Allergy Asthma Immunol Res. 2025 Nov;17(6):754-764
https://doi.org/10.4168/aair.2025.17.6.754
pISSN 2092-7355·eISSN 2092-7363

Allergy, Asthma & Immunology Research AAIR

Original Article

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The Prevalence of Allergic Rhinitis in Korean Children: Nationwide Surveys in the Periods 1995-2022

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OPEN ACCESS

Received: Apr 13, 2025
Revised: Jul 29, 2025
Accepted: Aug 19, 2025
Published online: Sep 18, 2025

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ABSTRACT

Purpose: This study aimed to assess the current prevalence of allergic rhinitis (AR) among Korean children based on a 2022 nationwide survey and to analyze long-term trends from 1995 to 2022.
Methods: A nationwide cross-sectional study was conducted in 2022, involving 12,558 children aged 6–13 years from randomly selected elementary and middle schools across Korea. The AR prevalence and risk factors were assessed using the modified International Study of Asthma and Allergies in Childhood Questionnaire. The data were compared with epidemiological surveys conducted in 1995, 2000, and 2010 to evaluate long-term trends.
Results: The prevalence rates of AR symptoms during the last 12 months were 45.2%, 48.2%, and 47.8%, respectively, in children aged 6–7, 9–10, and 12–13 years, respectively. Among children aged 6–7 years, the prevalence of AR symptoms showed a long-term upward trend, rising from 29.9% in 1995 to 26.0% in 2000, 43.6% in 2010, and 45.2% in 2022 ($P < 0.001$). Among children aged 12–13 years, the prevalence rates also increased steadily, from 26.7% in 1995 to 31.0% in 2000, 42.7% in 2010, and 47.8% in 2022 ($P < 0.001$). A parental history of allergic disease and a diagnosis of atopic dermatitis were risk factors for AR symptoms during the last 12 months across all study populations from both the 2010 and 2022 surveys. Antibiotic use during infancy and male sex were significant contributors to AR development

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Disclosure
There are no financial or other issues that might lead to conflict of interest.

in children aged 6–7 years, whereas female sex was a significant risk factor in adolescents aged 12–13 years in 2022.
Conclusions: The prevalence of AR among Korean children has increased over the past few decades, highlighting the importance of continuous surveillance and preventive measures. Identifying modifiable risk factors, such as early-life exposure and environmental influences, is crucial for developing targeted intervention strategies.

Keywords: Allergic rhinitis; children; prevalence; risk factors; epidemiology

INTRODUCTION

Allergic rhinitis (AR) is characterized by nasal inflammation triggered by allergens, with symptoms such as sneezing, nasal congestion, itching, and rhinorrhea. It is one of the most prevalent allergic diseases worldwide, significantly affecting quality of life, academic performance, and productivity.[1] Its prevalence varies across regions and age groups and is influenced by genetic predisposition as well as environmental factors such as air pollution, climate change, and urbanization. The prevalence of AR fluctuates with changing environmental conditions, necessitating continuous assessment.

Previous epidemiological studies have indicated a steady global increase in allergic diseases.[2-4] Recent research reports that the prevalence of AR continues to rise, whereas the prevalence of asthma and atopic dermatitis (AD) appears to be stabilizing or even declining in certain populations and age groups.[5-7] In Korea, nationwide epidemiological surveys on allergic diseases have been conducted periodically since 1995.[3,4,8] Nationwide surveys targeting students aged 6–7 and 12–13 years were conducted in 1995, 2000, and 2010. Additionally, regional surveys were conducted in Seoul in 2005 (among 6- to 7-year-olds) and in 2008 (among both 6- to 7 and 12- to 13-year-olds). A subsequent nationwide survey conducted in 2015 focused on children aged 6-7 years.[8]

In these nationwide surveys of 6- to 7-year-old children conducted in the years 1995, 2000, 2010, and 2015, the prevalence of physician-diagnosed AR showed a continuous increase, with the rates reported at 15.5%, 20.4%, 37.0%, and 45.2%, respectively. In contrast, the prevalence rates of physician-diagnosed asthma and AD during the same period initially showed an upward trend but later declined, with asthma prevalence rates reported at 7.7%, 9.1%, 10.2%, and 5.8%, and AD prevalence rates reported at 16.6%, 24.9%, 35.6%, and 20.0%, respectively.[4,9-12] Monitoring disease prevalence trends is crucial for understanding these conditions and planning effective management strategies. Continuous investigation is needed to identify risk factors associated with AR and to establish effective prevention and treatment strategies.

This study aimed to provide an updated nationwide assessment of AR prevalence among Korean children based on a 2022 survey and analyze long-term trends from 1995 to 2022. Risk factors contributing to the development of AR were also explored to offer insights that may guide future prevention and management strategies.

MATERIALS AND METHODS

Study population and design

A nationwide cross-sectional study was conducted in 2022, involving 12,558 children (4,038, 4,251, and 4,269 aged 6–7, 9–10, and 12–13 years, respectively) from 213 elementary and 103 middle schools randomly selected across Korea (**Table 1**).

The participants were sampled by selecting schools using systematic probability sampling methods stratified by geographic regions, school location type, and the proportion of households residing in apartment complexes.[3] One class per grade was then selected as the sample class, with parental consent obtained for participation. Data collection took place from September to November 2022, using a modified International Study of Asthma and Allergies in Childhood (ISAAC) questionnaire, administered either in-person or online. Additionally, findings from this 2022 survey were compared with data from previous nationwide epidemiological surveys conducted in 1995, 2000, and 2010, which used the same ISAAC questionnaire and were carried out between September and November of each respective year.[3,4,12] This study was approved by the Institutional Review Board (IRB) of Inje University Seoul Paik Hospital (IRB approval number: PAIK 2022-01-006). Written informed consent was obtained from all parents prior to their children's participation, as confirmed by the IRB.

Questionnaire

The Korean version of the modified ISAAC questionnaire was used to assess the prevalence of AR and associated risk factors. The questionnaire included the following components:

1. Participant characteristics: age, sex, body mass index, birth history, area of residence

Table 1. Characteristics of the study population in 2022

Characteristics	6–7 yr (n = 4,038)	9–10 yr (n = 4,251)	12–13 yr (n = 4,269)
Sex (male)	2,037 (50.4)	2,120 (49.9)	2,143 (50.2)
Body mass index (kg/m^2)	16.76 ± 2.72	19.29 ± 3.61	20.66 ± 3.72
Parental history of allergic diseases	2,506 (62.1)	2,496 (57.8)	2,205 (51.7)
Maternal education level			
≤ High school	759 (18.8)	878 (21.7)	1,175 (27.5)
≥ University	3,078 (76.2)	3,172 (78.3)	2,829 (66.3)
Mode of delivery			
Vaginal delivery	2,332 (57.8)	2,655 (62.5)	2,667 (62.5)
Cesarean section	1,706 (42.2)	1,596 (37.5)	1,602 (37.5)
Gestational period			
≤ 36 wk	523 (13.0)	538 (12.7)	561 (13.1)
37–42 wk	3,434 (85.0)	3,618 (85.1)	3,584 (84.0)
≥ 43 wk	80 (2.0)	94 (2.2)	124 (2.9)
Birth weight			
< 3.1 kg	1,475 (36.6)	1,488 (35.0)	1,492 (34.9)
3.1–3.5 kg	1,802 (44.7)	1,927 (45.3)	1,928 (45.2)
≥ 3.6 kg	758 (18.8)	835 (19.6)	849 (19.9)
History of bronchiolitis	1,232 (30.5)	1,174 (27.6)	864 (20.2)
Antibiotic use*	1,539 (38.1)	1,553 (36.5)	1,242 (29.1)
Maternal smoke†	32 (0.8)	42 (1.0)	47 (1.1)
Pet ownership‡	361 (8.9)	268 (6.3)	234 (5.5)
Asthma symptoms, last 12 mon	122 (3.0)	121 (2.8)	239 (5.6)
Atopic dermatitis symptoms, last 12 mon	511 (12.7)	588 (13.8)	466 (10.9)
Allergic conjunctivitis symptoms, last 12 mon	580 (14.4)	741 (17.4)	570 (13.4)

Values are presented as number (%) or mean ± standard deviation.
*Antibiotic use during infancy; †Maternal smoke history during pregnancy or in the first year of age; ‡Pet ownership during pregnancy or in the first year of age.

https://doi.org/10.4168/aair.2025.17.6.754

2. Parental and perinatal factors: parental history of allergic diseases, maternal education level, delivery mode, gestational age, birth weight
3. Early-life exposures: history of bronchiolitis, antibiotic use during infancy, maternal smoking, and pet ownership during pregnancy or in the child's first year of life
4. Comorbid allergic diseases: asthma, AD, allergic conjunctivitis
5. Indicators of AR prevalence:
   - Has your child ever had a problem with sneezing, a runny, or blocked nose when he/she did not have a cold or flu (rhinitis symptoms, ever)?
   - During the last 12 months, has your child had this nose problem when he/she did not have a cold or flu (rhinitis symptoms, last 12 months)?
   - Has your child ever been diagnosed with AR by a doctor (AR diagnosis, ever)?
   - Has your child been treated for AR during the last 12 months (AR treatment, last 12 months)?

Statistical analysis

Trends in AR prevalence were analyzed using trend tests. Logistic regression analysis was performed to identify risk factors for AR symptoms during the last 12 months, adjusting for potential confounding factors including sex, family history of allergic diseases, mode of delivery, gestational age, birth weight, antibiotic use during infancy, maternal smoking history, pet ownership during pregnancy or in the child's first year of life, and comorbid allergic diseases, such as AD. The SURVEYLOGISTIC procedure was used for analysis, and all statistical analyses were performed using SAS version 9.4 (SAS Institute, Cary, NC, USA). A P value < 0.05 was considered statistically significant.

RESULTS

Characteristics of the study population

The proportion of male participants was 50.4% (n = 2,037) among children aged 6–7 years, 49.9% (n = 2,120) among children aged 9–10 years, and 50.2% (n = 2,143) among those aged 12–13 years (**Table 1**). A parental history of allergic diseases was reported in 62.1% (n = 2,506), 57.8% (n = 2,496), and 51.7% (n = 2,205) of children in each respective age group.

Prevalence of AR

The prevalence of AR in the study population in the 2022 survey is presented in **Fig. 1**. "Rhinitis symptoms, ever" were reported by 50.4% of children aged 6–7 years, 53.3% of those aged 9–10 years, and 56.1% of those aged 12–13 years (P < 0.001). "Rhinitis symptoms, last 12 months" were reported by 45.2% of children aged 6–7 years, 48.2% of those 9–10 years, and 47.8% of those aged 12–13 years, respectively (P = 0.014). "AR diagnosis, ever" was reported by 45.4% of children aged 6–7 years, 47.9% of those aged 9–10 years, and 32.6% of those aged 12-13 years (P < 0.001). Similarly, "AR treatment, last 12 months" was reported by 35.5% of children aged 6–7 years, 35.1% of those aged 9–10 years, and 18.0% of those aged 12–13 years, respectively (P < 0.001).

Regional differences in AR symptoms during the last 12 months varied by age group. Sejong-si and Jeollabuk-do reported the highest prevalence among children aged 6–7 years, whereas Gyeongsangbuk-do had the lowest prevalence (**Fig. 1B**). Among children aged 9–10 years, Daejoen-si reported the highest prevalence, and Chungcheongbuk-do the lowest (**Fig. 1C**). For children aged 12–13 years, Chungcheongnam-do reported the highest prevalence, whereas

https://doi.org/10.4168/aair.2025.17.6.754

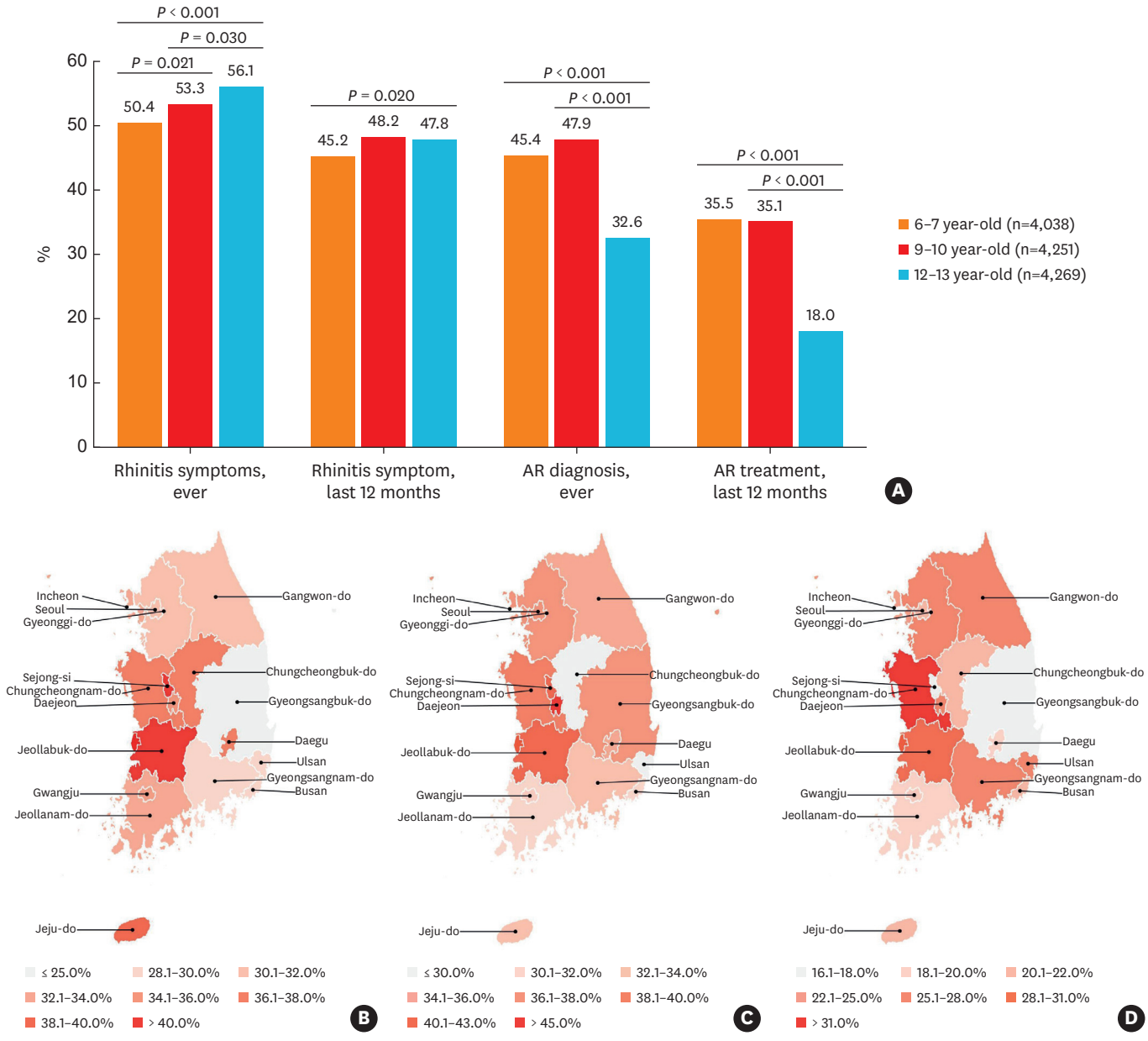

Fig. 1. Prevalence of AR in 2022 (A) and choropleth map showing AR symptoms in the past 12 months among children aged 6–7 years (B), 9–10 years (C), and 12–13 years (D).
AR, allergic rhinitis.

Sejong-si and Gyeongsangbuk-do had the lowest (**Fig. 1D**). Overall, the western region of central Korea tended to have higher prevalence rates, whereas the eastern region showed lower rates.

Fig. 2 depicts the trends in AR prevalence over time based on nationwide epidemiological studies from 1995 to 2022. All rhinitis phenotypes showed an increasing trend in children aged 6–7 years and 12–13 years. The prevalence of "rhinitis symptoms, ever" increased from 34.7% in 1995 to 30.6% in 2000, 46.5% in 2010, and 50.4% in 2022 ($P < 0.001$ for trend) in children aged 6–7 years. Over the same period, the prevalence rose from 35.1% to 56.1% in

https://doi.org/10.4168/aair.2025.17.6.754

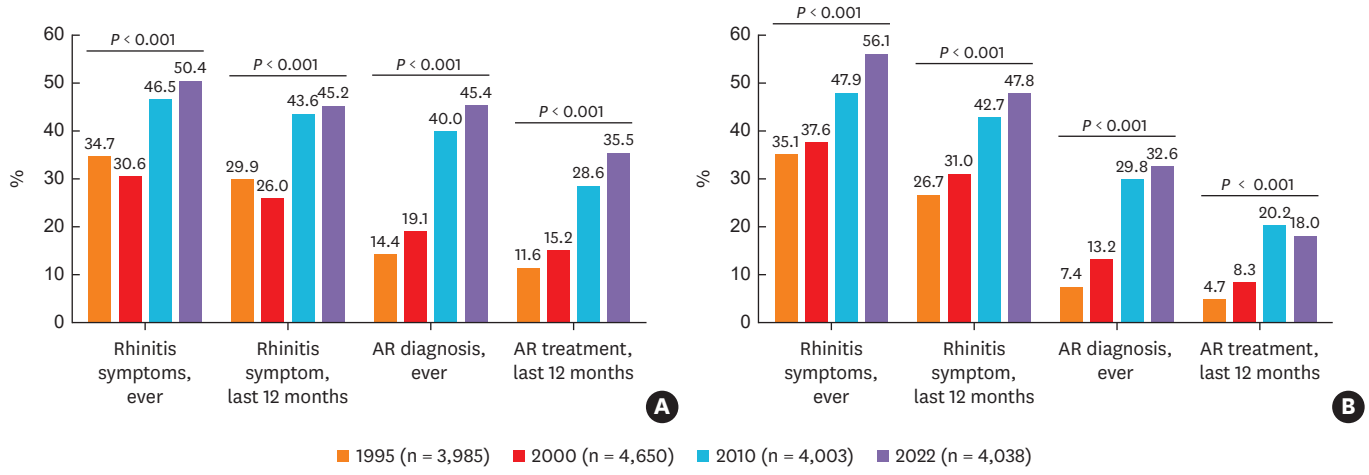

Fig. 2. Temporal trend of the prevalence of AR in children aged 6–7 years (A) and 12–13 years (B) from 1995 to 2022.
AR, allergic rhinitis.

children aged 12–13 years ($P < 0.001$ for trend). The prevalence of "rhinitis symptoms, last 12 months" also increased from 29.9% in 1995, 26.0% in 2000, 43.6% in 2010, and 45.2% in 2022 in children aged 6–7 years ($P < 0.001$ for trend), and from 26.7% to 47.8% in children aged 12–13 years ($P < 0.001$ for trend). "AR diagnosis, ever" showed a marked increase, rising from 14.4% in 1995 to 19.1% in 2000, 40.0% in 2010, and 45.4% in 2022 in children aged 6–7 years ($P < 0.001$ for trend), and from 7.4% to 32.6% in children aged 12–13 years ($P < 0.001$ for trend). Similarly, the prevalence of "AR treatment, last 12 months" increased from 11.6% in 1995 to 15.2% in 2000, 28.6% in 2010, and 35.5% in 2022 in children aged 6–7 years, and from 4.7% to 18.0% in children aged 12–13 years ($P < 0.001$ for trend).

Rhinitis phenotypes in children aged 12–13 years also showed an upward trend over time: the prevalence of "rhinitis symptom, ever" was 35.1% in 1995, 37.6% in 2000, 47.9% in 2010, and 56.1% in 2022 ($P < 0.001$); the prevalence of "rhinitis symptoms, last 12 months" was 26.7% in 1995, 31.0% in 2000, 42.7% in 2010, and 47.8% in 2022 ($P < 0.001$); the prevalence of "AR diagnosis, ever" was 7.4% in 1995, 13.2% in 2000, 29.8% in 2010, and 32.6% in 2022 ($P < 0.001$); and the prevalence of "AR treatment, last 12 months" was 4.7% in 1995, 8.3% in 2000, 20.2% in 2010, and 18.0% in 2022 ($P < 0.001$; **Fig. 2B**).

Risk factors for AR symptoms during the last 12 months

Risk factors associated with AR symptoms during the last 12 months are presented in **Table 2**. In children aged 6–7 years, male sex, parental history of allergic diseases, antibiotic use during infancy, and AD diagnosis were consistently associated with "rhinitis symptoms, last 12 months" in both the 2010 and 2022 surveys. Among children aged 12–13 years, male sex, parental history of allergic diseases, and AD diagnosis were significant risk factors in the 2010 survey. However, in the 2022 survey, female sex, parental history of allergic diseases, and AD diagnosis were identified as significant factors. In the 2022 survey, parental history of allergic diseases, antibiotic use during infancy, pet ownership during pregnancy or in the first year of life, and AD diagnosis were identified as significant risk factors in children aged 9–10 years (**Supplementary Table S1**).

https://doi.org/10.4168/aair.2025.17.6.754

Table 2. Comparing risk factors for allergic rhinitis symptoms during the last 12 months in children aged 6–7 years and 12–13 years in 2010 and 2022

Variables	6–7 yr				12–13 yr			
	2010		2022		2010		2022	
	aOR (95% CI)	*P* value	aOR (95% CI)	*P* value	aOR (95% CI)	*P* value	aOR (95% CI)	*P* value
Sex (M:F)	0.71 (0.58–0.88)	0.001	0.68 (0.50–0.93)	0.015	0.75 (0.62–0.90)	0.002	1.29 (1.01–1.66)	0.043
BMI (kg/m^2)	0.99 (0.95–1.04)	0.713	1.00 (0.95–1.06)	0.894	0.99 (0.97–1.03)	0.797	1.03 (0.99–1.06)	0.101
Parental history*	2.70 (2.19–3.32)	< 0.001	2.77 (1.99–3.86)	< 0.001	2.36 (1.95–2.86)	< 0.001	2.11 (1.65–2.70)	< 0.001
Mode of delivery	0.82 (0.64–1.03)	0.089	1.17 (0.86–1.60)	0.318	1.10 (0.90–1.35)	0.348	0.99 (0.76–1.28)	0.973
Gestational age	1.08 (0.85–1.38)	0.536	0.66 (0.44–0.99)	0.047	0.93 (0.77–1.12)	0.458	1.15 (0.83–1.58)	0.399
Birth weight	1.10 (0.94–1.28)	0.232	1.07 (0.86–1.32)	0.572	0.93 (0.82–1.06)	0.270	1.06 (0.89–1.26)	0.517
Antibiotic use†	0.63 (0.51–0.78)	< 0.001	1.41 (1.04–1.92)	0.029	1.00 (0.81–1.25)	0.972	1.18 (0.90–1.54)	0.237
Maternal smoke‡	0.36 (0.10–1.37)	0.135	0.68 (0.20–2.32)	0.535	0.36 (0.12–1.09)	0.070	1.06 (0.39–2.84)	0.915
Pet ownership§	1.08 (0.69–1.68)	0.738	1.30 (0.96–1.77)	0.088	0.77 (0.50–1.19)	0.243	1.25 (0.92–1.70)	0.154
AD, diagnosis	1.65 (1.33–2.05)	< 0.001	1.90 (1.20–3.02)	0.006	1.62 (1.31–2.01)	< 0.001	2.41 (1.75–3.32)	< 0.001

aOR, adjusted odds ratio; CI, confidence interval; BMI, body mass index; AD, atopic dermatitis.
*Parental history of allergic diseases, †antibiotic use during infancy, ‡maternal smoking history during pregnancy or in the first year of age, §pet ownership during pregnancy or in the first year of age.

DISCUSSION

This study provides an updated, nationwide assessment of AR prevalence among Korean children in 2022 and examines long-term trends from 1995 to 2022. Nationwide monitoring of pediatric allergic diseases in Korea began in 1995. This study aimed to assess current prevalence patterns and to identify the risk factors associated with AR development by integrating data from previous studies.[8] Our findings revealed that the prevalence of AR symptoms during the last 12 months reached 45.2%, 48.2%, and 47.8% in children aged 6–7, 9–10, and 12–13 years, respectively. Notably, compared with previous epidemiological studies, the prevalence of AR has shown a clear increasing trend over time. The prevalence of "AR diagnosis, ever" and "AR treatment, last 12 months" followed a similar upward trajectory.

This upward trend of AR prevalence is consistent with that of previous research, highlighting the rising burden of allergic diseases worldwide.[6,13] The recently observed plateau and decline in AR prevalence rates in Europe and North America, where prevalence has historically been high, are potentially due to improved allergen control and medical care,[14,15] urbanization and environmental changes (*e.g.,* air pollution and climate change),[16,17] as well as lifestyle modifications, such as a westernized diet and reduced microbial exposure due to more frequent indoor living.[18] The hygiene hypothesis, which proposes that reduced microbial exposure in early life leads to allergic sensitization, also offers a compelling explanation.[19,20]

In contrast, the prevalence of AR continues to rise in many Asian countries, including Korea, which is consistent with our findings.[14,21] Regions characterized by high levels of air pollution and urban density tend to exhibit higher AR prevalence, highlighting the importance of environmental factors. The prevalence of asthma and AD in Korea initially increased before showing signs of decline, whereas AR has continued to exhibit an upward trend. Parallel studies have reported decreasing asthma prevalence and mixed trends in AD prevalence, with a decline in younger children and an increase among adolescents.[22,23] Despite these changes, AR prevalence remains persistently high, underscoring the need for a better understanding of the drivers of this ongoing increase. Longitudinal studies incorporating genetic predispositions and environmental exposures are essential for unraveling the complex etiology of AR in Korea.

Our findings indicate age-dependent sex differences in AR prevalence. In a 2010 survey, male participants demonstrated a higher risk of AR among younger children and adolescents

https://doi.org/10.4168/aair.2025.17.6.754

(12–13 years). Conversely, in 2022, female sex emerged as a significant risk factor for AR in adolescents. A similar sex shift has been well-documented in asthma, where boys exhibit higher prevalence in early childhood, whereas post-pubertal girls exhibit greater prevalence and disease severity.[24] This pattern has been less clearly established for AR. However, a systematic review and meta-analysis have reported sex-related shifts around puberty in Western populations, suggesting hormonal and immunological influences.[25] Such a shift has not been previously observed in Asia[26]; however, Korea's ongoing lifestyle changes and increasing urbanization may be contributing factors. Future studies should explore whether these environmental and lifestyle shifts are influencing sex-specific AR patterns. Underlying mechanisms such as hormonal influences, immune modulation, and environmental exposures should also be investigated. Continued epidemiological monitoring will be critical for confirming these trends.

Genetic predisposition remains a key factor in AR development. Consistent with prior research, our study confirmed that parental history of allergic diseases was a significant risk factor for AR across all age groups, with odds ratios ranging from 2.19 to 2.88.[26-28] This finding highlights the strong hereditary component of AR and underscores the importance of early identification and monitoring of high-risk children for timely interventions and preventive strategies.

Notably, AD diagnosis emerged as a significant risk factor for AR in this study, an observation that deserves particular attention. Considering the concept of the "allergic march," which describes the typical progression of allergic diseases from eczema in infancy to AR and asthma later in life,[29] AD was incorporated into the risk model for this analysis. This revealed a meaningful association between AD and AR, suggesting that children with AD may be predisposed to subsequent development of AR. This supports the allergic march hypothesis and emphasizes the need for early dermatological and allergy-focused interventions to potentially interrupt the progression to respiratory allergic diseases.

Antibiotic use during infancy was identified as a significant risk factor for AR, particularly in children aged 6-7 years. This finding is consistent with the well-established hygiene hypothesis, which suggests that reduced microbial exposure in early childhood influences immune system development by shifting the T helper (Th)1/Th2 balance toward Th2 dominance, thereby increasing susceptibility to allergic diseases.[30] Our results support this concept, highlighting the role of early-life exposures in AR pathogenesis.[31] Antibiotics may disrupt the gut microbiota, leading to diminished immune regulation and heightened risk of allergic diseases.[32,33] Disruptions in beneficial gut bacteria such as *Bifidobacterium* and *Lactobacillus* may impair immune tolerance and promote allergic responses. These findings emphasize the importance of cautious antibiotic use in infancy to preserve microbial balance and highlight the broader need for preventive strategies against early-life respiratory infections. This study provides valuable epidemiological insights into the early-life risk factors for AR and contributes to our understanding of allergic disease prevention and management strategies.

Other perinatal and environmental factors, including delivery mode, birth weight, prematurity, tobacco smoke exposure, and pet ownership, have previously been proposed as potential risk factors for allergic diseases.[34,35] However, our study did not identify significant associations between these factors and AR in Korean children. These findings are consistent with a prior study from Taipei that was conducted in 2007 among first-grade elementary

school students. The study also reported no significant associations between these variables and AR prevalence.[36]

As this survey was conducted during the coronavirus disease 19 (COVID-19) pandemic, the potential influence of the COVID-19 pandemic-related behaviors on AR prevalence warrants consideration. Although social distancing, mask-wearing, and reduced outdoor activities during the pandemic may have temporarily limited respiratory infection and allergen exposure, AR prevalence continued to rise. This suggests that short-term behavioral changes were insufficient to counteract the ongoing upward trend in AR. Continued surveillance is required to assess whether future birth cohorts experience different patterns in AR prevalence in the post-pandemic era.

This study offers several strengths, including its large, nationally representative sample and the longitudinal comparison of AR prevalence trends from 1995 to 2022. Our comprehensive risk factor analysis identified both modifiable and non-modifiable contributors to AR development and revealed changes in risk profiles over time.

This study has some limitations. The reliance on self-reported questionnaire data may introduce recall bias and the potential misclassification of AR status. The absence of objective diagnostic methods, such as skin prick testing or measurement of serum immunoglobulin E levels, limits the clinical accuracy of AR diagnosis in this study. Additionally, environmental exposure data, such as air pollution levels and indoor allergen concentrations, were not directly measured in this study.

In conclusion, this study highlights the ongoing increase in the prevalence of all AR phenotypes among Korean children from 1995 to 2022 and underscores the importance of identifying modifiable risk factors to inform prevention and management strategies. Continuous surveillance and targeted interventions are essential for mitigating the burden of AR and improving the quality of life for affected children.

ACKNOWLEDGMENTS

This work was supported by the Research Program funded by the Korea Centers for Disease Control and Prevention (2021-11-034).

SUPPLEMENTARY MATERIAL

Supplementary Table S1

Risk factors for allergic rhinitis symptoms in the past 12 months in children aged 9–10 years in 2022

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