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Epidemiology of adult asthma in Asia: toward a better understanding

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Asia is the world's most dynamic area. Asthma is a major chronic disease in Asia, like other continents. However, unlike childhood asthma, the epidemiological burden of asthma in Asian adults has been unclear. Here we reviewed the currently available literatures on the epidemiology of adult asthma in the Asian community populations. Adult asthma prevalence was generally lower in Asian than in Europe, but the increasing trends suggested the disease burden to rise in the near future. However, for better understanding, it may be essential to prepare for the Asian multinational network for the standardization and collaboration of research.

Key words: Asthma; Epidemiology; Review; Asia

INTRODUCTION

Asia is the world's largest and most populated continent. It covers 30% of the Earth's land area, and hosts 60% of the world's current population [1]. During recent decades, the Asian population has quadrupled, and the economy has enormously grown up [2]. Thus now, Asia is the world's most 'dynamic' region.

Asthma is a major chronic disease in Asia, like other continents [3, 4]. The prevalence of childhood asthma has continuously increased over the decades in Asia [5]. This increasing significance has been well reflected in the activity of asthma research in Asian countries, which has doubled during the last decade [6]. However, in Asian adults, the epidemiological burden of asthma is largely unknown this lack is quite in contrast to extensive and systemic research efforts ongoing for childhood asthma epidemiology such as the International Study of Asthma and Allergies in Childhood (ISAAC) projects in Asian children [5].

How prevalent is asthma in Asian adult community populations? Is asthma increasing in Asian adults too? If we extrapolate previous findings from Asian children or the European Community

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Respiratory Health Survey (ECRHS) [7], we might simply expect that asthma is also increasing among Asian adult populations. However, factors underlying the epidemiology are not uniform across different demographic groups; and thus, there should be many questions to be directly answered in this population.

Here we aimed to review the literature on the epidemiology, and to identify tasks to improve our understanding of asthma in Asian adult populations.

LITERATURE SEARCH

We conducted a semisystematic literature review to identify papers reporting the prevalence of asthma among Asian adult community populations. The PubMed was searched with the term 'asthma AND (epidemiology OR prevalence OR incidence)' for Asian countries. The publication period was not restricted, but the language was confined to English publication. Finally, we identified 42 original studies reporting the asthma prevalence in Asian adults. Outcomes were extracted for study design, population, research questions, case definition, and asthma prevalence (Tables 1–3).

HOW PREVALENT IS ADULT ASTHMA IN ASIA?

Prevalence data from nationwide surveys were summarized in Table 1. A total of 14 prevalence data have been reported from 9 countries. The prevalence varied from 0.7% to 11.9%, but the asthma definitions varied widely. Only one study had utilized objective testing (bronchodilator response) to define asthma, whereas others used questionnaires. Seven studies asked the

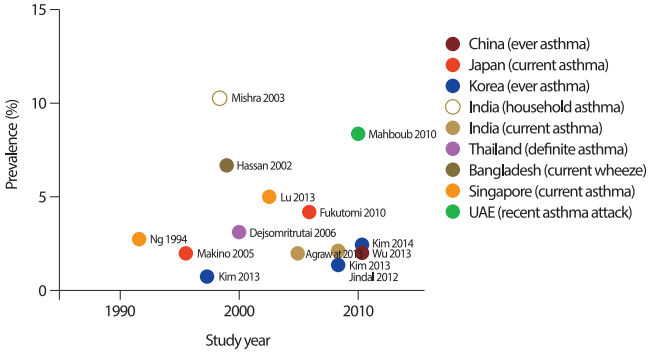

Fig. 1. Cross-sectional prevalence of adult asthma from nationwide studies in Asia. Reference label indicates the first author and publication year [9-14, 19, 28, 38, 39, 44, 51, 57].

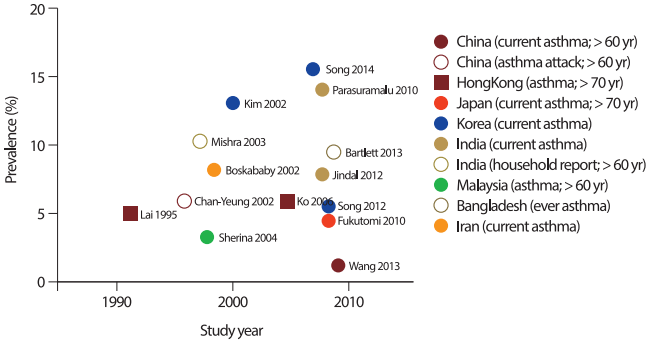

Fig. 2. Cross-sectional prevalence of elderly asthma in Asian countries. Reference label indicates the first author and publication year [10, 11, 15, 17, 20, 21, 25, 31, 32, 34, 45, 49, 51, 58].

1-year prevalence of 'current asthma (defined by recent symptoms plus physician diagnosed asthma)' [8-14], but their definitions also varied between studies. These nationwide findings were depicted in Fig. 1.

Local area surveys were summarized in Table 2 (28 studies from 13 countries). Specifically, local area prevalence in China was reported as 0.7–3.8% [15-19]. In two Korean local area studies, current asthma prevalence was 3.6–5.8% when defined by combination of questionnaire and methacholine challenge tests [20, 21]. In Ulaanbaatar, Mongolia, ever physician diagnosis of asthma varied from 1.1% in 1999 to 4.7% in 2009 [22, 23]. In Iran, three different local area surveys found current asthma prevalence as 1.4–6.1% [24-26]. In Al Ain, the United Arab Emirates, asthma prevalence was the highest as 12%, but the definition was not strict [27]. Four local area studies were conducted in India; the prevalence of current asthma ranged from 2.4% to 3.5% [28-31]. Other South & Southeast Asian studies found 2.4–3.9% prevalence [32-36].

Interestingly, asthma was frequently reported to increase with aging in Asia. In two different local population surveys in Korea, current asthma (defined by current wheeze and positive airway hyperresponsiveness) was consistently more prevalent among the elderly (12.7–15.3%) [20, 21]. These age-related increase were similarly observed in several questionnaire-based studies from China [15, 17], Taiwan [37], Mongolia [22], Korea [38], Iran [25], India [8, 11, 28, 31], and Bangladesh [32, 39]. In Japanese nationwide surveys using questionnaires, only wheeze but not physician diagnosed asthma increased with aging [10]. The age-specific prevalence of asthma in elderly groups (≥60–70 years old) was presented in Fig. 2.

Despite the heterogeneity in study designs and years, we presented a crude prevalence map in order to have a quick

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Table 1. Nationwide prevalence data for adult asthma in Asian countries

First author, publication year [reference]	Area	Study year	Participants (n, age)	Recruitment, dataset	Prevalence	Asthma definition
Wu 2013 [19]	China	2010	n = 13,157, ≥50 yr	Random sample, the study on global AGEing and adult health China wave 1	Asthma: 1.9%	Have you ever been diagnosed with asthma by a health care professional?
Hwang 2010 [56]	Taiwan	2000–2007	n = 997,729; mean age, 33.8 yr	Random selection, National Health Insurance register database	Asthma: 2.9%	Diagnostic code (ICD-9-CM)
Makino 2005 [57]	Japan	1996	n = 11,495, adults (age not specified)	The Coordinated Research Project on Long-Term Chronic Disease	Asthma: 1.7%	Symptoms based on ATS-DLD questionnaire
Fukutomi 2010 [10], or Fukutomi 2012 [48]	Japan	2006–2007	n = 23,483, 20–79 yr	Random sample	Current asthma: 4.2%	"Have you ever had asthma?" and "Was this confirmed by a doctor?" and "Having at least one asthma-related symptom in the last 12 months."
Kim 2013 [38]	Korea	1998, 2008	n = 7,146 (1998), n = 4,980 (2008), 20–59 yr	Random selection, the Korean National Health and Nutrition Examination Survey (KNHANES) I and IV	Physician-diagnosed asthma: 0.7% and 2.0%	Have you ever been diagnosed with asthma by a doctor?
Kim 2014 [44]	Korea	2007–2011	n = 19,659, 19–64 yr	Random selection, KNHANES V	Asthma: 2.4%	Have you ever been diagnosed with asthma by a doctor?
Mishra 2003 [51]	India	1998, 1999	n = 38,595, ≥60 yr	Multistage cluster sample, National Family Health Survey 2 (NFHS-2)	Asthma: 10.3%	Does anyone listed (in the household) suffer from asthma?
Jindal 2012 [11]	India	2007–2009	n = 169,575, ≥15 yr	Random sample, the Indian Study on Epidemiology of Asthma, Respiratory Symptoms and Chronic Bronchitis	Asthma: 2.0%	Positive to at least one of the two questions on wheezing and tightness of the chest, plus one of the three questions on history of previous diagnosis of asthma, an attack of asthma and use of medication for asthma, in the past 12 months
Agrawal 2013 [8]	India	2005, 2006	n = 157,186, 20–49 yr	Multistage cluster sample, NFHS 3	Asthma: 1.9%	Do you currently have asthma?
Dejsomritrutai 2006 [9]	Thailand	2000	n = 3,454, 20–44 yr	Multistage stratified random sample	Definite asthma: 2.9%	Reversible airway obstruction by spirometry, or any asthma symptoms within the last 12 months in addition to bronchial hyperresponsiveness
Hassan 2002 [39]	Bangladesh	1999	n = 5,642, mainly 15-44 yr (≥5 yr)	Random selection and face-to-face interview	Asthma (recent wheeze): 6.9%	Having the whistling sound arising from the chest and not from the nose or throat within the last 12 months
Ng 1994 [14]	Singapore	1992	n = 2,868, 20–74 yr	Stratified disproportionate random sample, the Singapore Adult Respiratory Health Study	Current asthma: 2.2%	Current asthma symptom (any of episodic wheeze, attack of shortness of breath, nocturnal attack of wheeze or shortness of breath within the past year) and physician diagnosed asthma
Lu 2013 [12]	Singapore	2003–2004	n = 2,847, 20–59 yr	Random sample, the National Mental Health Survey of Singapore	Asthma: 5.1%	"In the past 12 months, have you been told by a doctor, nurse, or other health professional that you had asthma?" and "Do you still have asthma?"
Mahboub 2012 [13]	United Arab Emirates	2010	n = 1,220, age 20–44 yr	Random sample	Asthma attack: 8.0%	Have you had an attack of asthma in the last 12 months?

ICD-9-CM, The International Classification of Diseases, 9th revision, clinical modification; ATS-DLD, American Thoracic Society-Division of Lung Disease.

Table 2. Local prevalence data for adult asthma in Asian countries

First author, publication year [reference]	Area	Study year	Participants (n, age)	Recruitment, dataset	Prevalence	Asthma definition
East Asia						
Xu 1993 [52]	Beijing, China	1986	n = 3,606, 40–69 yr	Random sample	Asthma: 3.8%	"Have you ever had asthma?" and "Was the asthma diagnosed by a physician?"
Lai 1995 [58]	Hong Kong, China	1991–1992	n = 2,032, ≥70 yr	Random sampling from the old age and disability allowance list and postal survey	Asthma: 5.1%	Have you had asthma?
Chan-Yeung 2002 [15]	Beijing (rural area), China	1996–1997	n = 22,561, ≥15 yr	Random selection	Asthma attack: 0.7%	Have you had an attack of asthma in the last 12 months?
Ko 2006 [45]	Hong Kong, China	2003–2004	n = 1,524, ≥70 yr	Random sampling and telephone survey	Asthma: 5.8%	Have you had asthma?
Wilson 2008 [18]	Liaoning, China	2002	n = 31,704; mean age, 47.7 yr	Parents and grandparents of schoolchildren	Asthma: 1.0%	All of the following: History of a wheezing attack that caused sudden shortness of breath, history of ≥wheezing attacks. Diagnosis of asthma by a doctor
Shi 2012 [16]	Jiangsu, China	2007	n = 1,486, ≥20 yr	Random sample, the Chinese National Nutrition and Health Survey	Asthma: 1.4%	Have you been diagnosed with asthma by a doctor?
Wang 2013 [17]	Jinan, China	2009	n = 13,419, all ages	Random sample	Asthma: 0.8%	Both of (1) "Have you ever been diagnosed with asthma by a physician?" and/or "Have you ever had asthma?"; and (2) "In the past, at any time, have you experienced recurrent (more than three times) sudden attacks of at least one of the following symptoms: whistling in the chest or paroxysmal dyspnea, wheezing, chest tightness or cough?"
Jan 2004 [37]	Taipei, Taiwan	1999	n = 2,076, ≥18 yr	Cluster sampling	Current asthma: 4.1%	Diagnosed as asthma by physician, or "Does your chest sound wheezy or whistling when you have a cold?" or "Does your chest sound wheezy or whistling occasionally apart from when you have a cold?"
Fukutomi 2011 [43]	Fujieda, Japan	1999 and 2006	n = 4,187 and n = 3,935, ≥15 yr (1999) and 20–79 yr (2006)	Door-to-door survey, and postal survey	Current asthma: 1.5% (1999) and 3.4% (2006)	"Have you ever been diagnosed with asthma?" and any of asthma symptoms in the recent 2 years (1999) "Have you ever had asthma?" and "Was this confirmed by a doctor?" and having one or more asthma symptoms in the last 12 months (2006)
Kim 2002 [20]	Four cities (urban and rural), Korea	2000	n = 2,467, ≥20 yr	Random sample from the health service list	Current asthma: 3.6%	Wheezing within the recent 12 months and positive AHR

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Table 2. Continue

First author, publication year [reference]	Area	Study year	Participants (n, age)	Recruitment, dataset	Prevalence	Asthma definition
Song 2012 [49], or Song 2013 [54]	Seongnam, Korea	2005–2006	n = 994, ≥65 yr	Random sample	Current asthma: 5.4%	"Have you ever had been diagnosed with asthma?" and "Have you had a wheezing or whistling in the chest during the last 12 months?"
Song 2014 [21], or Choi 2011 [53]	Changwon and Sancheong, Korea	2007	n = 1,080, ≥30 yr	Community residents	Current asthma: 5.8%	"Have you had a wheezing or whistling in the chest during the last 12 months?" and positive methacholine AHR
Viinanen 2005 [23]	Ulaanbaatar, Mongolia	1999–2000	n = 9,453, 10–60 yr	Random sample from the files of family doctors	Asthma: 1.1%	Have you ever had asthma?
Sonomjamts 2014 [22]	Ulaanbaatar, Mongolia	2009	n = 1,201, ≥20 yr	Random selection from family clinics	Doctor diagnosed asthma: 4.7%	Have you ever been diagnosed to have asthma?
West & Central Asia						
Schachter 1984 [59]	Conn, Lebanon	1978	n = 1,303, ≥7 yr	Community sample	Asthma: 6.0%	Have you ever had bronchial asthma?
Boskabady 2002 [25]	Mashhad, Iran	1999	n = 5,579, ≥20 yr	Random sample	Asthma: 2.8%	(1) Two or more asthma symptoms (recurrent wheeze, recurrent cough or tightness at rest, night cough and wheeze or cough during exercise) or (2) Previously diagnosed with asthma
Golshan 2002 [26]	Isfahan (rural), Iran	2000	n = 994; mean age, 25.2 yr	Random selection and inhabitant contact	Current asthma: 6.1%	Either any history of physician-diagnosed asthma resulting in intermittent use of antiasthmatic drugs or a recent history (within the past 12 months) of dyspnoeic attacks combined with wheezy breathing
Rahimi-Rad 2008 [24]	Urmia, Iran	2004	n = 2,987, 20–44 yr	Random cluster sample	Current asthma: 1.4%	"Have you had an attack of asthma in the last 12 months?" or "Are you currently taking any medication (including inhalers, aerosols or tablets) for asthma?"
Alsowaidi 2010 [27]	Al Ain, United Arab Emirates	2007–2008	n = 6,543, ≥13 yr (median 30 yr, adolescents and parents)	Multistage random sample	Asthma: 12%	Having had wheezing in the past 12 months, or ever had asthma?
South & Southeast Asia						
Chowgule 1998 [29]	Mumbai, India	1992–1995	n = 2,213, 20–44 yr	Random selection ECRHS phase I	Asthma: 3.5%	(1) Have you had an attack of asthma in the last 12 months? or (2) Are you currently taking any medicine (including inhalers, aerosols, or tablets) for asthma?

Table 2. Continue

First author, publication year [reference]	Area	Study year	Participants (n, age)	Recruitment, dataset	Prevalence	Asthma definition
Jindal 2000 [30]	Chandigarh, India	1995–1997	n = 2016, ≥18 yr	Home visit	Asthma: 2.8%	One or both of two questions: (1) Have you ever had wheezing or whistling sounds in your chest at any time in the last 12 months? (2) Have you woken up with a feeling of tightness in your chest first thing in the morning at any time in the last 12 months? and, one or more of three questions: (1) Have you ever had asthma? (2) Have you had an attack of asthma at any time in last 12 months? (3) Are you currently using any medicine including inhalers, aerosols, or tablets for asthma?
Aggarwal 2006 [28]	Several regions, India	2000s?	n = 73,605, ≥15 yr	Random selection	Asthma: 2.4%	Both to (1) wheezing or whistling sound from chest, or chest tightness or breathlessness in morning, and (2) having suffered from asthma, or having an attack of asthma in past 12 months, or using inhaled or oral bronchodilators.
Parasuramalu 2010 [31]	Bangalore, India	2008	n = 3,194, ≥18 yr	Cluster sample	Asthma: 2.9%	(1) whistling sound from chest, or chest tightness, or breathlessness in the morning, and (2) having suffered from asthma, or having an attack of asthma in the past 12 months, or using bronchodilators
Bartlett 2013 [32]	Two rural (Abhoynagar and Mirsarai) and one urban areas (Kamalapur), Bangladesh	2009	n = 32,665, >25 yr	Household visits	Asthma: 3.9%	Have you had ever been diagnosed with asthma?
Lam 2011 [33]	Northern Vietnam (urban and rural)	2007–2008	n = 5,782, 23–72 yr	Random sample and field survey	Physician diagnosed asthma: 3.9%	Have you been diagnosed as having asthma by a physician?
Sy 2007 [36]	Dalat, Vietnam	2004	n = 9,984, mostly ≥15 yr	Random sample	Asthma or asthma-like symptoms: 2.4%	Have you been diagnosed as asthma by a physician? or any of 1. "Have you heard wheezing in your chest at any time in the last 12 months?" 2. "Have you felt as if you were suffocating while reclining during the day at any time in the last 12 months?" 3. "Have you been awakened by an attack of breathlessness at any time in the last 12 months?"
Sundaru 2005 [35]	Jakarta, Indonesia	Before 1990	NA	NA	Asthma: 3.4%	Doctor diagnosed asthma
Sherina 2004 [34]	Selangor, Malaysia	1999	n = 223, ≥60 yr	Stratified proportionate cluster sample	Asthma: 3.1%	Diagnosed by certified doctors

AHR, airway hyperresponsiveness; ECRHS, European Community Respiratory Health Survey; NA, not available.

Table 3. Summary of research questions addressed in individual studies

Addressed questions	Reference
Cross-sectional prevalence	[8-11, 13-15, 17-20, 22-37, 39, 56-59]
Longitudinal prevalence trends	[38, 43, 45]
Association with smoking	[31, 33]
Association with obesity	[48, 49]
Association with socio-demographic factor	[32]
Association with kimchi intake	[44]
Association with serum vitamin D level	[50]
Association with indoor air pollution from biomass combustion	[51]
Association with psychiatric disorder	[12]
Association with occupational dust/gas/fume exposure	[52]
Association with monosodium glutamate intake or dietary pattern	[16]
Association with clonorchis infection	[53]
Association with staphylococcal enterotoxin IgE	[21]
Association with rhinitis	[54]
Risk factor exploration	[8, 11, 14, 17, 18, 20, 22, 24, 27, 28, 37, 39]
Comparison with western populations	[15, 58]

glimpse of geographical variation of asthma prevalence in Asian countries (Fig. 3). Each representative prevalence was primarily retrieved from nationwide data, if available; otherwise, the pooled estimation from available local area studies was utilized as alternatives. To summarize, currently available data indicated that crude asthma prevalence was generally less than 5% in Asian adults. The Asian prevalence estimate was lower than the European data from the ECRHS phase I surveys (median, 4.5%; range, 2.0–11.9% in stage 1; and median, 5.2%; range, 1.2–13.0% in stage 2 [7]). These geographical difference between Asian and European populations were in line with the ISAAC surveys for childhood asthma [40].

IS ASTHMA INCREASING IN ASIAN ADULTS?

In a recent systematic review, 48 well-designed cohort or repeated cross-sectional studies were analyzed to determine if asthma prevalence was declining recently (1990–2008) [41]. The analyses concluded that asthma prevalence recently continues to increase or remains stable in most parts of the world. However, the included studies were mostly childhood population studies, or from western populations, possibly due to lack of high quality longitudinal studies in Asian adult populations. In European adults, the ECRHS phase I and II comparison analyses (1991–1993 vs. 1998–2003) found the significant increase in 'asthma attack' (+0.8%; 95% confidence interval [CI], 0.2 to 1.4; $p = 0.001$), 'current asthma medication (+2.1%; 95% CI, 1.6 to 2.6; $p < 0.001$) or 'diagnosed asthma' (+2.2%; 95% CI, 1.6 to 2.9; $p = 0.037$), but no significant change in 'current wheeze' (–0.9%; 95% CI, –1.9 to 0.2; $p = 0.122$) over the 5- to 10-year follow-ups of young adults [42].

In our review, temporal changes in Asian adult asthma prevalence were identified in three countries (Japan [43], Korea [38, 44], and Hong Kong [45]). Interestingly, the data demonstrated consistent trends for increasing prevalence, in several asthma definitions including ever asthma, current asthma, or current wheeze (Fig. 4). Statistical significance was directly calculated in the 12-year comparison studies from Hong Kong [45]; they found significant increase in current wheeze (7.5% in 1991 vs. 12.1% in 2003; $p < 0.01$) but borderline significance in ever asthma (5.1% in 1991 vs. 5.8% in 2003; $p = 0.065$). In a suburban area in Japan, current wheeze (4.2% in 1985 vs. 7.6% in 1999), ever asthma (5.1% in 1999 vs. 6.7% in 2006) and current asthma (1.5% in 1999 vs. 3.4% in 2006) all showed consistent increase over time [43].

It is not certain whether the adult asthma is also increasing in other Asian countries, as no other longitudinal data are currently available; however, considering the rapid urbanization in Asia, the prevalence is expected to increase in various developing countries. Within the same inherent genetic background, living areas have been associated with the risk of childhood asthma [46]. Adult asthma may be carried over from childhood disease, or newly develop by occupational or environmental irritant exposure [47].

WHICH QUESTIONS HAVE BEEN ADDRESSED SO FAR?

We summarized the research questions addressed in individual studies based on their study purposes (Table 3). Prevalence estimation and risk factor exploration were the most frequent topic. Otherwise, various specific factors were examined in relation to asthma risk, including lifestyle factors (obesity [48, 49] and

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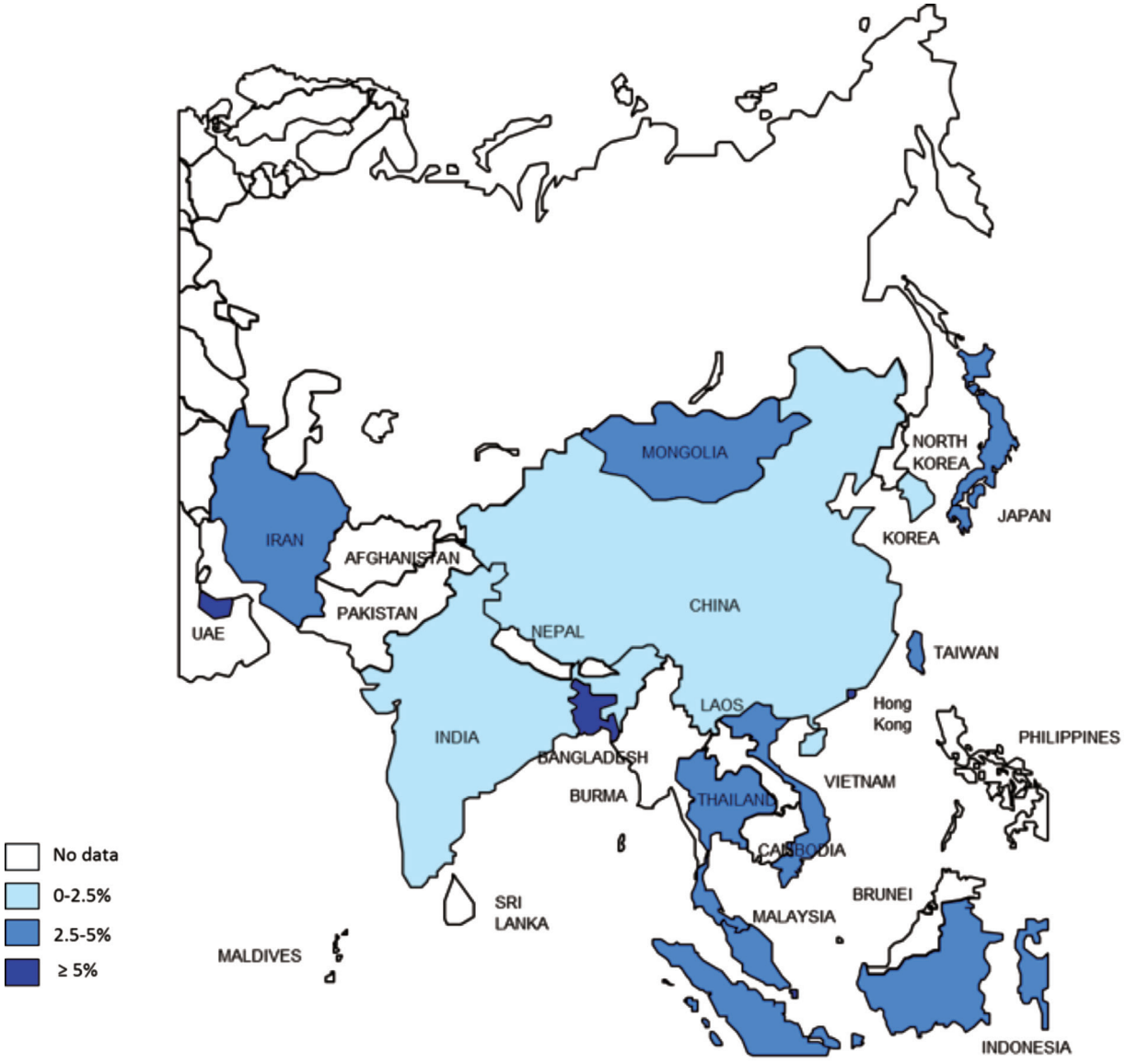

Fig. 3. Geographical difference of adult asthma prevalence in Asian countries. The representative prevalence was primarily retrieved from nationwide data if available. Otherwise, the summation of local area studies were utilized as alternative.

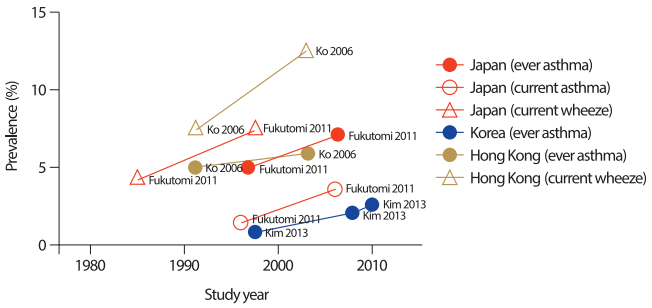

Fig. 4. Changes in the prevalence of asthma in Asian adults. Reference label indicates the first author and publication year [38, 43-45].

smoking [31, 33]), dietary or nutritional factors (vitamin D level [50], kimchi [44] or monosodium glutamate intake [16]), pollutant exposure [51, 52], psychiatric disorder [12], clonorchis infection [53], rhinitis [54], or staphylococcal enterotoxin sensitization [21]. These topics of interests have reflected the ideas of Asian researchers, regarding what may underlie the adult asthma.

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TOWARD A BETTER UNDERSTANDING OF ASTHMA IN ASIANS

Here we summarized the current status of epidemiological research on adult asthma in Asia. Overall prevalence was lower than 5% in Asian adult community populations, which appeared less prevalent than in European adult populations. Importantly, the prevalence of elderly asthma was 1.3–15.3% in Asia, which is relatively high. Because of the population aging due to rising life expectancy and/or declining birth rates in Asia, we have to pay attention to the elderly asthma in this region. However, the methodological heterogeneity was a major limitation hindering the comparison of regional prevalence, despite that the number of conducted studies was not so small in Asia. Temporal trends in prevalence suggested the recent increase of adult asthma in Hong Kong, Japan, and Korea; however, the findings warrant replication in other Asian developing countries.

For these, the utilization of standardized questionnaire tools needs to be encouraged in Asian countries. Although there is no gold standard definition for asthma in epidemiological surveys, at least the academic consensus should be made on the common framework and protocols. The ECRHS and the Global Allergy and Asthma European Network (GA2LEN) projects may be excellent examples to follow. The ECRHS project was initiated for adult respiratory diseases in 1990, consisting of 140,000 participants from 22 countries [7]; currently, the ECRHS phase III follow-up survey is undergoing. The GA2LEN project, consisting of 60 allergy centers from 20 European countries, was a more recent collaboration to integrate European research efforts and capacities for allergy and asthma, and to establish permanent international research network [55]. In each of the projects, the study protocols have been shared in every participating center. In this regard, it may be necessary to prepare for establishing the Asian network for allergy and asthma epidemiological research collaboration. The first workgroup meeting may be held in the next meeting of the Asia Pacific Association of Allergy, Asthma and Clinical Immunology.

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