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Current Review

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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**).

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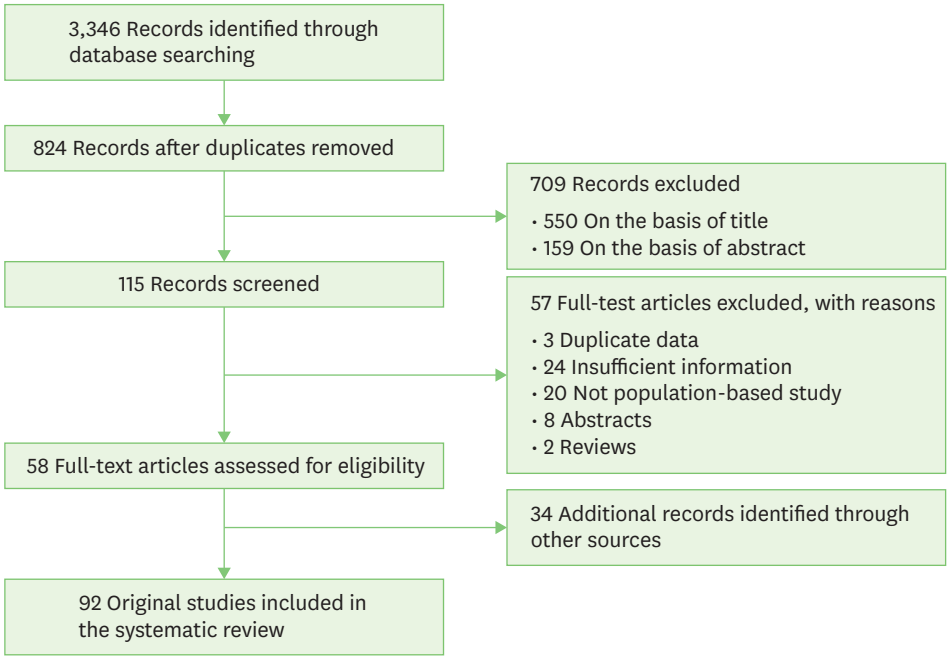

Fig. 1. Flow chart of study selection

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

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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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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**).

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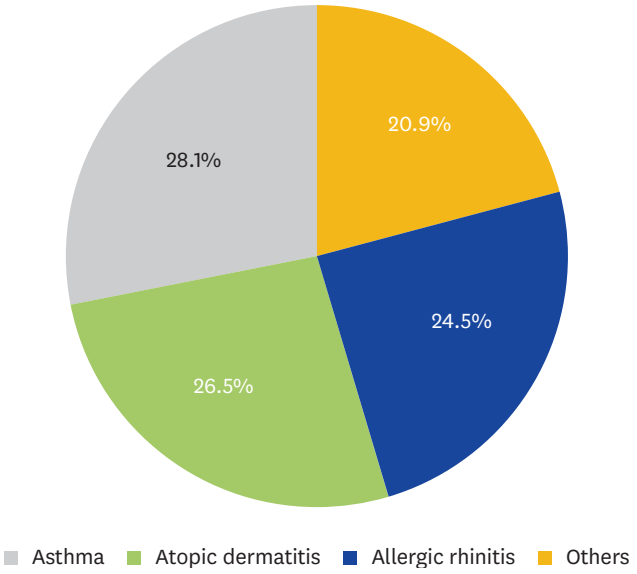

Fig. 2. The percentage of articles published on allergic diseases.

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

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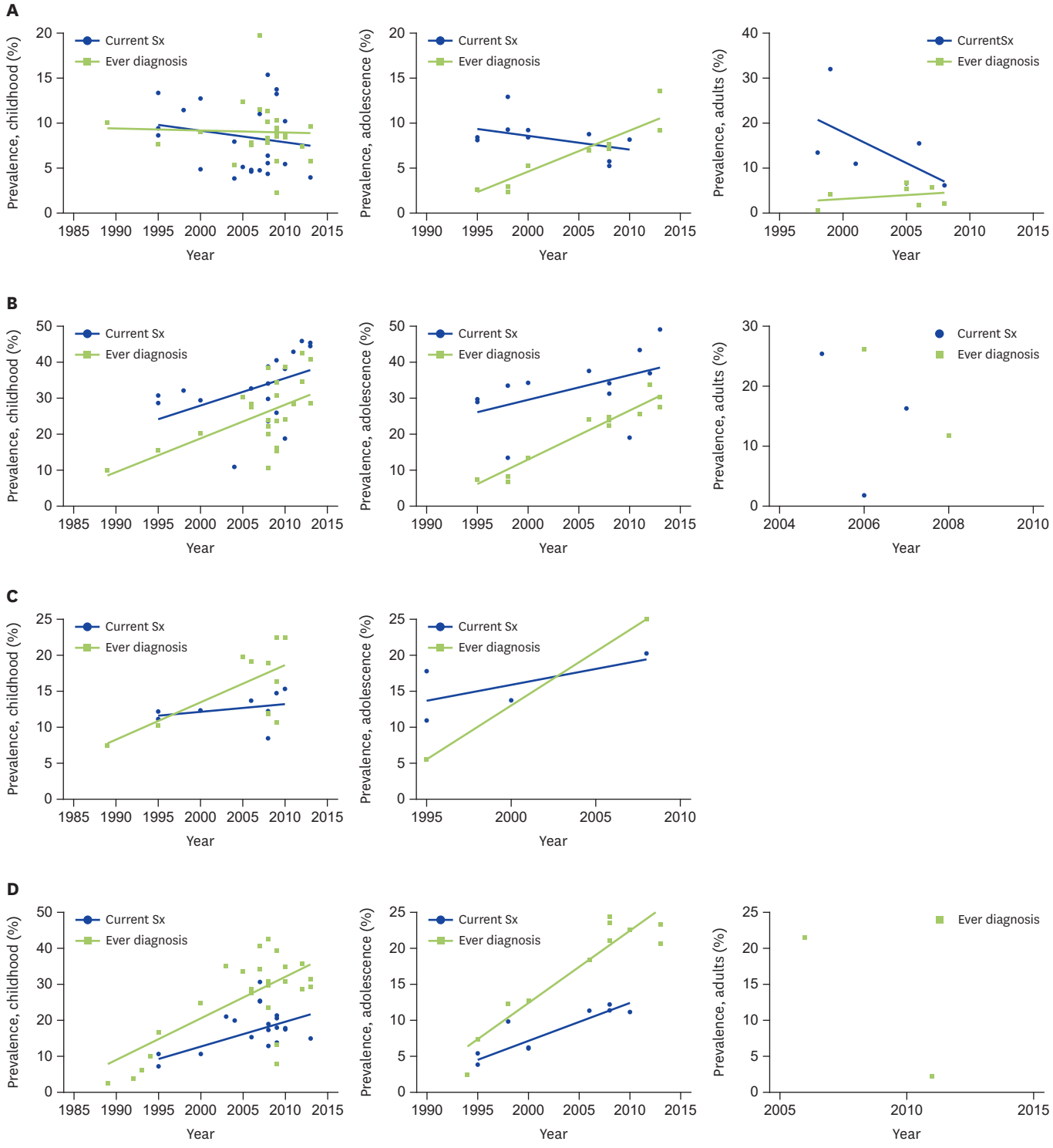

Fig. 3. Trends in the prevalence of allergic diseases by age groups during the study period for asthma (A), allergic rhinitis (B), allergic conjunctivitis (C), and atopic dermatitis (D). Sx, symptoms. Current symptoms defined as prevalence of symptoms of allergic diseases within the last 12 months. Ever 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.

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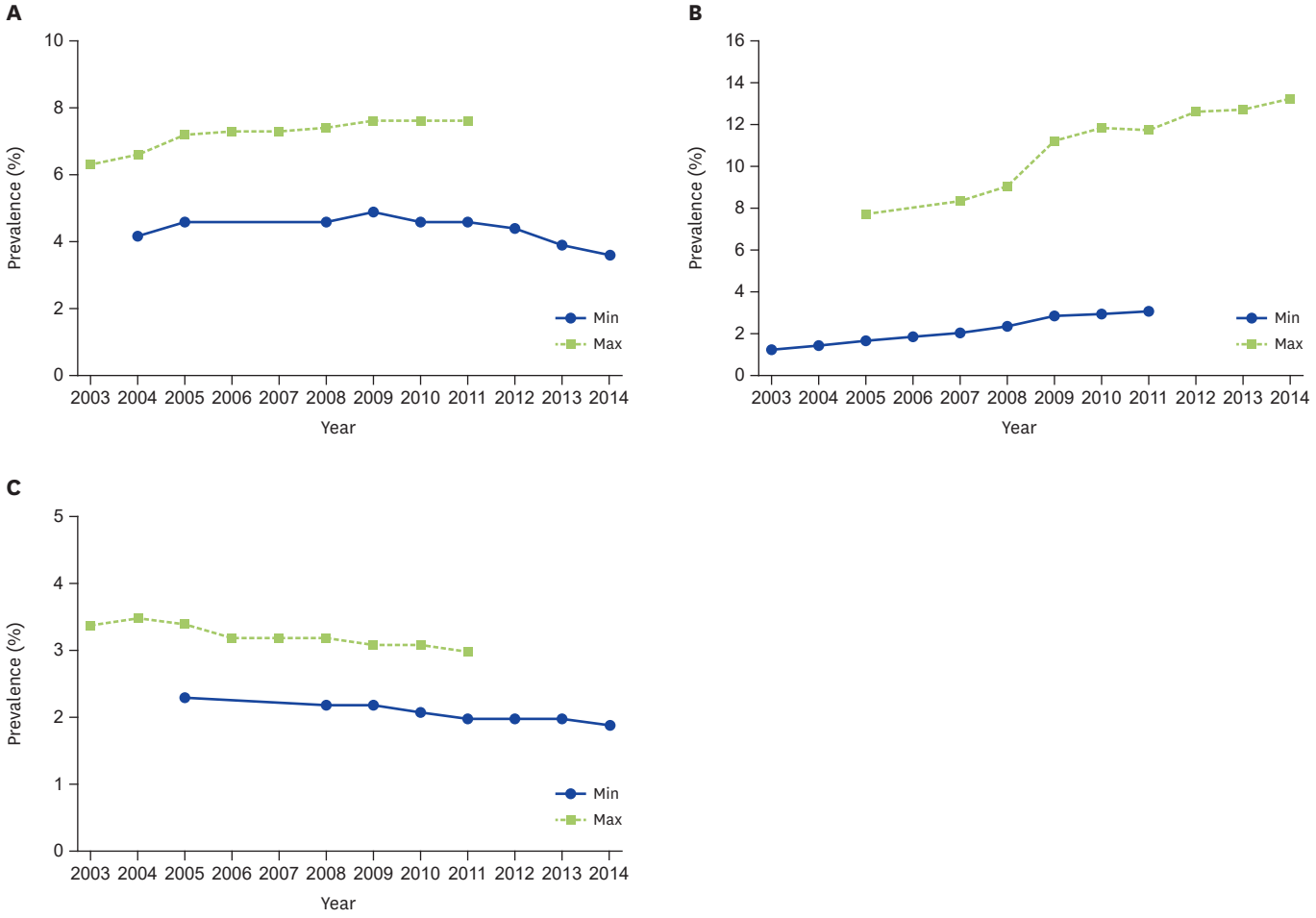

Fig. 4. Changes in the prevalence of asthma (A), allergic rhinitis (B), and atopic dermatitis (C) from the National Health Insurance data in Korea 2003–2014. The study population included the entirety of the Korean population. The dashed line with asterisk corresponds to the maximal (Max) prevalence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

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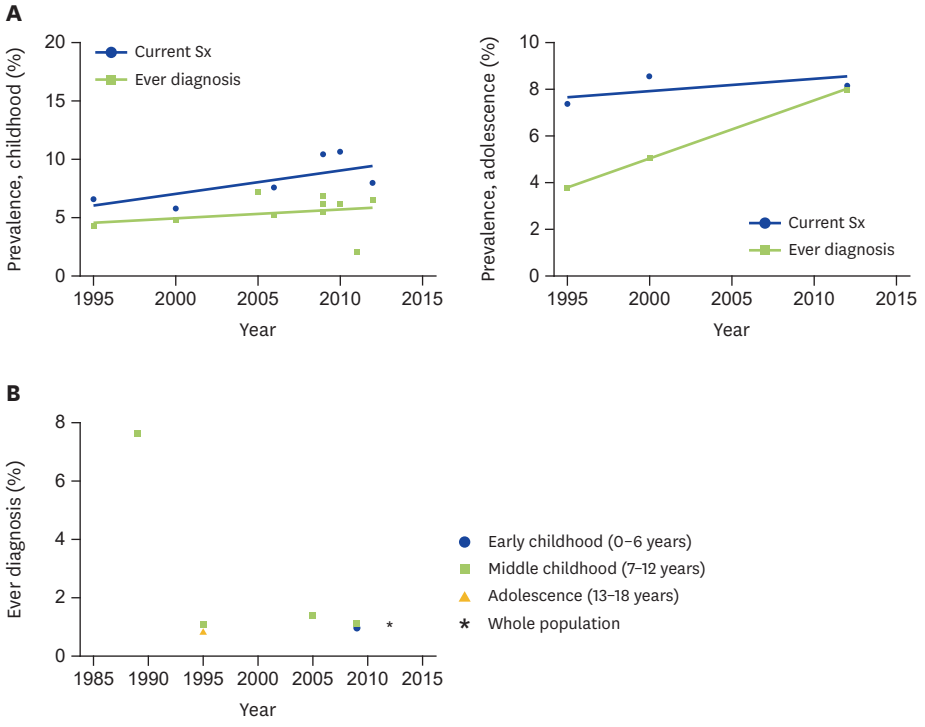

Fig. 5. Trends in the prevalence of allergic diseases by age groups during the study period for food allergy (A) and drug allergy (B). Sx, symptoms. Current symptoms defined as prevalence of symptoms of allergic diseases within the last 12 months. Ever diagnosis defined as lifetime prevalence of any 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

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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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