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, 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 and 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
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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).
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...
### 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, AR, AD, urticaria |
| Lee [16]    | 1998           | Nationwide               | 1994–1995               | 13,160              | Elementary/ middle/high school students | Questionnaires + SPT, MBPT | 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, Chunjung, 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, Golsan | 2001 | 2,432 | ≥20 | Modified ISAAC + SPT, MBPT | AS                     |
| Oh [28]     | 2003           | Seoul, Suwon, Chunjung, 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                     |
| Oh [29]     | 2004           | Seoul, Suwon, Chunjung, Chunju, Changwon, Chunchon, Cheju, Ulsan, Ansan: preschool age | 2003 (preschool age) | 1,511, preschool age | 5 (preschool) | Modified ISAAC | AD                     |
| Hong [29]   | 2004           | Seoul, Suwon, Chunjung, Chunju, Changwon, Chunchon, Cheju, Ulsan, Ansan | 1995, 2000 | 14,946/15,214 (95/00) | 12–15 | Modified ISAAC | AS                     |
| Oh [30]     | 2004           | Seoul, Suwon, Chunjung, 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, Chunjung, 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, 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 |
|---------|----------------|--------------------------|-------------------------|---------------------|----------------|----------------------|-------------------------|
| 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/ middle/high school students | Questionnaires + SPT | FA                      |
| Kim [50] | 2011           | Seoul                    | 2009                    | 917                 | 2–7           | Modified ISACA      | AS, AR, AD               |
| Kwon [51] | 2011          | Seoul                    | 2008                    | 4,554               | 9.5           | Modified ISACA      | AS                      |
| Suh [52] | 2011           | Nationwide              | 2006                    | 30,893              | 8–11          | Modified ISACA      | 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 | 2006–2009              | 2,729               | 7–11          | Modified ISACA      | AD                      |
| Jung [55] | 2011           | Seoul, Gwacheon, Ilsen  | 2010                    | 919                 | 1.5–8         | Modified ISACA      | FA                      |
| Yoon [56] | 2011           | Ulsan                   | 2010                    | 1,323               | 6–11          | ISACA + SPT         | AS, AR, AC, AD          |
| Kwon [57] | 2011           | Seoul                    | 2008                    | 1,376               | 9.4           | Modified ISACA      | 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 ISACA      | AD                      |
| Hwang [64] | 2012          | Seoul, Andong           | 2009                    | 1,819               | 6–13          | Modified ISACA      | AS                      |
| Lee [65]  | 2012           | Ulsan                   | 2009–2010               | 4,607               | 7–12          | Modified ISACA      | 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 ISACA + SPT | AS, AR, AD               |
| Lee [70]  | 2012           | Jeju                     | 2008                    | 5,249               | 0–6           | Modified ISACA      | 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 ISACA      | 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 ISACA      | 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       | AR                      |
| Lee [79]  | 2013           | Nationwide               | 2012                    | 27,679              | Elementary/high school students | Modified ISAAC | FA                      |
| Hong [80] | 2013           | Changwon                 | 2012                    | 2,118               | Elementary/middle school students | ISAAC        | AD                      |
| Song [81] | 2013           | Seongnam                 | 2005–2006               | 857                 | ≥65            | Questionnaires       | Chronic cough           |
| Song [82] | 2013           | Seongnam                 | 2005–2006               | 984                 | ≥65            | Questionnaires       | AS, rhinitis            |
| Hwang [83]| 2013           | Incheon, Ulsan, Jeju, Gyeonggi-do, Chungcheongbuk-do | 2010–2012              | 13,492              | Elementary/middle/high school students | ISAAC + PFT | AR                      |
| Kim [84]  | 2014           | Sancheong, Changwon      | 2007                    | 1,080               | ≥30            | Questionnaires + PFT, MBPT, sIgE | AS, AR, AD |
| Cho [85]  | 2014           | Nationwide               | 2012                    | 1,002               | 2–6            | Questionnaires       | AS, AR, AD |
| Rhee [86]| 2014           | Seoul                    | 2011                    | 16,749              | 0–6            | Questionnaires       | FA                      |
| Lee [87]  | 2014           | Nationwide (KNHANES)     | 2010                    | 2,305               | ≥0             | Questionnaires + PEx | AR                      |
| Kim [88]  | 2014           | 1 City, anonymous        | 2013                    | 2,415               | 6–59           | Modified ISAAC + SPT | FA                      |
| Yoo [90]  | 2015           | Nationwide               | 2003–2011               | 19,659              | 19–64          | Questionnaires + PFT | AS                      |
| Chang [91]| 2015           | 1 City, anonymous        | 2013                    | 6,398               | Elementary/middle 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              | Questionnaires | AS, AD |
| Kim [97]  | 2016           | Nationwide               | 2008–2014               | 19,874              | ≥0             | ISAAC + SPT          | 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.

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Am J Respir Crit Care Med. 2015;191(7):785–793. Study, using the Korean National Health Insurance data, involved the entire population of Korea.

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).
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
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.
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), case definition may be confounded if objective testing to differentiate asthma or allergic sensitization is absent. In addition, unlike the ISAAC project...
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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**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.
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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