

Current Review



Time trends of the prevalence of allergic diseases in Korea: A systematic literature review

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ABSTRACT

The prevalence of allergic diseases has increased dramatically in recent decades, and are now considered major chronic diseases at the global level. The increasing burden of allergic diseases has led to numerous worldwide and local researchers to investigate the time trends in its prevalence and identify its driving factors. Environmental changes such as urbanization and industrialization have been suggested to explain the increasing prevalence, but recent reports from Western countries suggest that this prevalence has reached a plateau or even possibly, started to decrease. However, such environmental changes are still occurring in many Asia-Pacific countries, including Korea, and it is speculated that the peak in allergy epidemics has yet to come. The present systematic literature review aimed to explore the time trends in the prevalence of allergic diseases in Korea and to identify the unmet needs for facilitating further studies.

Keywords: Allergic diseases; Epidemiology; Prevalence; Incidence; Trends; Korea

INTRODUCTION

The global prevalence of allergic diseases increased dramatically in recent decades such that they are now considered major chronic diseases worldwide [1]. These increases were significantly related to environmental changes such as industrialization, improved hygiene, and urbanization in many parts of the world including the Asia-Pacific region; thus, supporting the “hygiene hypothesis” in the epidemiology of allergic diseases globally [2, 3]. It is now estimated that approximately 1 in 5 people suffer from some form of allergic disease such as allergic rhinitis, asthma, atopic dermatitis, or food allergy [4]. Meanwhile, recent reports from Western countries have suggested a possible downward trend in the prevalence of allergic diseases [5]. However, urbanization and the loss of rural environments are still on the rise in developing countries have led to the speculation that the peak in allergy epidemics has yet to come in these areas, including Asia [2].

Likewise, the burden of allergic diseases has been increasingly recognized in Korea. Accumulated evidence suggests that the prevalence and socioeconomic burden of allergic

Author Contributions

Conceptualization: Sung-Yoon Kang, Woo-Jung Song, Yoon-Seok Chang, Sang-Heon Cho. Data curation: Sung-Yoon Kang, Woo-Jung Song. Formal analysis: Sung-Yoon Kang. Funding acquisition: Yoon-Seok Chang, Sang-Heon Cho. Investigation: Sung-Yoon Kang, Woo-Jung Song. Project administration: Yoon-Seok Chang. Resources: Yoon-Seok Chang. Supervision: Sang-Heon Cho, Yoon-Seok Chang. Validation: Sung-Yoon Kang, Yoon-Seok Chang. Writing - original draft: Sung-Yoon Kang, Woo-Jung Song. Writing - review & editing: Sung-Yoon Kang, Woo-Jung Song, Yoon-Seok Chang.

diseases are considerable [6]. Following the publishing of earlier studies in the 1980 and 1990s [7, 8], there have been many epidemiologic studies that have increased in their inclusion of the Korean population [9]. In this review, we aimed to explore the time trends in the prevalence of allergic diseases in Korea, and to identify the unmet needs for facilitating further studies.

METHODS**Literature search**

A literature search was performed using PubMed, Scopus, Embase, Web of Science, the Cochrane Library, Google Scholar, and other citation sources (KoreaMed, KISS, and DBpia) over the time line that spans the inception of data collection records on each database to June 2016 using text keywords and MeSH (medical subject headings). The keywords were as follows: asthma, rhinitis, atopic dermatitis, anaphylaxis, drug hypersensitivity, food allergy, urticaria, angioedema, cough, prevalence, incidence, epidemiology, and Korea. We also conducted a manual search within the stated timeline using Google scholar. The search strategies and keywords used are presented in the **Supplementary Table 1**.

Study selection, data extraction, and presentation

The compliance of the individual studies selection with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) statement guidelines was present in this review [10]. Inclusion criteria were (1) studies reporting the prevalence or incidence of any allergic diseases, and (2) those conducted in the Korean general population (either nationwide or local area surveys). Exclusion criteria included (1) hospital- or clinic-based population surveys and (2) hospital administrative data analyses without sufficient information of prevalence or diagnostic criteria. Abstracts for conferences, unpublished dissertations and theses, case reports, case series, letters to editors, commentaries, review articles, laboratory studies, and any other irrelevant studies were excluded. The publication language was restricted to either English or Korean.

The initial search yielded 3,346 papers from the core databases (PubMed, Scopus, Embase, Web of Science, and Cochrane Library). After removing 2,522 duplicates, we screened the titles and abstracts of the remaining 824 articles. A total of 115 articles were selected for full paper review, of which 58 articles were found to meet the inclusion guidelines. In addition, a further 34 eligible articles were identified from Google Scholar and other citation sources (KoreaMed, KISS, and DBpia). Following these criteria, a total of 92 studies were included in our final review. The details of the search process are presented in **Fig. 1**.

We extracted the following data from each study based on first author, year of publication, language of publication, subject characteristics (study region, sex, age, and sample size), study methods (time of survey, type of survey, and disease definition), and reported prevalence. In the case of insufficient or missing data, we attempted to collect data by identifying and extracting figures, tables and the relevant data within each study. The studies were classified by disease, study type (primary survey vs. secondary analysis of healthcare database), and age group (children vs. adult). The age group covering children was further divided into 2 subgroups: childhood (ages 0–12 years old) and adolescence (ages 13–18 years old). Time trends in the prevalence of each allergic disease were presented by survey year (**Supplementary Tables 2, 3**).

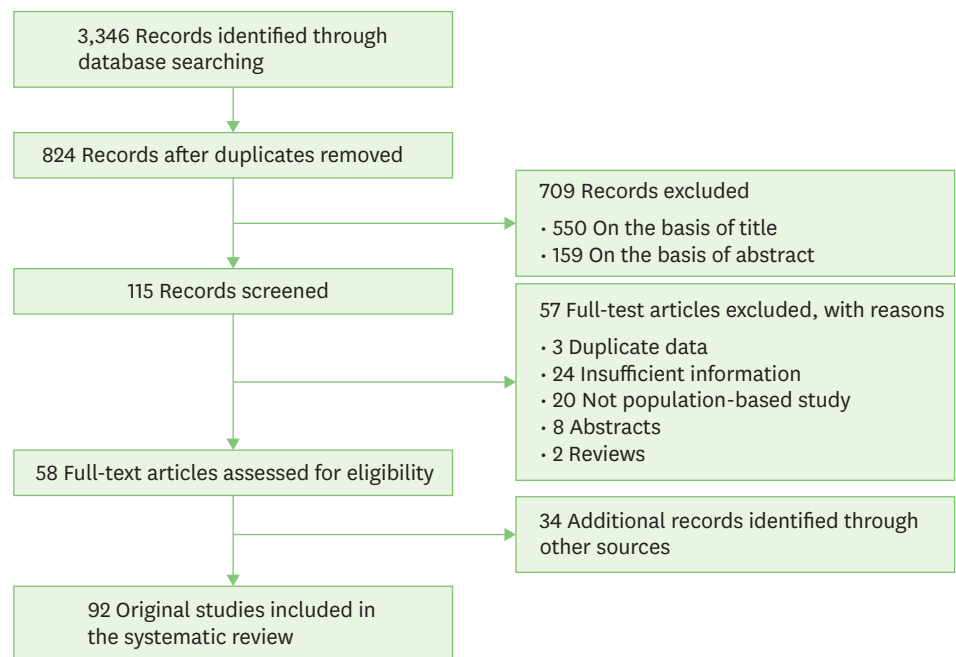


Fig. 1. Flow chart of study selection

OVERVIEW OF PREVALENCE STUDIES

The characteristics of the 92 included studies are shown in Table 1 [7, 8, 11-100]. Overall, the disease triad, so-called allergic triad, with the most common research interest included asthma, allergic rhinitis, and atopic dermatitis. Asthma was the most common constituent (28.1%), followed by atopic dermatitis (26.5%), allergic rhinitis (24.5%), food allergy (9.2%), allergic conjunctivitis (5.6%), drug allergy (4.1%), chronic cough (1.0%), and urticaria (1.0%) (Fig. 2). The selected studies included a total of 74% conducted on children, 13% on adults, and 13% in an all-age (entire age) population. The majority of the studies (53%) used modified or a Korean-translated version of the International Study of Asthma and Allergies in Childhood (ISAAC) questionnaires to assess prevalence. This was followed by other structured questionnaires or methacholine challenge tests (34%), health insurance databases (9%), and physical examinations only (4%). Due to the substantial heterogeneities present in study location, design and methodology, pooled analyses were not performed.

Prevalence trends of asthma

Time trends in asthma prevalence reported in primary surveys were presented in Fig. 3A. The majority of studies were conducted in children. The prevalence of physician-diagnosed asthma showed a slight, decreasing trend in childhood studies. The prevalence of current asthma symptoms in childhood and adolescence appears to have decreased slightly or remain stationary between 1995 and 2013; however, the rate of ever asthma diagnosis continued to increase particularly among adolescents. In adults, the limited number of studies demonstrated that the prevalence of ever diagnosis is less than 10% but showed trends to slightly increase (range, 1.9%–6.8%) during the 2000s. Of note, unlike in children, the prevalence of ever diagnosis (0.7%–6.8%) was much less than that of current asthma symptoms (6.3%–32.2%), where the possibility of underdiagnosis of asthma may be postulated in Korean adults. Meanwhile, 6 studies were identified as secondary analyses using the Korean National Health Insurance (NHI) database to examine the prevalence of

Time trends of allergic diseases in Korea

Table 1. Studies reporting on the prevalence of allergic diseases in Korea

Study	Published year	Place of data collection	Year of data collection	Sample size (total)	Age group (yr) [†]	Outcome measurements	Allergic diseases types
Kim [11]	1979	Incheon	1978	516	< 6	PEX	AD
Shin [7]	1990	Seoul	1989	4,139	6–13	Questionnaires	AS, AR, AC, AD, FA, DA, urticaria
Ahn [12]	1990	Seoul	1988	661	Elementary school students	Questionnaires + SPT	AS, AR, AD, AC, FA, DA
Lee [13]	1995	Bucheon	1993	925	5–6	PEX	AD
Lee [14]	1995	Bucheon	1992	4,018	6–7	PEX	AD
Min [15]	1997	Nationwide	1991	9,069	≥0	Questionnaires + PEX	Perennial allergic rhinitis
Kim [8]	1997	Seoul, Chungju	1996	3,219	7–19	Questionnaires + SPT, MBPT	AS
Lee [16]	1998	Nationwide	1994–1995	13,160	Elementary/middle/high school students	Questionnaires + SPT	AS, AR, AD, urticaria
Min [17]	1999	Jeju	1998	1,236	7–16/18–87	ISAAC + SPT	AR
Kim [18]	1999	Jeju	1998	4,132	7–9/10–12	Modified ISAAC + SPT	AS, rhinitis
Kim [19]	2000	Seoul, Ulsan, Chuncheon	1994–1995	6,070	6–8/10–12/16–18	Questionnaires + PEX	AD
Lee [20]	2001	Seoul, Suwon, Chungju, Chunju, Changwon, Chunchon, Cheju, Ulsan, Ansan	1995	38,955	6–12/12–15	Modified ISAAC	AS, AR, AC, AD, FA, DA
Lee [21]	2001	Jeju	1998	7,053	7–15	Modified ISAAC + SPT	AR
Kim [22]	2001	Jeju	1998	3,009	13–15	Modified ISAAC + SPT	AS, rhinitis, conjunctivitis
Lee [23]	2001	Jeju	1997, 2000	299	7–12	Modified ISAAC + SPT, MBPT	AS
Kim [24]	2001	Seoul	1999	718	16–70	Modified ISAAC + SPT, MBPT	AS
Lee [25]	2002	Jeju	1997, 2000	1,027/755 (97/00)	7–15	Modified ISAAC + SPT, MBPT	AS
Kim [26]	2002	Jeju	1998	1,727	16–18	ISAAC + SPT	AS, AR, AD
Kim [27]	2002	Seoul, Cheonan, Incheon, Goisan	2001	2,432	≥20	Modified ISAAC + SPT, MBPT	AS
Oh [28]	2003	Seoul, Suwon, Chungju, Chunju, Changwon, Chunchon, Cheju, Ulsan, Ansan: school age	1995, 2000 (school age)	40,429/42,202, school age (95/00)	6–12/12–15 (school age)	Modified ISAAC	AD
		Seoul, Ansan, Siheung, Gimje, Namwon, Iksan, Jeongeup, Wanju: preschool age	2003 (preschool age)	1,511, preschool age	5 (preschool)		
Hong [29]	2004	Seoul, Suwon, Chungju, Chunju, Changwon, Chunchon, Cheju, Ulsan, Ansan	1995, 2000	14,946/15,214 (95/00)	12–15	Modified ISAAC	AS
Oh [30]	2004	Seoul, Suwon, Chungju, Chunju, Changwon, Chunchon, Cheju, Ulsan, Ansan	1995, 2000	38,955/42,081 (95/00)	6–12/12–15	Modified ISAAC	AD, FA
Shin [31]	2004	Ansan, Ansung	2001	8,140	40–69	Questionnaires	Chronic cough
Nam [32]	2005	Seoul	2004	593	4.8	Questionnaires	AS, AR, AD
Kim [33]	2007	Guri, Namyangju, Chuncheon	2004	2,365	9–11	Questionnaires	AS
Kim [34]	2007	Seoul, Kangneng, Ulsan	2006	1,492	High school students	Modified ISAAC + MBPT	AS, AR, AD
Son [35]	2007	Ilsan	2005	2,535	Elementary school students	Modified ISAAC + SPT	AS, AR, AC, AD, FA, DA
Yoo [36]	2007	Seoul	2006	537	University freshmen	Questionnaires	AS, AR, AD
Lee [37]	2008	1 City, anonymous	2007	8,347	4–8/6–13	Modified ISAAC	AS
Lee [38]	2008	1 City, anonymous	2007	8,347	4–8/6–13	Modified ISAAC	AD
Lee [39]	2008	Nationwide	1995, 2000	15,894/15,481 (95/00)	6–7/13–14	ISAAC	AS
Hong [40]	2008	Seoul, Suwon, Chungju, Chunju, Changwon, Chunchon, Cheju, Ulsan, Ansan	1995, 2000	40,063/43,045 (95/00)	6–12/12–15	Modified ISAAC	AS, AR, AC, AD, FA

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Time trends of allergic diseases in Korea

Table 1. (Continued) Studies reporting on the prevalence of allergic diseases in Korea

Study	Published year	Place of data collection	Year of data collection	Sample size (total)	Age group (yr) [†]	Outcome measurements	Allergic diseases types
Nam [41]	2009	Yanggu	2008	172	0–15	Modified ISAAC + SPT	AD, FA
Bae [42]	2009	Jeju	2008	4,605	Elementary/middle/high school students	Questionnaires	AD
Jee [43]	2009	Seoul, Gyeonggi-do, Gangwon-do, Chungcheongbuk-do, Chungcheongnam-do, Jeollabuk-do, Jeollanam-do, Gyeongsangbuk-do, Gyeongsangnam-do, Jeju-do, Busan, Daegu, Incheon, Gwangju, Daejeon, Ulsan	2006	37,365	6–13	ISAAC	AS, AR, AD
Lee [44]	2009	Incheon	2007	2,523	3–6	Questionnaires + PEx	AD
Kim [45]	2010	Nationwide	2007	Korean population*	≥ 0	National Health Insurance data	AR
Kim [46]	2010	Nationwide	2004	Korean population*	≥ 0	National Health Insurance data	AS
Kim [47]	2010	Daegu	2009	733	3–6	Questionnaires + PEx	AD
Lee [48]	2011	Nationwide (KNHANES)	2005	8,631	0–18	Questionnaires	AS, AR, AD
Kim [49]	2011	Seoul	2010	1,020	Elementary school students	Questionnaires + SPT	FA
Kim [50]	2011	Seoul	2009	917	2–7	Modified ISAAC	AS, AR, AD
Kwon [51]	2011	Seoul	2008	4,554	9.5	Modified ISAAC	AS
Suh [52]	2011	Nationwide	2006	30,893	8–11	Modified ISAAC	AS, AR, AC, AD, FA
Ahn [53]	2011	Nationwide	2010	8,035	6–7/13–14	ISAAC	AS, AR, AD
Lee [54]	2011	Incheon, Gwangju, Busan, Ulsan	2008–2009	2,729	7–11	Modified ISAAC + PEx	AD
Jung [55]	2011	Seoul, Gwacheon, Ilsan	2010	919	1.5–8	Modified ISAAC + SPT	FA
Yoon [56]	2011	Ulsan	2010	1,323	6–11	ISAAC + SPT	AS, AR, AC, AD
Kwon [57]	2011	Seoul	2008	1,376	9.4	Modified ISAAC + SPT	AR
Yu [58]	2012	Nationwide	2003–2008	Korean population*	≥ 0	National Health Insurance data	AD
Seong [59]	2012	Nationwide	2005, 2008	Korean population*	≥ 0	National Health Insurance data	AS, AR, AD
Hong [60]	2012	Seoul	2010	31,201	0–13	ISAAC	AS, AR, AD
Lee [61]	2012	Jeju	2008	25,024	0–18	ISAAC	AS, AR, AC, AD, FA, DA
Ahn [62]	2012	Nationwide	2010	7,882	6–7/12–13	Questionnaires + SPT, sIgE	FA
Choi [63]	2012	Seoul	2008	6,453	0–6	Modified ISAAC + PEx	AD
Hwang [64]	2012	Seoul, Andong	2009	1,819	6–13	Modified ISAAC	AS
Lee [65]	2012	Ulsan	2009–2010	4,607	7–12	Modified ISAAC	AS, AR, AD
Myong [66]	2012	Nationwide (KNHANES)	1998, 2001, 2005, 2007–2009	17,311 (07–09)	≥ 19	Questionnaires	AR
Kim [67]	2012	Jeju	2009	4,028	6–12	PEx	AD
Oak [68]	2012	Nationwide (KYRBS)	2010	37,570	Middle school students	Questionnaires	AD
Lee [69]	2012	Seoul, Jeongeup	2008	1,749	9–12	Modified ISAAC + SPT	AS, AR, AD
Lee [70]	2012	Jeju	2008	5,249	0–6	Modified ISAAC	AS, AR, AD
Lee [71]	2012	Jeju	2008	4,098	15–18	Questionnaires	AS, AR, AD
Song [72]	2012	Seongnam	2005–2006	994	≥65	Modified ISAAC + SPT	AS
Kim [73]	2013	Nationwide	2007	Korean population*	≥0	National Health Insurance data	AS
Kim [74]	2013	Nationwide	2006–2010	Korean population*	≥18	National Health Insurance data	AS
Kim [75]	2013	Seongnam	2009	615	3–6	Modified ISAAC	AS, AR, AC, AD, FA, DA
Lee [76]	2013	Jeju	2012	925	1–94	ISAAC	AS, AR, AC, AD, FA, DA

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Table 1. (Continued) Studies reporting on the prevalence of allergic diseases in Korea

Study	Published year	Place of data collection	Year of data collection	Sample size (total)	Age group (yr) [†]	Outcome measurements	Allergic diseases types
Baek [77]	2013	Seoul	2009	8,750	0–6/7–12	ISAAC	AS, AR, AC, AD, FA, DA
Kim [78]	2013	Nationwide (KNHANES)	1998, 2008	12,126	20–59	Questionnaires	AS
Lee [79]	2013	Nationwide	2012	27,679	Elementary/ middle/high school students	Modified ISAAC	FA
Hong [80]	2013	Changwon	2012	2,118	Elementary school students	ISAAC	AD
Song [81]	2013	Seongnam	2005–2006	857	≥65	Questionnaires	Chronic cough
Song [82]	2013	Seongnam	2005–2006	984	≥65	Questionnaires + SPT	AS, rhinitis
Hwang [83]	2013	Incheon, Ulsan, Jeju, Gyeonggi-do, Chungcheongbuk-do	2010–2012	13,492	Elementary/ middle/high school students	ISAAC + SPT	AR
Song [84]	2014	Sancheong, Changwon	2007	1,080	≥30	Questionnaires + SPT, MBPT, sIgE	AS, rhinitis
Cho [85]	2014	Nationwide	2012	1,002	2–6	Questionnaires	AS, AR, AD
Park [86]	2014	Seoul	2011	16,749	0–6	Questionnaires	FA
Rhee [87]	2014	Nationwide (KNHANES)	2010	2,305	≥0	Questionnaires + PEx	AR
Lee [88]	2014	1 City, anonymous	2013	2,415	6–59	Modified ISAAC + SPT	FA
Kim [89]	2014	Nationwide (KNHANES)	2007–2011	19,659	19–64	Questionnaires + PFT	AS
Yoo [90]	2015	Nationwide	2003–2011	Korean population*	≥1	National Health Insurance data	AS, AR, AD
Chang [91]	2015	1 City, anonymous	2013	6,398	Elementary school students	Modified ISAAC	AS, AR, AD
Lee [92]	2015	Jeju	2008, 2013	1,296/878 (08/13)	7–18	ISAAC	AS, AR, AD
Kwon [93]	2015	Gwangju	2013	2,363	5–6 and elementary/ middle/high school students	ISAAC + SPT	AR
Choi [94]	2015	Pohang	2008	1,043	4–69	ISAAC + SPT	AR
Kim [95]	2015	Nationwide	2012–2013	1,820	<19	ISAAC + SPT	AS, AR, AD
Kim [96]	2015	Nationwide (KNHANES)	2010–2012	18,066	≥19	Questionnaires	AS, AD
Kim [97]	2016	Nationwide	2009–2014	Korean population*	≥0	National Health Insurance data	AS, AR, AD
Ahn [98]	2016	Nationwide (KNHANES)	2008–2012	35,511	≥7	Questionnaires + sIgE	AR
Lee [99]	2016	Nationwide (KNHANES)	2008–2011	8,947	1–18	Questionnaires	AD
Han [100]	2016	Nationwide (KYRBS)	2013	72,435	Middle/high school students	Questionnaires	AS, AR, AD

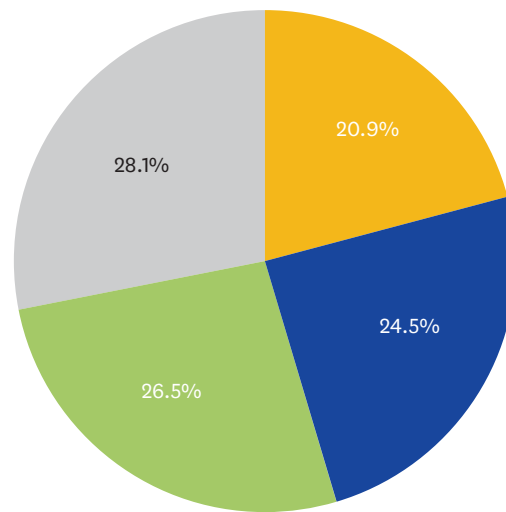
PEx, physical examination; SPT, skin prick test; MBPT, methacholine bronchial provocation test; sIgE, serum specific IgE; PFT, pulmonary function test; ISAAC, the International Study of Asthma and Allergies in Childhood; KNHANES, Korea National Health and Nutrition Examination Survey; KYRBS, Korea Youth Risk Behavior Web-based Survey; AS, asthma; AR, allergic rhinitis; AD, atopic dermatitis; AC, allergic conjunctivitis; FA, food allergy; DA, drug allergy.

*The study, using the Korean National Health Insurance data, involved the entire population of Korea. †These data present the mean age or age range.

asthma in the all-age group during the period of 2003–2014; the prevalence of this group peaked at around 4.9% to 7.6% (variability depending on working definition) and has showed a declining trend since 2010 (Fig. 4A).

Prevalence trends of allergic rhinitis and conjunctivitis

Prevalence trends of allergic rhinitis reported in primary surveys were presented in Fig. 3B. Studies of children, in children-of-any-age subgroups, indicated consistently increasing trends in the prevalence of both current symptoms and physician-diagnosed history of allergic rhinitis. Only 4 studies reported the prevalence of current symptoms and ever diagnosis for allergic rhinitis among adults, thus the time trends could not be explored. Temporal trends in the prevalence of allergic conjunctivitis were generally similar to those of allergic rhinitis (Fig. 3C). Four studies were identified as secondary analyses using the Korean NHI database, and similarly demonstrated increasing patterns of allergic rhinitis prevalence over time, which ranged from 1.3% to 3.1% or 7.8% to 13.3% (Fig. 4B).



■ Asthma ■ Atopic dermatitis ■ Allergic rhinitis ■ Others

Fig. 2. The percentage of articles published on allergic diseases.

Prevalence trends of atopic dermatitis

Primary surveys of children and adolescents demonstrated increasing trends in the prevalence of current symptoms and ever diagnosis history of atopic dermatitis (**Fig. 3D**). Only 2 studies reported the prevalence of atopic dermatitis in adults, but with the presence of wide variability. Four secondary analyses using the Korean NHI database reported a slowly decreasing trend of atopic dermatitis prevalence over time (**Fig. 4C**).

Prevalence trends of food allergy

The prevalence of food allergy was only reported in children, and ranged from 2% to 10% (**Fig. 5A**). Overall, the prevalence appears to either be stationary or to have increased from 1995 to 2013.

Prevalence trends of other allergic diseases; drug allergy, chronic cough, and urticaria

A total of 7 reported studies showed a prevalence of self-reported drug allergy in children, and 1 reported prevalence in both children and adults. Prevalence of current symptoms due to medications ranged from 0.5% to 1.5%. Around 1% of children and adults reported a physician-diagnosed drug allergy (**Fig. 5B**). Two studies reported chronic cough with a prevalence of 3.7% to 4.6% in community-based adult populations. Meanwhile, 2 studies reported the prevalence of urticaria of 4.7% in children in the rural areas and 16.4% in children living in Seoul, Korea.

DISCUSSION OF FINDINGS

This systematic review identified the relevant literature necessary to explore the time trends in the prevalence of allergic diseases in Korean children and adults during recent 3 decades. As pooled analyses of prevalence could not be performed due to heterogeneity, the time trends were presented for overview and exploration. Increasing trends were observed for allergic rhinitis, allergic conjunctivitis, atopic dermatitis, and food allergy in

Time trends of allergic diseases in Korea

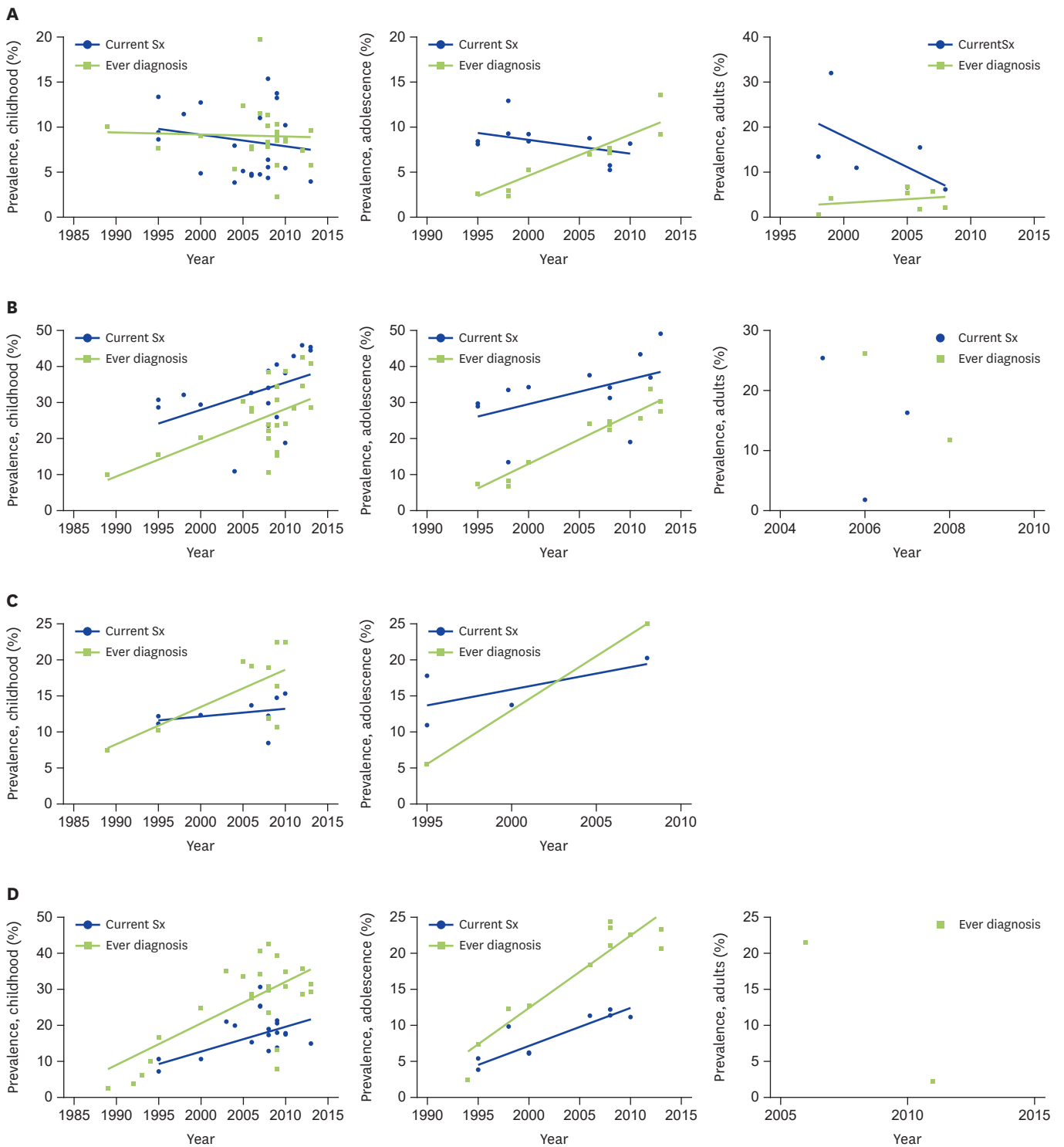


Fig. 3. Trends in the prevalence of allergic diseases by age groups during the study period for asthma (A), allergic rhinitis (B), allergic conjunctivitis (C), and atopic dermatitis (D). Sx, symptoms. Current symptoms defined as prevalence of symptoms of allergic diseases within the last 12 months. Ever diagnosis defined as the lifetime prevalence of any allergic diseases diagnosed by a physician. Data are presented as a scatter plot, with linear trend lines.

Time trends of allergic diseases in Korea

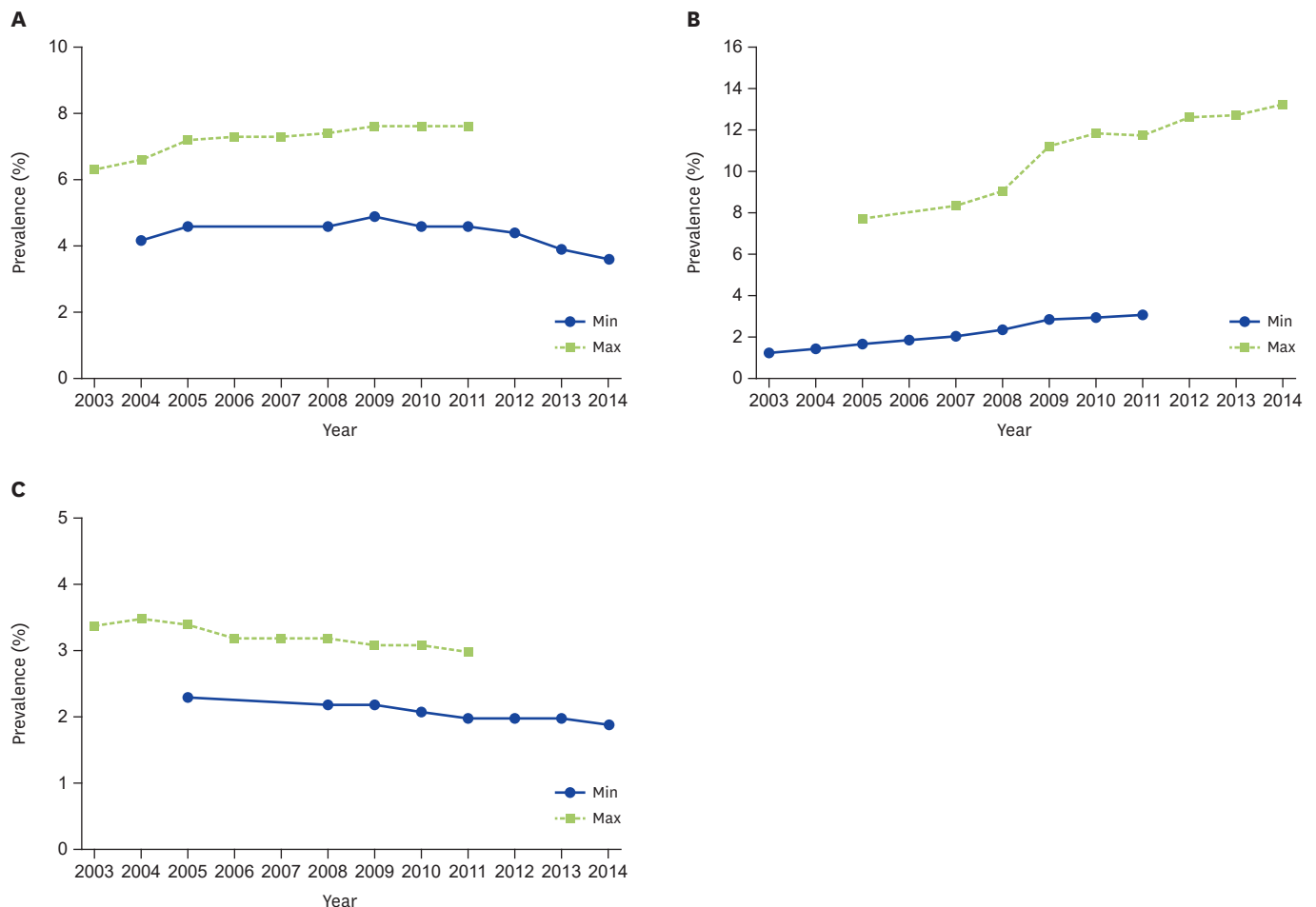


Fig. 4. Changes in the prevalence of asthma (A), allergic rhinitis (B), and atopic dermatitis (C) from the National Health Insurance data in Korea 2003–2014. The study population included the entirety of the Korean population. The dashed line with asterisk corresponds to the maximal (Max) prevalence rate, and the thick line with the closed circle indicates the minimal (Min) prevalence rate.

primary surveys of children and adolescents, suggesting an ongoing epidemic in the young age group. Although asthma did not show consistent patterns between age subgroups, it showed increasing trends of ever diagnosis in adolescents, but not in early childhood. These discrepancies between age subgroups and diseases warrant further longitudinal investigation using standardized protocols.

Meanwhile, in adults, the number of primary studies was generally very limited so that temporal trends in prevalence did not lend itself to being conjectured. Available primary studies on adult asthma indicated the range of prevalence (1.9%–6.8%) during the 2000s, but of note, they demonstrated a larger discrepancy between the prevalence of ever diagnosis history and current asthma symptoms compared to childhood asthma. Several reasons may underlie the relative lack of primary surveys for adult allergic diseases in Korea. Most of all, a major factor would be the methodological difficulty. More precisely, the selection of a community population and random recruitment poses complications in adults, as access to this group is limited given that they are likely to be at work during the daytime. Also, due to the age-related increase in asthma-mimicking conditions and comorbidities (particularly in the elderly) [101], case definition may be confounded if objective testing to differentiate asthma or allergic sensitization is absent. In addition, unlike the ISAAC project

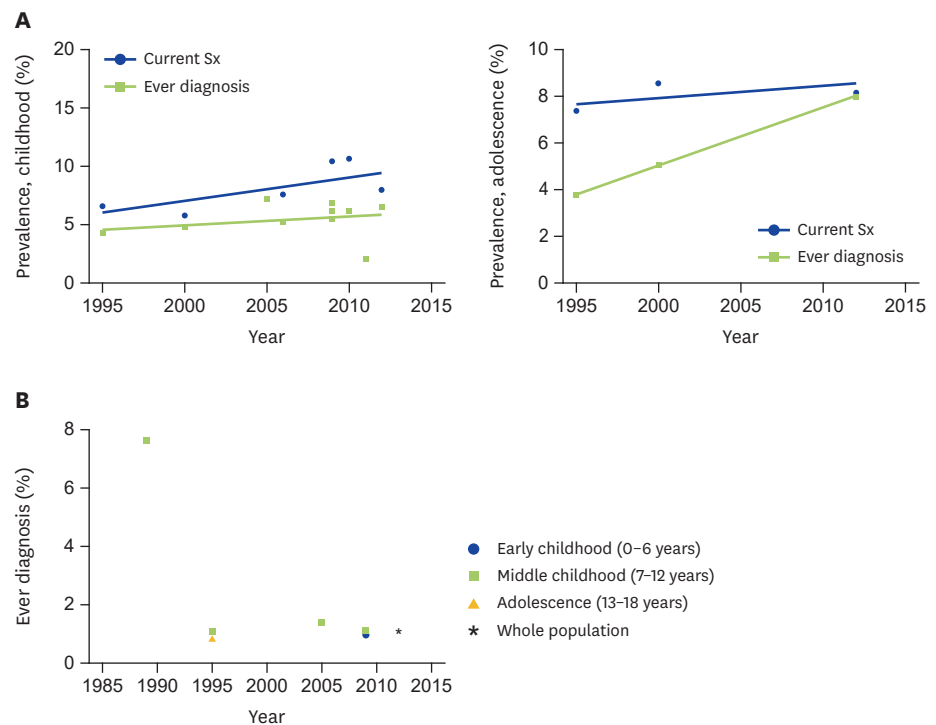


Fig. 5. Trends in the prevalence of allergic diseases by age groups during the study period for food allergy (A) and drug allergy (B). Sx, symptoms. Current symptoms defined as prevalence of symptoms of allergic diseases within the last 12 months. Ever diagnosis defined as lifetime prevalence of any allergic diseases diagnosed by a physician. The results that correspond to the asterisk were from a population-based study in the age group of 1 to 94 years. Data are presented as a scatter plot, with linear trend lines.

in children [102], there has been no global initiative to address the prevalence of asthma and allergic diseases in adults that included Asian countries [103]. In adults, the survey protocols from the European Community Respiratory Health Survey (ECRHS) have been considered as reasonable tools for large-scale community population surveys, and would enable international comparison and longitudinal follow-ups [104]. Currently, the ECRHS questionnaires for asthma prevalence have been translated and validated into several Asian languages including Korean, Japanese, and Mongolian [105-107].

Most of the publications were found to have focused on asthma, allergic rhinitis, and atopic dermatitis. The lack of studies on food allergy, drug allergy, and urticaria may be attributed to difficulties with objective definitions. So far, the studies have mostly relied on self-reported histories of symptoms and/or diagnosis. Given their substantial socioeconomic burden, further studies are warranted to develop and validate consensus definitions for epidemiologic surveys.

Meanwhile, the number of studies has recently increased for these previously “underrecognized” diseases. These include chronic urticaria, chronic cough, drug allergy, and anaphylaxis using nationwide surveys and healthcare databases in Korea [108-111]. Nationwide community population survey databases, such as the Korea National Health and Nutrition Examination Survey and the Korea Youth Risk Behavior Web-based Survey, were frequently utilized as they have the advantages of national representativeness and generalizability [112, 113].

Analyses of national healthcare utilization and insurance databases may be of particular use in estimating the prevalence of rare allergic diseases such as drug allergic reactions or

anaphylaxis. However, various problems may occur when utilizing health insurance data in epidemiological studies. These databases were not originally constructed for research, but rather for the purpose of reimbursement. Thus, reliability and validity of disease reporting is a concern. Additionally, these databases contain little clinical information about medical history and laboratory findings. In order to overcome such limitations, 2 steps should be taken to provide a more robust and beneficial source of data. First, there should exist standardized operational definitions that are based on a consensus of the academic community. Second, databases should be supplemented with additional medical records such as hospital records, prescription data, national health nutrition data, and health examination data [114].

Questionnaires are the key tool for community population surveys, particularly in studies of large-scale populations. In our review, most studies (87%) used questionnaires; 39 were exclusively questionnaire-based, and 41 used a combination of questionnaires and objective measurements, such as the level of atopy, lung function tests and biomarkers. While it is highly important to utilize standardized and well-validated questionnaire tools, such as the ISAAC protocol for children and the ECRHS protocol for adults, when measuring for prevalence as these tools enable a comparison between studies, areas, or different time points, some areas of concern do exist. One such concern brings into question whether the status of asthma or allergic conditions are well defined by the method of dichotomous questionnaire assessment. Moreover, questionnaire-based definitions are subject to recall bias, which is particularly important when historical self-reported information is elicited from respondents [115]. In the case of atopic dermatitis, the prevalence shown by questionnaire-based surveys appears rather high compared with those made by dermatological examinations [44, 67]. Discrepancies were also observed between results from questionnaire only responses and those from a combination of questionnaires and objective measurements for asthma and allergic rhinitis (methacholine bronchial provocation test and inhalant allergen skin prick test) [17, 82-84, 93-95]. Along with recent advances in our understanding of disease pathophysiology, many allergic diseases are recognized as heterogeneous syndromes consisting of several phenotypes and endotypes [116]. Therefore, concerted efforts to characterize multiple key traits and components in each disease (using questionnaires and objective assessment tools) would be the next important step toward further understanding epidemiological changes.

In conclusion, the present study reviewed temporal trends in the prevalence of allergic diseases in Korea and identified several unmet needs. The prevalence of allergic rhinitis, conjunctivitis, atopic dermatitis, and food allergy showed steadily increasing trends among children, whereas asthma did not show a consistent pattern. Primary studies on other allergic conditions were very limited, thus warranting further studies to estimate time trends. Utilization of large-scale databases could be particularly valuable for rare or underrecognized allergic diseases. Standardization of survey tools and working definitions would facilitate further studies for elucidating time trends.

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SUPPLEMENTARY MATERIALS

Supplementary Table 1

Search strategy

[Click here to view](#)

Supplementary Table 2

Summary of prevalence in allergic diseases from primary data*

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Supplementary Table 3

Summary of prevalence in allergic diseases from the Korean National Health Insurance database

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Supplementary References

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REFERENCES

1. Pawankar R. Allergic diseases and asthma: a global public health concern and a call to action. *World Allergy Organ J* 2014;7:12.
[PUBMED](#) | [CROSSREF](#)
2. Song WJ, Wong GW. Changing trends and challenges in the management of asthma in Asia. *J Allergy Clin Immunol* 2017;140:1272-4.
[PUBMED](#) | [CROSSREF](#)
3. Nicolaou N, Siddique N, Custovic A. Allergic disease in urban and rural populations: increasing prevalence with increasing urbanization. *Allergy* 2005;60:1357-60.
[PUBMED](#) | [CROSSREF](#)
4. Pawankar R, Canonica GW, Holgate ST, Lockey RF, Blaiss MS. World Allergy Organisation (WAO) white book on allergy: update 2013. Milwaukee (WI): World Allergy Organization; 2013.
5. Anandan C, Nurmatov U, van Schayck OC, Sheikh A. Is the prevalence of asthma declining? Systematic review of epidemiological studies. *Allergy* 2010;65:152-67.
[PUBMED](#) | [CROSSREF](#)
6. Kim YY. Past, present, and future of allergy in Korea. *Allergy Asthma Immunol Res* 2010;2:155-64.
[PUBMED](#) | [CROSSREF](#)
7. Shin T, Lee G, Yoon H. A survey of the distribution of allergic diseases in primary school children. *Allergy* 1990;10:201-12.
8. Kim YY, Cho SH, Kim WK, Park JK, Song SH, Kim YK, Jee YK, Ha MN, Ahn YO, Lee SI, Min KU. Prevalence of childhood asthma based on questionnaires and methacholine bronchial provocation test in Korea. *Clin Exp Allergy* 1997;27:761-8.
[PUBMED](#) | [CROSSREF](#)
9. Song WJ, Jee HM, Suh DI, Yang HJ, Yoon JS, Yu J, Kim SH, Ye YM, Kim TB, Shin SY, Li K, Kim CW; KAAACI Scientific Program Committee. Progress and prospect: a bibliometric analysis of research papers by Korean allergists over recent five years (2009-2013). *Allergy Asthma Immunol Res* 2015;7:507-12.
[PUBMED](#) | [CROSSREF](#)
10. Moher D, Liberati A, Tetzlaff J, Altman DG; PRISMA Group. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *PLoS Med* 2009;6:e1000097.
[PUBMED](#) | [CROSSREF](#)

11. Kim YH, Kim JW, Houh W. A study on incidence and genetic background of atopic dermatitis. *Korean J Dermatol* 1979;17:105-10.
12. Ahn Y, Choi E. The result of skin prick tests with 9 common aeroallergen in Korea and RAST reactivity to *D. farinae* in a community school children. *Allergy* 1990;10:213-25.
13. Kim JW, Lee WC, Lee SC, Byun DG. The prevalence and clinical features of atopic dermatitis in kindergarten children in Puchon city, Kyonggi-Do. *Allergy* 1995;15:639-49.
14. Lee SC, Byun DG, Lee WC, Kim JW. The prevalence and some minor clinical features of atopic dermatitis. *Korean J Dermatol* 1995;33:17.
15. Min YG, Jung HW, Kim HS, Park SK, Yoo KY. Prevalence and risk factors for perennial allergic rhinitis in Korea: results of a nationwide survey. *Clin Otolaryngol Allied Sci* 1997;22:139-44.
[PUBMED](#) | [CROSSREF](#)
16. Lee JG, Moon HJ, Kim KS, Yoon JH, Kim SS, Park IY. Epidemiological study for allergic disease of school aged children and adolescence in rural area of Korea. *Korean J Otolaryngol-Head Neck Surg* 1998;41:1156-63.
17. Min KU, Kim YK, Jang YS, Jung JW, Bahn JW, Lee BJ, Kim HY, Lee SR, Son JW, Cho SH, Park HS, Lee MH, Kim YY. Prevalence of allergic rhinitis and its causative allergens in people in rural area of Cheju Island. *J Asthma Allergy Clin Immunol* 1999;19:42-9.
18. Park HS, Kim HY, Sohn JW, Kim YY, Jee YK, Kim YK, Lee MH, Chang YS, Jung JW, Cho SH, Min KU, Lee BJ, Lee SR, Kim WK, Bae JM, Hong SC. Sensitization rate to citrus red mite (*Panonychus citri*) allergen in primary school children living in rural areas on Cheju Island and environmental influence on the risk of specific sensitization. *J Asthma Allergy Clin Immunol* 1999;19:952-8.
19. Kim CW, Park CJ, Kim JW, Koo DW, Kim KW, Kim TY. Prevalence of atopic dermatitis in Korea. *Acta Derm Venereol* 2000;80:353-6.
[PUBMED](#) | [CROSSREF](#)
20. Lee SI, Shin MH, Lee HB, Lee JS, Son BK, Koh YY, Kim KE, Ahn YO. Prevalences of symptoms of asthma and other allergic diseases in Korean children: a nationwide questionnaire survey. *J Korean Med Sci* 2001;16:155-64.
[PUBMED](#) | [CROSSREF](#)
21. Lee MH, Hong SC, Kim YK, Cho SH, Min KU, Kim YY. Prevalence of atopic rhinitis and causative allergens in children living in rural areas of Cheju island. *J Asthma Allergy Clin Immunol* 2001;21:198-204.
22. Kim SH, Oh SY, Lee BJ, Hong SC, Bae JM, Lee MH, Kim YK, Cho SH, Min KU, Kim YY. Risk factors for the sensitization to citrus red mite (*Panonychus citri*) in adolescents living in rural areas of Cheju island. *J Asthma Allergy Clin Immunol* 2001;21:73-9.
23. Lee MH, Hong SC, Kim TB, Son SW, Jang YS, Kim SH, Chung JW, Kim YK, Cho SH, Min KU, Kim YY. A prospective study of asthma prevalence and atopy rate in children living in rural area of Cheju Island for 3 years. *Pediatr Allergy Respir Dis* 2001;11:224-32.
24. Kim SH, Lee JY, Son SW, Chang YS, Jung JW, Kim YK, Cho SH, Min KU, Kim YY. Prevalence of adult asthma based on questionnaires and methacholine bronchial provocation test in Seoul. *J Asthma Allergy Clin Immunol* 2001;21:618-27.
25. Lee MH, Hong SC, Kim SH, Bahn JW, Kim TB, Kim YK, Cho SH, Min KU, Kim YY. Prevalence of asthma and atopy in children living in rural areas of Cheju island for an interval of three years. *J Asthma Allergy Clin Immunol* 2002;22:85-91.
26. Kim SH, Hong SC, Bae JM, Lee MH, Kim YK, Cho SH, Min KU, Kim YY. Distinct effect of sensitization of house dust mite and citrus red mite (*Panonychus citri*) in the development of allergic diseases in 16-18 year old adolescents living in rural areas of Jeju island. *J Asthma Allergy Clin Immunol* 2002;22:92-9.
27. Kim YK, Kim SH, Tak YJ, Jee YK, Lee BJ, Kim SH, Park HW, Jung JW, Bahn JW, Chang YS, Choi DC, Chang SI, Min KU, Kim YY, Cho SH. High prevalence of current asthma and active smoking effect among the elderly. *Clin Exp Allergy* 2002;32:1706-12.
[PUBMED](#) | [CROSSREF](#)
28. Oh JW, Kim KE, Pyun BY, Lee HR, Choung JT, Hong SJ, Park KS, Lee SY, Song SW, Kim CH, Ahn KM, Nam SY, Shon MH, Kim WK, Lee MH, Kwon BC, Choi SY, Lee SY, Lee HB, Lee SI, Lee JS. Nationwide study for epidemiological change of atopic dermatitis in school aged children between 1995 and 2000 and kindergarten aged children in 2003 in Korea. *Pediatr Allergy Respir Dis* 2003;13:227-37.
29. Hong SJ, Lee MS, Sohn MH, Shim JY, Han YS, Park KS, Ahn YM, Son BK, Lee HB; Korean ISAAC Study Group. Self-reported prevalence and risk factors of asthma among Korean adolescents: 5-year follow-up study, 1995-2000. *Clin Exp Allergy* 2004;34:1556-62.
[PUBMED](#) | [CROSSREF](#)
30. Oh JW, Pyun BY, Choung JT, Ahn KM, Kim CH, Song SW, Son JA, Lee SY, Lee SI. Epidemiological change of atopic dermatitis and food allergy in school-aged children in Korea between 1995 and 2000. *J Korean Med Sci* 2004;19:716-23.
[PUBMED](#) | [CROSSREF](#)

31. Shin C, Lee S, Abbott RD, Kim JH, Lee SY, In KH, Kimm K. Respiratory symptoms and undiagnosed airflow obstruction in middle-aged adults: the Korean Health and Genome Study. *Chest* 2004;126:1234-40.
[PUBMED](#) | [CROSSREF](#)
32. Nam SY, Yoon HS, Kim WK. Prevalence of allergic disease in kindergarten age children in Korea. *Pediatr Allergy Respir Dis* 2005;15:439-45.
33. Kim JL, Elfman L, Norbäck D. Respiratory symptoms, asthma and allergen levels in schools--comparison between Korea and Sweden. *Indoor Air* 2007;17:122-9.
[PUBMED](#) | [CROSSREF](#)
34. Kim BS, Kim HB, Lee SY, Kim JH, Jin HS, Kim BJ, Yu JH, Yoo SM, Hong SJ. Prevalence of allergic diseases in high school students in Korea. *Korean J Asthma Allergy Clin Immunol* 2007;27:168-75.
35. Son KY, Park KS, Hwang HH, Yun BS, Lee SJ, Kim MA, Park JY, Kim KE, Jang KC. Prevalence of allergic diseases among primary school children in Ilsan, Gyeonggi and changes of symptoms after environmental control in 2005. *Pediatr Allergy Respir Dis* 2007;17:384-93.
36. Yoo Y, Ko HK, Han JJ, Lee Y, Seo KJ, Choung JT, Tockgo YC, Choe JG. The prevalence of atopy and asthma among university freshmen in Seoul, Korea: association with obesity. *J Asthma* 2007;44:45-9.
[PUBMED](#) | [CROSSREF](#)
37. Lee YM, Kim BS. Prevalence and risk factors of asthma in community childhood. *J Korean Biol Nurs Sci* 2008;10:53-61.
38. Lee YM, Hwang SW. Prevalence and risk factors for atopic dermatitis in pre-school and school aged children. *J Korean Acad Child Health Nurs* 2008;14:285-94.
39. Lee HB, Shin SA, Oh JW. New patterns of childhood asthma prevalence in six Asian countries: comparison of ISAAC phases I and III. *Pediatr Allergy Respir Dis* 2008;18:70-7.
40. Hong SJ, Ahn KM, Lee SY, Kim KE. The prevalences of asthma and allergic diseases in Korean children. *Pediatr Allergy Respir Dis* 2008;18:15-25.
41. Nam EW, Kim SH, Choi EH, Choi LH, Moon JY, Kim JH. The prevalence rate and risk factors of atopic dermatitis in pre-schoolers, elementary school students, middle school students at Yanggu County. *Korean Public Health Res* 2009;35:53-62.
42. Bae JM, Shin KS. Estimating the prevalence of atopic dermatitis in school students of jeju-do, Korea. *J Prev Med Public Health* 2009;42:171-6.
[PUBMED](#) | [CROSSREF](#)
43. Jee HM, Kim KW, Kim CS, Sohn MH, Shin DC, Kim KE. Prevalence of asthma, rhinitis and eczema in Korean children Using the International Study of Asthma and Allergies in Childhood (ISAAC) questionnaires. *Pediatr Allergy Respir Dis* 2009;19:165-72.
44. Lee HY, Lee JR, Roh JY. Epidemiological features of preschool childhood atopic dermatitis in Incheon. *Korean J Dermatol* 2009;47:164-71.
45. Kim SY, Yoon SJ, Jo MW, Kim EJ, Kim HJ, Oh IH. Economic burden of allergic rhinitis in Korea. *Am J Rhinol Allergy* 2010;24:e110-3.
[PUBMED](#) | [CROSSREF](#)
46. Kim CY, Park HW, Ko SK, Chang SI, Moon HB, Kim YY, Cho SH. The financial burden of asthma: a nationwide comprehensive survey conducted in the republic of Korea. *Allergy Asthma Immunol Res* 2011;3:34-8.
[PUBMED](#) | [CROSSREF](#)
47. Kim JY, Lim HJ, Kim HY, Lee WK, Kim BS, Lee WJ, Lee SJ, Kim DW. Difference in the prevalence rate according to diagnostic criteria in atopic dermatitis: prevalence rate of atopic dermatitis according to Hanifin-Rajka, Japanese, Korean diagnostic criteria and characteristics of three different diagnostic criteria. *Korean J Dermatol* 2010;48:649-56.
48. Lee H, Kim GS. Geographical and sociodemographic risk factors for allergic diseases in Korean children. *Asian Nurs Res (Korean Soc Nurs Sci)* 2011;5:1-10.
[PUBMED](#) | [CROSSREF](#)
49. Kim DS, Ban JS, Park EA, Lee JY, Lee JO, Chang EY, Kim J, Han Y, Ahn K, Lim IS. Survey of food allergy in elementary school students in Dongjak-gu using questionnaire. *Korean J Asthma Allergy Clin Immunol* 2011;31:254-9.
50. Kim YH, Urm SH, Kim WK. Prevalence of allergic diseases and risk factors in preschool children, 2009. *Pediatr Allergy Respir Dis* 2011;21:165-75.
[CROSSREF](#)
51. Kwon JW, Kim BJ, Song Y, Seo JH, Kim TH, Yu J, Kim HB, Lee SY, Kim WK, Kim KW, Ji HM, Kim KE, Kim H, Hong SJ. Changes in the prevalence of childhood asthma in Seoul from 1995 to 2008 and its risk factors. *Allergy Asthma Immunol Res* 2011;3:27-33.
[PUBMED](#) | [CROSSREF](#)

52. Suh M, Kim HH, Sohn MH, Kim KE, Kim C, Shin DC. Prevalence of allergic diseases among Korean school-age children: a nationwide cross-sectional questionnaire study. *J Korean Med Sci* 2011;26:332-8.
[PUBMED](#) | [CROSSREF](#)
53. Ahn K, Kim J, Kwon HJ, Chae Y, Hahn MI, Lee KJ, Park YM, Lee SY, Han M, Kim WK. The prevalence of symptoms of asthma, allergic rhinoconjunctivitis, and eczema in Korean children: Nationwide cross-sectional survey using complex sampling design. *J Korean Med Assoc* 2011;54:769-78.
[CROSSREF](#)
54. Lee JH, Kim EH, Cho J, Kim HY, Suh J, Ahn K, Cheong HK, Lee SI. Comparison of prevalence and risk factors of atopic dermatitis by physical examination and questionnaire survey in elementary school children. *Pediatr Allergy Respir Dis* 2011;21:186-96.
[CROSSREF](#)
55. Jung YH, Ko H, Kim HY, Seo JH, Kwon JW, Kim BJ, Kim HB, Lee SY, Jang GC, Song DJ, Kim WK, Shim JY, Hong SJ. Prevalence and risk factors of food allergy in preschool children in Seoul. *Korean J Asthma Allergy Clin Immunol* 2011;31:177-83.
56. Yoon JK, Sim CS, Choi SW, Oh IB, Lee JH, Kim Y. Prevalence of atopic and allergic disorders in children attending an elementary school in Ulsan. *Korean J Asthma Allergy Clin Immunol* 2011;31:105-15.
57. Kwon JW, Seo JH, Yu J, Kim BJ, Kim HB, Lee SY, Kim WK, Kim KW, Ji HM, Kim KE, Shin YJ, Kim MH, Kim H, Hong SJ. Relationship between the prevalence of allergic rhinitis and allergen sensitization in children of Songpa area, Seoul. *Pediatr Allergy Respir Dis* 2011;21:47-55.
[CROSSREF](#)
58. Yu JS, Lee CJ, Lee HS, Kim J, Han Y, Ahn K, Lee SI. Prevalence of atopic dermatitis in Korea: analysis by using national statistics. *J Korean Med Sci* 2012;27:681-5.
[PUBMED](#) | [CROSSREF](#)
59. Seong HU, Cho SD, Park SY, Yang JM, Lim DH, Kim JH, Son BK. Nationwide survey on the prevalence of allergic diseases according to region and age. *Pediatr Allergy Respir Dis* 2012;22:224-31.
[CROSSREF](#)
60. Hong S, Son DK, Lim WR, Kim SH, Kim H, Yum HY, Kwon H. The prevalence of atopic dermatitis, asthma, and allergic rhinitis and the comorbidity of allergic diseases in children. *Environ Health Toxicol* 2012;27:e2012006.
[PUBMED](#) | [CROSSREF](#)
61. Lee HS, Lee J, Kim JW, Hong SC, Kim SY, Lee KH. The Prevalence of allergic diseases in children living in Jeju. *Pediatr Allergy Respir Dis* 2012;22:248-55.
[CROSSREF](#)
62. Ahn K, Kim J, Hahn MI, Lee SY, Kim WK, Chae Y, Park YM, Han MY, Lee KJ, Kim JK, Yang ES, Kwon HJ. Prevalence of immediate-type food allergy in Korean school children: a population-based study. *Allergy Asthma Proc* 2012;33:481-7.
[PUBMED](#) | [CROSSREF](#)
63. Choi WJ, Ko JY, Kim JW, Lee KH, Park CW, Kim KH, Kim MN, Lee AY, Cho SH, Park YL, Choi JH, Seo SJ, Lee YW, Roh JY, Park YM, Kim DJ, Ro YS. Prevalence and risk factors for atopic dermatitis: a cross-sectional study of 6,453 Korean preschool children. *Acta Derm Venereol* 2012;92:467-71.
[PUBMED](#) | [CROSSREF](#)
64. Hwang GS, Choi JW, Yoo Y, Chung JT, Yoon CS. Residential environmental risk factors for childhood asthma prevalence in metropolitan and semirural cities in Korea. *Asia Pac J Public Health* 2012;24:58-67.
[PUBMED](#) | [CROSSREF](#)
65. Lee JH, Oh IB, Sim CS, Yoo CI, Kim Y. Prevalence of children's allergic diseases in Ulsan: Local differences and environmental risk factors. In: *International Forum on Strategic Technology (IFOST)*; 2012 Sep 18-21; Tomsk, Russia. Piscataway (NJ): Institute of Electrical and Electronics Engineers; 2012. p. 1-4.
66. Myong JP, Kim H, Lee K, Chang S. Time trends of allergic rhinitis and effects of residence on allergic rhinitis in Korea from 1998 through 2007-2009. *Asian Nurs Res (Korean Soc Nurs Sci)* 2012;6:102-6.
[PUBMED](#) | [CROSSREF](#)
67. Kim DS, Lee JH, Lee KH, Lee MG. Prevalence and severity of atopic dermatitis in Jeju Island: a cross-sectional study of 4,028 Korean elementary school children by physical examination utilizing the three-item severity score. *Acta Derm Venereol* 2012;92:472-4.
[PUBMED](#) | [CROSSREF](#)
68. Oak JW, Lee HS. Prevalence rate and factors associated with atopic dermatitis among Korean middle school students. *J Korean Acad Nurs* 2012;42:992-1000.
[PUBMED](#) | [CROSSREF](#)
69. Lee SY, Kwon JW, Seo JH, Song YH, Kim BJ, Yu J, Park KS, Kim H, Kim EJ, Lee JS, Hong SJ. Prevalence of atopy and allergic diseases in Korean children: associations with a farming environment and rural lifestyle. *Int Arch Allergy Immunol* 2012;158:168-74.
[PUBMED](#) | [CROSSREF](#)

70. Lee HS, Lee J, Hong SC, Kim JW, Kim SY, Lee KH. Prevalence and risk factors for allergic diseases of preschool children living in Seogwipo, Jeju, Korea. *Korean J Asthma Allergy Clin Immunol* 2012;32:107-14.
71. Lee H, Hong S, Kim S, Kim J, Lee K, Lee J. Prevalence of allergic diseases and risk factors: a cross-sectional study of 4,098 high school students at Seogwipo, Jeju province. *Korean Public Health Res* 2012;38:45-55.
72. Song WJ, Kim SH, Lim S, Park YJ, Kim MH, Lee SM, Lee SB, Kim KW, Jang HC, Cho SH, Min KU, Chang YS. Association between obesity and asthma in the elderly population: potential roles of abdominal subcutaneous adiposity and sarcopenia. *Ann Allergy Asthma Immunol* 2012;109:243-8.
[PUBMED](#) | [CROSSREF](#)
73. Kim EJ, Yoon SJ, Jo MW, Kim HJ. Measuring the burden of chronic diseases in Korea in 2007. *Public Health* 2013;127:806-13.
[PUBMED](#) | [CROSSREF](#)
74. Kim S, Kim J, Kim K, Kim Y, Park Y, Baek S, Park SY, Yoon SY, Kwon HS, Cho YS, Kim TB, Moon HB. Healthcare use and prescription patterns associated with adult asthma in Korea: analysis of the NHI claims database. *Allergy* 2013;68:1435-42.
[PUBMED](#) | [CROSSREF](#)
75. Kim HY, Kwon EB, Baek JH, Shin YH, Yum HY, Jee HM, Yoon JW, Han MY. Prevalence and comorbidity of allergic diseases in preschool children. *Korean J Pediatr* 2013;56:338-42.
[PUBMED](#) | [CROSSREF](#)
76. Lee HS, Hong SC, Kim JH, Kim JW, Lee KH, Lee J, Jeong JH. Complete enumeration for the prevalence of allergic disease in Udo Isle's inhabitants. *Allergy Asthma Respir Dis* 2013;1:116-22.
[CROSSREF](#)
77. Baek JO, Hong S, Son DK, Lee JR, Roh JY, Kwon HJ. Analysis of the prevalence of and risk factors for atopic dermatitis using an ISAAC questionnaire in 8,750 Korean children. *Int Arch Allergy Immunol* 2013;162:79-85.
[PUBMED](#) | [CROSSREF](#)
78. Kim SY, Jung JY, Park MS, Kang YA, Kim EY, Kim SK, Chang J, Kim YS. Increased prevalence of self-reported asthma among Korean adults: an analysis of KNHANES I and IV data. *Lung* 2013;191:281-8.
[PUBMED](#) | [CROSSREF](#)
79. Lee AH, Kim KE, Lee KE, Kim SH, Wang TW, Kim KW, Kwak TK. Prevalence of food allergy and perceptions on food allergen labeling in school foodservice among Korean students. *Allergy Asthma Respir Dis* 2013;1:227-34.
[CROSSREF](#)
80. Hong WH. Prevalence rate and indoor risk factors for atopic dermatitis in the school aged children in Changwon. *Korean J Community Living Sci* 2013;24:369-79.
[CROSSREF](#)
81. Song WJ, Morice AH, Kim MH, Lee SE, Jo EJ, Lee SM, Han JW, Kim TH, Kim SH, Jang HC, Kim KW, Cho SH, Min KU, Chang YS. Cough in the elderly population: relationships with multiple comorbidity. *PLoS One* 2013;8:e78081.
[PUBMED](#) | [CROSSREF](#)
82. Song WJ, Kim MY, Jo EJ, Kim MH, Kim TH, Kim SH, Kim KW, Cho SH, Min KU, Chang YS. Rhinitis in a community elderly population: relationships with age, atopy, and asthma. *Ann Allergy Asthma Immunol* 2013;111:347-51.
[PUBMED](#) | [CROSSREF](#)
83. Hwang SH, Jung SY, Lim DH, Son BK, Kim JH, Yang JM, Oh IB, Kim Y, Lee JH, Lee KH, Kim SY, Hong SC, Lee HS. Epidemiology of allergic rhinitis in Korean children. *Allergy Asthma Respir Dis* 2013;1:321-32.
[CROSSREF](#)
84. Song WJ, Chang YS, Lim MK, Yun EH, Kim SH, Kang HR, Park HW, Tomassen P, Choi MH, Min KU, Cho SH, Bachert C. Staphylococcal enterotoxin sensitization in a community-based population: a potential role in adult-onset asthma. *Clin Exp Allergy* 2014;44:553-62.
[PUBMED](#) | [CROSSREF](#)
85. Cho YM, Ryu SH, Choi MS, Tinyami ET, Seo S, Choung JT, Choi JW. Asthma and allergic diseases in preschool children in Korea: findings from the pilot study of the Korean Surveillance System for Childhood Asthma. *J Asthma* 2014;51:373-9.
[PUBMED](#) | [CROSSREF](#)
86. Park M, Kim D, Ahn K, Kim J, Han Y. Prevalence of immediate-type food allergy in early childhood in seoul. *Allergy Asthma Immunol Res* 2014;6:131-6.
[PUBMED](#) | [CROSSREF](#)
87. Rhee CS, Wee JH, Ahn JC, Lee WH, Tan KL, Ahn S, Lee JH, Lee CH, Cho YS, Park KH, Lee KH, Kim KS, Lee A, Kim JW. Prevalence, risk factors and comorbidities of allergic rhinitis in South Korea: The Fifth Korea National Health and Nutrition Examination Survey. *Am J Rhinol Allergy* 2014;28:e107-14.
[PUBMED](#) | [CROSSREF](#)

88. Lee KH. An Analysis on prevalence and allergen of food allergies. *J Agric Med Community Health* 2014;39:14-24.
[CROSSREF](#)
89. Kim H, Oh SY, Kang MH, Kim KN, Kim Y, Chang N. Association between kimchi intake and asthma in Korean adults: the fourth and fifth Korea National Health and Nutrition Examination Survey (2007-2011). *J Med Food* 2014;17:172-8.
[PUBMED](#) | [CROSSREF](#)
90. Yoo B, Park Y, Park K, Kim H. A 9-year trend in the prevalence of allergic disease based on National Health Insurance Data. *J Prev Med Public Health* 2015;48:301-9.
[PUBMED](#) | [CROSSREF](#)
91. Chang CM, Chun SH, Choi JY. The Prevalence of asthma, allergic rhinitis, and atopic dermatitis in elementary school students according to the body mass index. *J Korean Acad Community Health Nurs* 2015;26:230-7.
[CROSSREF](#)
92. Lee HS, Hong SC, Kim JH, Kim JW, Lee KH, Lee J. A cross-sectional epidemiological study on trends in the prevalence of allergic diseases among children and adolescents in the Jeju Area in 2008 and 2013. *J Korean Acad Community Health Nurs* 2015;26:160-8.
[CROSSREF](#)
93. Kwon SE, Lim DH, Kim JH, Son BK, Park YS, Jang HJ, Kim BH, Kim GM, Yoo YS, Park KW. Prevalence and allergens of allergic rhinitis in children and adolescents in Gwangju. *Allergy Asthma Respir Dis* 2015;3:54-61.
[CROSSREF](#)
94. Choi BK, Lim HS, Chung YS. Prevalence of allergic rhinitis between urban and rural residents in a local community. *J Agric Med Community Health* 2015;40:148-57.
[CROSSREF](#)
95. Kim Y, Seo JH, Kwon JW, Lee E, Yang SI, Cho HJ, Ha M, Burm E, Lee KJ, Kim HC, Lim S, Kang HT, Son M, Kim SY, Cheong HK, Kim YM, Oh GJ, Sakong J, Lee CG, Kim SJ, Beak YW, Hong SJ. The prevalence and risk factors of allergic rhinitis from a nationwide study of Korean elementary, middle, and high school students. *Allergy Asthma Respir Dis* 2015;3:272-80.
[CROSSREF](#)
96. Kim BJ, Jung JA, Lee JS. Association between social economic status and atopic dermatitis in Korean adult: an analysis of the Fifth Korea National Health and Nutrition Examination Survey (2010-2012). *Allergy Asthma Respir Dis* 2015;3:128-33.
[CROSSREF](#)
97. Kim BK, Kim JY, Kang MK, Yang MS, Park HW, Min KU, Cho SH, Kang HR. Allergies are still on the rise? A 6-year nationwide population-based study in Korea. *Allergol Int* 2016;65:186-91.
[PUBMED](#) | [CROSSREF](#)
98. Ahn JC, Kim JW, Lee CH, Rhee CS. Prevalence and risk factors of chronic rhinosinusitis, allergic rhinitis, and nasal septal deviation: results of the Korean National Health and Nutrition Survey 2008-2012. *JAMA Otolaryngol Head Neck Surg* 2016;142:162-7.
[PUBMED](#) | [CROSSREF](#)
99. Lee JH, Han KD, Kim KM, Park YG, Lee JY, Park YM. Prevalence of atopic dermatitis in Korean children based on data from the 2008-2011 Korean National Health and Nutrition Examination Survey. *Allergy Asthma Immunol Res* 2016;8:79-83.
[PUBMED](#) | [CROSSREF](#)
100. Han JY, Park HS. Prevalence of allergic diseases and its related factors in Korean adolescents-Using data from the 2013 Korea youth risk behavior web-based survey. *J Korean Data Inf Sci Soc* 2016;27:155-68.
101. Song WJ, Cho SH. Challenges in the management of asthma in the elderly. *Allergy Asthma Immunol Res* 2015;7:431-9.
[PUBMED](#) | [CROSSREF](#)
102. Wong GW, Leung TF, Ko FW. Changing prevalence of allergic diseases in the Asia-pacific region. *Allergy Asthma Immunol Res* 2013;5:251-7.
[PUBMED](#) | [CROSSREF](#)
103. Song WJ, Kang MG, Chang YS, Cho SH. Epidemiology of adult asthma in Asia: toward a better understanding. *Asia Pac Allergy* 2014;4:75-85.
[PUBMED](#) | [CROSSREF](#)
104. Burney PG, Luczynska C, Chinn S, Jarvis D. The European Community Respiratory Health Survey. *Eur Respir J* 1994;7:954-60.
[PUBMED](#) | [CROSSREF](#)

105. Watanabe J, Taniguchi M, Takahashi K, Nakagawa T, Ooya Y, Akazawa A, Akiyama K. Validation of ECRHS Questionnaire in Japanese to use for nation-wide prevalence study of adult asthma. *Aerugi* 2006;55:1421-8.
[PUBMED](#)
106. Sonomjamts M, Dashdemberel S, Logii N, Nakae K, Chigusa Y, Ohhira S, Ito C, Sagara H, Makino S. Prevalence of asthma and allergic rhinitis among adult population in Ulaanbaatar, Mongolia. *Asia Pac Allergy* 2014;4:25-31.
[PUBMED](#) | [CROSSREF](#)
107. Song WJ, Lee SH, Kang MG, Kim JY, Kim MY, Jo EJ, Lee SY, Lee SE, Kim MH, Yang MS, Kim SH, Kang HR, Park HK, Park HW, Chang YS, Kim SS, Lee JM, Min KU, Cho SH. Validation of the Korean version of the European Community Respiratory Health Survey screening questionnaire for use in epidemiologic studies for adult asthma. *Asia Pac Allergy* 2015;5:25-31.
[PUBMED](#) | [CROSSREF](#)
108. Yang MS, Lee JY, Kim J, Kim GW, Kim BK, Kim JY, Park HW, Cho SH, Min KU, Kang HR. Incidence of Stevens-Johnson Syndrome and toxic epidermal necrolysis: a nationwide population-based study using National Health Insurance database in Korea. *PLoS One* 2016;11:e0165933.
[PUBMED](#) | [CROSSREF](#)
109. Yang MS, Kim JY, Kim BK, Park HW, Cho SH, Min KU, Kang HR. True rise in anaphylaxis incidence: Epidemiologic study based on a national health insurance database. *Medicine (Baltimore)* 2017;96:e5750.
[PUBMED](#) | [CROSSREF](#)
110. Lee N, Lee JD, Lee HY, Kang DR, Ye YM. Epidemiology of chronic urticaria in Korea using the Korean Health Insurance Database, 2010-2014. *Allergy Asthma Immunol Res* 2017;9:438-45.
[PUBMED](#) | [CROSSREF](#)
111. Kang MG, Song WJ, Kim HJ, Won HK, Sohn KH, Kang SY, Jo EJ, Kim MH, Kim SH, Kim SH, Park HW, Chang YS, Lee BJ, Morice AH, Cho SH. Point prevalence and epidemiological characteristics of chronic cough in the general adult population: The Korean National Health and Nutrition Examination Survey 2010-2012. *Medicine (Baltimore)* 2017;96:e6486.
[PUBMED](#) | [CROSSREF](#)
112. Kweon S, Kim Y, Jang MJ, Kim Y, Kim K, Choi S, Chun C, Khang YH, Oh K. Data resource profile: the Korea National Health and Nutrition Examination Survey (KNHANES). *Int J Epidemiol* 2014;43:69-77.
[PUBMED](#) | [CROSSREF](#)
113. Kim Y, Choi S, Chun C, Park S, Khang YH, Oh K. Data Resource Profile: The Korea Youth Risk Behavior Web-based Survey (KYRBS). *Int J Epidemiol* 2016;45:1076-1076e.
[PUBMED](#)
114. Sá-Sousa A, Jacinto T, Azevedo LF, Morais-Almeida M, Robalo-Cordeiro C, Bugalho-Almeida A, Bousquet J, Fonseca JA. Operational definitions of asthma in recent epidemiological studies are inconsistent. *Clin Transl Allergy* 2014;4:24.
[PUBMED](#) | [CROSSREF](#)
115. Coughlin SS. Recall bias in epidemiologic studies. *J Clin Epidemiol* 1990;43:87-91.
[PUBMED](#) | [CROSSREF](#)
116. Muraro A, Lemanske RF Jr, Hellings PW, Akdis CA, Bieber T, Casale TB, Jutel M, Ong PY, Poulsen LK, Schmid-Grendelmeier P, Simon HU, Seys SF, Agache I. Precision medicine in patients with allergic diseases: Airway diseases and atopic dermatitis-PRACTALL document of the European Academy of Allergy and Clinical Immunology and the American Academy of Allergy, Asthma & Immunology. *J Allergy Clin Immunol* 2016;137:1347-58.
[PUBMED](#) | [CROSSREF](#)