)	Prevalence (%)	95% CI
Allergic rhinitis	89	72.9	65.1–80.8
Asthma/recurrent wheezing	76	62.3	53.7–70.9
Atopic dermatitis	45	36.9	28.3–45.4
Allergic urticaria	38	31.1	22.9–39.4
≥1 allergic condition	**114**	**93.4**	**87.8–96.8**

Table 2. Sensitization prevalence by allergen groups with individual allergen details (N = 122)

Allergen group	Sensitized (n)	Prevalence (%)	95% CI	Top 3 individual allergens	Prev. (%)
Dust mites	109	89.3	83.9–94.8	*D. pteronyssinus*	71.3
				D. farinae	68.9
				B. tropicalis	64.8
Foods	82	67.2	58.4–75.2	Shrimp	27.9
				Milk	23.0
				Egg white	19.7
Insects	71	58.2	49.3–66.7	Mosquito	36.9
				American cockroach	31.1
				Ant	23.8
Fungi	55	45.1	36.4–54.0	*Alternaria alternata*	34.4
				Aspergillus fumigatus	25.4
Animal epithelia	50	41.0	32.5–50.0	Dog epithelium	28.7
				Cat epithelium	23.0

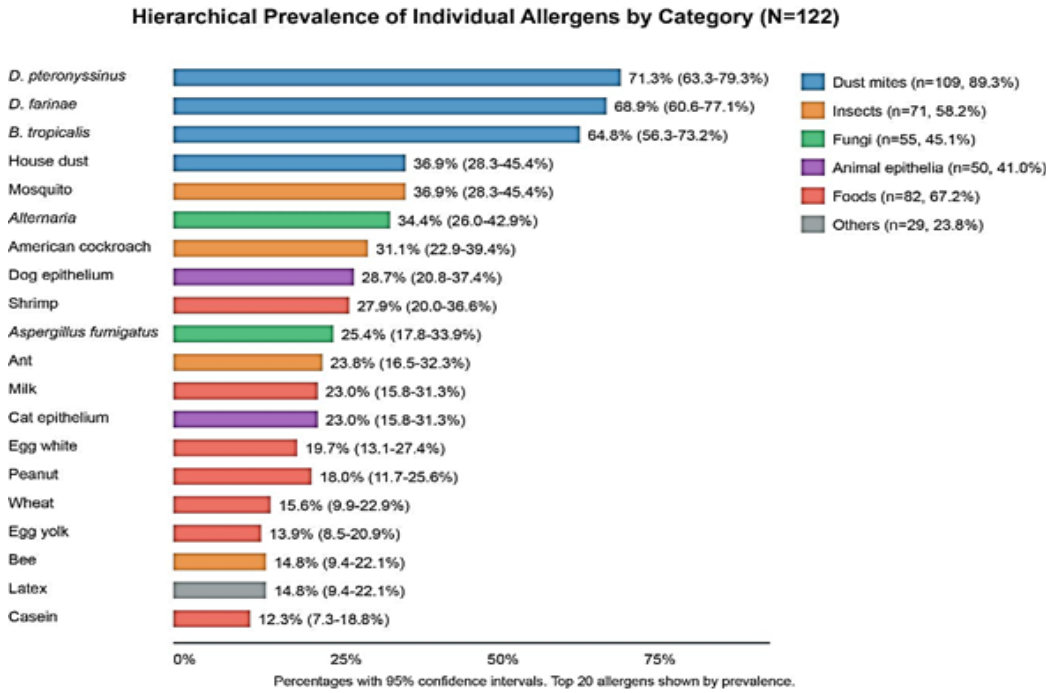

Figure 2. Hierarchical prevalence of individual allergens by category (N = 122). A horizontal bar chart shows sensitization prevalence for the 20 most common individual allergens, organized into color-coded groups. Percentages with 95% confidence intervals are shown for each allergen

Polysensitization analysis

Polysensitization to three or more allergens occurred in 74.6% of patients (95% CI 66.4–81.6%), indicating that approximately three-quarters of children develop multiple sensitizations in this tropical environment. Mean positive allergens per patient was 7.3 ± 4.2, with a median of 6 allergens. Only 6.6% showed no sensitization to the tested allergens. Distribution revealed 18.9% with 1–3 allergens, 25.4% with 4–6 allergens, 28.7% with 7–10 allergens, and 20.5% with severe polysensitization (≥11 allergens). The complete distribution of polysensitization is presented in Table 3.

The distribution of polysensitization demonstrates that multiple allergen reactivity is the clinical norm rather than an exception in this tropical setting. The substantial proportion of severely polysensitized patients (≥11 allergens) indicates complex immune dysregulation that requires comprehensive management.

Correlations and associations

The strongest correlations were observed between *Blomia tropicalis* and *D. pteronyssinus* (r = 0.966, 95% CI 0.952–0.976), *D. farinae* and *D. pteronyssinus* (r = 0.941, 95% CI 0.920–0.957), and *D. farinae* and *B. tropicalis* (r = 0.937, 95% CI 0.914–0.954). House dust demonstrated moderate correlations with all mite species (r = 0.58–0.65). These exceptionally high correlations reveal extensive co-sensitization among dust mite species, consistent with possible cross-reactivity; however, immunological confirmation through component-resolved diagnostics (e.g., molecular IgE testing) would be required to establish cross-reactivity definitively. The complete correlation matrix is shown in Figure 3.

Gender analysis demonstrated a higher prevalence of allergic rhinitis and urticaria in females (76.4% vs 70.1% and 34.5% vs 28.4%, respectively), whereas asthma showed a higher prevalence in males (65.7% vs 58.2%). However, confidence intervals for all odds ratios included 1.0, consistent with no meaningful gender-based difference in this sample. Urban patients showed numerically higher sensitization rates for most allergens, particularly dust mites, though confidence intervals overlapped substantially. The comparative analysis by geographic residence is shown in Figure 4.

Comorbidity patterns

Multiple allergic conditions frequently coexisted, with allergic rhinitis plus asthma being the most common, occurring in 47.5% of all patients (95% CI 38.6–56.5%). Other frequent combinations included rhinitis with atopic dermatitis (27.9%), asthma with atopic dermatitis (25.4%), and rhinitis with urticaria (23.8%). Notably, 14.8% of patients presented all four evaluated conditions simultaneously, indicating high disease complexity in this tropical pediatric

Table 3. Distribution of polysensitization patterns across the study population (N = 122)

Number of allergens	Patients (n)	Percentage (%)	95% CI
0	8	6.6	3.2–12.5
1–3	23	18.9	12.8–26.8
4–6	31	25.4	18.4–33.7
7–10	35	28.7	21.3–37.3
11–15	18	14.8	9.4–22.1
≥16	7	5.7	2.7–11.4
Polysensitization (≥3)	**91**	**74.6**	**66.4–81.6**

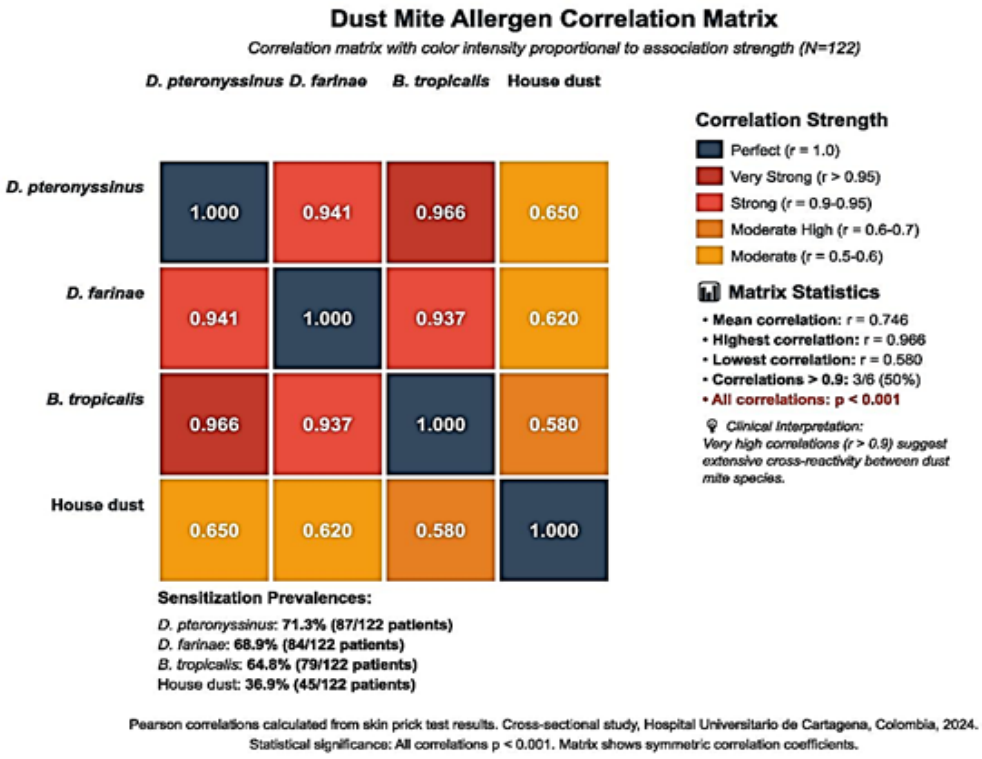

Figure 3. Dust mite allergen correlation matrix (N = 122). Correlation matrix displaying Pearson correlation coefficients between four dust mite allergens (*D. pteronyssinus, D. farinae, B. tropicalis*, house dust) with color intensity proportional to association strength. All correlation confidence intervals exclude zero. The matrix reveals exceptionally high correlations ($r > 0.9$) among the three mite species, indicating extensive co-sensitization consistent with possible cross-reactivity; component-resolved diagnostics are required to confirm shared allergenic epitopes definitively

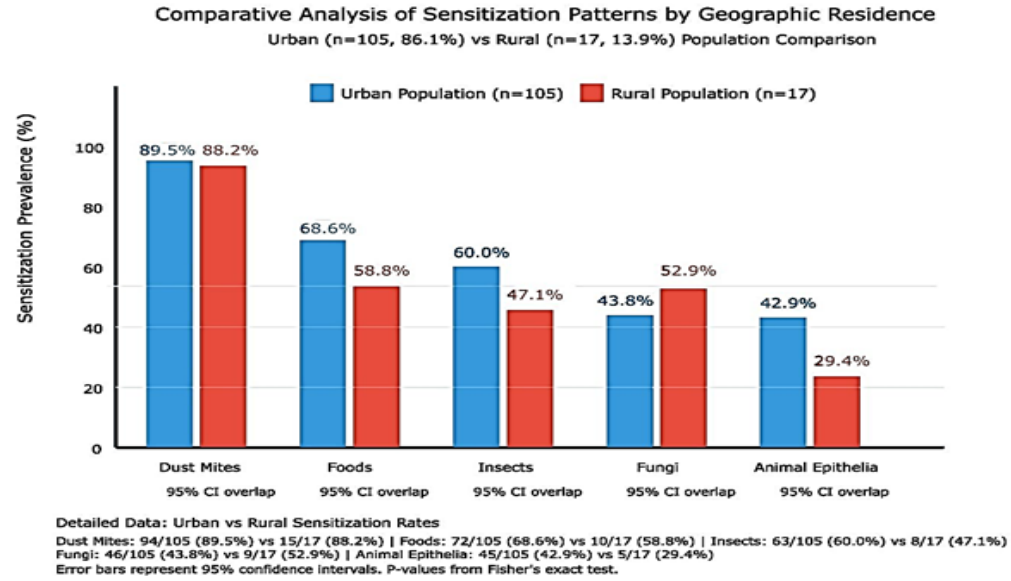

Figure 4. Comparative analysis of sensitization patterns by geographic residence. Grouped bar chart comparing allergen group sensitization rates between urban (n = 105) and rural (n = 17) populations. Error bars represent 95% confidence intervals. Confidence intervals for all urban–rural differences overlapped substantially, indicating no meaningful differential sensitization by geographic residence. Fisher's exact test was used for all comparisons

population. The detailed comorbidity analysis is presented in Table 4.

DISCUSSION

This study demonstrates a high prevalence of allergic diseases (93.4%, 95% CI: 87.8–96.8%) in the pediatric population studied, substantially exceeding world averages. Compared with comprehensive regional studies, our prevalence of allergic rhinitis (72.9%) notably exceeds the 18–35% ranges reported in population surveys in Latin America; this difference was expected given that our sample comprises patients already referred for specialized evaluation with clinical signs of atopic conditions (27–29). Mexican population studies report a prevalence of childhood asthma of 6–15%, while extensive Brazilian research consistently shows 18–25%, in contrast to our 62.3% (27,28,29). These differences reflect both Cartagena's tropical coastal environment (consistently high humidity (>75%), minimal seasonal temperature variation, and year-round conditions conducive to allergen proliferation) and the clinic-based referral design, which captured patients with established allergic disease rather than community-level prevalence.

International comparisons reveal even more striking differences. European population studies typically report an overall prevalence of 15–25% for allergic disease in children, while North American epidemiological data range from 20–35%, both substantially lower than our near-universal prevalence in this reference population (30,31). Our dust mite sensitization rate (89.3%) was among the highest documented worldwide in the pediatric literature reviewed. Recent data from comparable tropical reference populations have shown high rates of dust mite sensitization, but still lower than our data: Singapore (HDM sensitization >70% in allergic patients (32) and Thailand (*D. pteronyssinus* sensitization 43.5–63% in children with asthma/rhinitis (33), possibly reflecting the particularly favorable conditions in Cartagena for dust mite proliferation. In stark contrast, studies conducted in temperate climates across Europe and North America consistently report dust mite sensitization rates of 15–35%, underscoring the crucial role of climate in shaping sensitization patterns.

Our polysensitization rate (74.6%) exceeds most international reports, where typical temperate-region rates range from 30–50% in

Table 4. Principal allergic condition comorbidities and their clinical significance

Condition combination	Cases (n)	Total population (%)	Patients with first condition (%)	Clinical significance
Rhinitis + Asthma	58	47.5	65.2	Most prevalent comorbidity; supports "united airway" concept
Rhinitis + Atopic Dermatitis	34	27.9	38.2	Indicates systemic atopic march beyond the respiratory tract
Asthma + Atopic Dermatitis	31	25.4	40.8	High burden; requires combined dermatological-pulmonological management
Rhinitis + Urticaria	29	23.8	32.6	Suggests a systemic allergic response; consider comprehensive immunological evaluation
All four conditions simultaneously	**18**	**14.8**	—	Severe polysensitization phenotype; requires a multidisciplinary care approach

pediatric populations. However, tropical Asian studies demonstrate remarkably similar patterns, with Taiwan reporting 65.2% and Hong Kong 71.8%, strongly suggesting that tropical climates inherently predispose to broader sensitization spectra due to continuous multi-allergen exposure (34,35). This extensive polysensitization carries profound clinical implications, as it correlates with increased symptom severity, reduced quality-of-life metrics, greater healthcare utilization, and more complex therapeutic requirements. The exceptionally strong interspecific correlations among dust mite species ($r > 0.9$) revealed extensive co-sensitization, consistent with possible cross-reactivity via shared allergenic proteins. Definitive confirmation requires component-resolved diagnostics (e.g., molecular IgE testing for Der p 1, Der p 2, and Blo t 5). Nevertheless, this pattern suggested that diagnostic efficiency could potentially be improved by using representative allergens.

Food sensitization patterns, particularly the high prevalence of shrimp (27.9%), likely reflected the complex interplay between regional dietary preferences and cross-reactivity with environmental allergens via shared tropomyosin proteins. This phenomenon, extensively documented in coastal tropical regions worldwide, creates intricate sensitization networks where environmental and dietary allergens mutually reinforce allergic responses (36,37). The notable insect sensitization rate (58.2%), particularly to mosquitoes (36.9%), directly reflects the constant year-round exposure typical of tropical coastal environments and represents a unique regional challenge rarely addressed in standard temperate-climate management guidelines.

The clinical and public health implications of our findings are profound for tropical pediatric populations globally. The overwhelming predominance of dust mite sensitization strongly supports prioritizing comprehensive environmental control measures as primary interventions, including aggressive humidity control, widespread implementation of allergen-proof bedding systems, and intensive cleaning protocols tailored to tropical conditions (38,39). However, the extraordinarily high polysensitization rate fundamentally challenges traditional single-allergen-focused approaches, suggesting that broader, multi-target therapeutic strategies are needed.

The development of region-specific clinical guidelines appears essential, as standard recommendations developed for temperate climates fail to address the unique allergen profiles, continuous exposure patterns, and environmental conditions characteristic of tropical coastal environments. From a health policy perspective, these findings warrant urgent attention in resource allocation and healthcare system planning for tropical regions (40,41).

Study limitations include a cross-sectional design, which precludes assessment of causality, disease progression, and treatment response patterns over time. The clinic-based sampling approach introduces an inherent selection bias. All participants were referred to a specialized allergy clinic, and the prevalence figures reported here reflected a clinically referred population that cannot be directly extrapolated to the general pediatric population of the region. Comparisons with population-based studies must therefore be interpreted with caution, as high prevalence rates are expected in a referral clinic setting. The absence of specific IgE quantification and detailed measurements of environmental allergen exposure limits mechanistic understanding of dose-response relationships. Seasonal variation assessment was not feasible given the minimal climatic variation characteristic of this tropical coastal setting, though this limitation paradoxically strengthened our conclusions about continuous allergen exposure. Future research priorities should include longitudinal cohort studies with larger sample sizes to increase statistical power for subgroup analyses, randomized environmental intervention trials, multicenter comparative studies across tropical regions, and component-resolved molecular diagnostic studies to confirm the immunological basis of the observed co-sensitization patterns.

CONCLUSIONS

This comprehensive analysis revealed unprecedented allergic sensitization prevalence rates substantially exceeding global averages, establishing this as one of the highest reported burdens in a clinical referral setting — a finding that should be interpreted in the context of clinic-based sampling, which inherently selected for symptomatic patients. The near-universal prevalence of allergic conditions (93.4%, 95% CI 87.8–96.8%) and an exceptionally high dust mite sensitization rate (89.3%, 95% CI 83.9–94.8%) underscore the critical influence of tropical climatic conditions on allergen exposure and subsequent immune sensitization patterns.

Polysensitization predominance (74.6%) necessitates comprehensive multi-allergen diagnostic strategies and broad-spectrum environmental control measures in this population. Notably, the exceptionally strong inter-correlations among dust mite species (*D. pteronyssinus*, *D. farinae*, and *B. tropicalis*; $r > 0.9$, $p < 0.001$) indicated extensive cross-reactivity through shared allergenic proteins, suggesting that *D. pteronyssinus* alone might provide sufficient diagnostic information within this group, potentially streamlining allergen panels and reducing testing costs without compromising diagnostic accuracy.

From a public health perspective, the documented disease burden warrants urgent attention in health policy development and resource allocation for tropical pediatric populations. Region-specific clinical guideline development, tailored to unique tropical allergen profiles, appears essential for optimizing patient outcomes, while future research should focus on assessing longitudinal sensitization and evaluating targeted intervention strategies.

Conflicts of interest

The authors declare there are no conflicts of interest related to this study.

Ethics

Ethics committee approval: Institutional Ethics Committee, Clinica Respiratoria y de Alergias de Cartagena (Resolution 2024-CEI-045). The study was classified as minimal risk under Colombian regulations (Resolution 8430/1993). Written informed consent and assent were obtained from all participants and their guardians.

Source of Funding

This research received no external funding.

Authors' Contributions

CRediT taxonomy of academic collaboration roles: GRR: Conceptualization, Data Curation, Formal Analysis, Investigation, Methodology, Project Administration, Writing – Original Draft. **JPR:** Conceptualization, Formal Analysis, Methodology, Software, Visualization, Writing – Review & Editing. **JEA:** Investigation, Resources, Validation, Writing – Review & Editing. **IGB:** Investigation, Resources, Validation, Writing – Review & Editing. **MNR:** Data Curation, Investigation, Writing – Review & Editing. **ALC:** Data Curation, Investigation, Writing – Review & Editing. **LTG:** Data Curation, Investigation, Writing – Review & Editing. **JJA:** Data Curation, Investigation, Writing – Review & Editing. All authors approved the final version of the manuscript.

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