Journal of Asthma and Allergy

Dovepress
open access to scientific and medical research

Open Access Full Text Article

ORIGINAL RESEARCH

Global Burden of Asthma, and Its Impact on Specific Subgroups: Nasal Polyps, Allergic Rhinitis, Severe Asthma, Eosinophilic Asthma

Adrian Paul J Rabe[1,2], Wei Jie Loke[3], Khushboo Gurjar[4], Allison Brackley[5], Don Eliseo Lucero-Prisno III[6,7]

[1]BioPharmaceutical Medical, Respiratory & Immunology, AstraZeneca, Cambridge, UK; [2]Imperial College, London, UK; [3]East and North Hertfordshire NHS Trust, Stevenage, UK; [4]RWA Health Economics, Cytel Health Canada, Toronto, Ontario, Canada; [5]RWA Health Economics, Cytel, Inc, Waltham, MA, USA; [6]Department of Global Health and Development, London School of Hygiene and Tropical Medicine, London, UK; [7]University of the Philippines Open University, Los Baños City, Philippines

Correspondence: Allison Brackley, Cytel, Inc, 1050 Winter Street, Center Entrance 3rd Floor, Waltham, MA, 02451, USA, Tel +1 617 661 2011, Fax +1 617 661 4405, Email brackleyallison@gmail.com

Background: The complex nature of asthma has resulted in a poor understanding of its epidemiology, particularly in low-and middle-income countries (LMIC). Clinical subgroups, such as patients with severe asthma, eosinophilic asthma, allergic rhinitis, or nasal polyps, experience additional barriers to care.

Methods: Prevalence estimates for asthma and key clinical subgroups were extracted from the Global Burden of Diseases, Injuries, and Risk Factors Study 2019 and from a targeted literature review conducted through PubMed in October of 2021. National estimates were calculated and the roles of potential explanatory factors were explored through qualitative analysis.

Results: In total, 162 publications from 69 countries were included. Across continents, asthma prevalence values ranged from 3.44% (Asia), 3.67% (Africa), 4.90% (South America), 5.69% (Europe), 8.29% (North America), to 8.33% (Oceania). Globally, of those with asthma, 26.70% had severe asthma, 30.99% had eosinophilic asthma, 48.95% had allergic rhinitis, and 7.0% to 25.40% had nasal polyps. Countries with higher air quality, income status, and healthcare access and quality reported a higher asthma prevalence.

Conclusion: Asthma prevalence values were low in LMICs, potentially indicating health system deficiencies resulting in low diagnosis and reporting. The prevalence of eosinophilic asthma and severe asthma phenotypes was high in many countries, although the prevalence estimates of all asthma subgroups were quite variable.

Keywords: epidemiology, diagnosis, prevalence, low- and middle-income countries

Introduction

Asthma commonly presents as heterogeneous respiratory symptoms such as coughing, wheezing, shortness of breath, and chest tightness, which can complicate the diagnostic process.[1] While the use of clinical tests (eg, spirometry) is preferred for asthma diagnosis, real-world practices are heterogeneous and often reflect a lack of resources or medical training, particularly in low-or-middle-income countries (LMIC), although significant variations exist on a within-country scale.[1,2] Differences in diagnostic practices can result in underreporting and difficulty interpreting prevalence estimates.[1]

Aggressive treatment of early-disease asthma and the use of disease-modifying therapies may promote asthma remission.[3] Despite evidence that practical remission is a reasonable goal for many patients with asthma, symptom management is the objective most often considered by clinicians for adults. Some subpopulations of patients with asthma, however, face additional challenges in achieving remission, particularly those with certain asthma phenotypes, such as eosinophilic asthma (EA) or severe asthma (SA), and those with additional respiratory conditions, such as allergic rhinitis (AR) or nasal polyps (NP).

EA is characterized by eosinophilia in tissue and sputum and a thickening of the basement membrane.[4–6] Some patients with EA respond well to corticosteroids, while others experience improvements in exacerbation frequency, but not symptom

Received: 21 April 2023
Accepted: 24 September 2023
Published: 6 October 2023

intensity.[5] Other patients with EA are "steroid-refractory", or resistant to corticosteroids altogether, and often have better outcomes when treated with leukotriene receptor agonists.[5]

The European Respiratory Society and American Thoracic Society defines SA as asthma that can only be managed with a high dose of corticosteroids and a secondary controller, or asthma that is uncontrolled even with a high dose of corticosteroids and a secondary controller.[7] The prevalence of patients with SA who experience uncontrolled asthma, even when treated with a corticosteroid and secondary controller, was estimated at 12.9% to 100.0% in a recent systematic literature review that also considered patients with moderate asthma.[8]

Patients with AR experience inflammation of the nasal mucosa following exposure to environmental allergens.[9] Common symptoms include sneezing, rhinorrhea, itch, and nasal congestion. AR is usually treated with over-The-counter medication, making prevalence estimations difficult to ascertain.[9] AR often exists alongside asthma and worsens asthma symptoms while increasing the frequency of exacerbations and hospital visits.[9] Patients with AR often face a higher burden in accessing care, as visits with an ear, nose, and throat specialist or allergist may be required for treatment.[9]

Asthma may also be accompanied by chronic sinusitis with NPs.[10] NPs are hyperplastic, inflammatory outgrowths of the sinonasal mucosa.[11] Despite their characterization as benign, the inflammation from NPs can result in disruptive symptoms such as edema, loss of taste and/or smell, and chronic nasal congestion.[11]

The ongoing effort to improve care and reduce negative health outcomes relies on continually improving the epidemiological knowledge base for asthma and its associated comorbidities. Prevalence data informs the understanding of the clinical and economic burden of disease, while accurate epidemiology measures are used in priority setting by national health programs and medical societies. Despite the ubiquity of asthma and its clinical significance, there remains a need for further understanding of the global distribution of patients with asthma, and prevalence data for key clinical subgroups.

The goal of this study was to determine the global prevalence of asthma and its aforementioned phenotypes (EA and SA), along with the prevalence of asthma with AR or NPs, and to explore underlying drivers for the observed patterns. To do this, we examined the scientific literature for studies reporting asthma and subgroup prevalence, and compared our results to country-specific qualities like economic status and air quality.

Methods

Asthma Prevalence

To facilitate a comparison of asthma prevalence with the prevalence of its key clinical subgroups, asthma prevalence values for 69 countries were taken from the 2019 Global Burden of Disease (GBD) Study, which based its estimates on 405 sources from epidemiological reports and scientific literature.[12] Conducted by the World Health Organization (WHO), the 2019 GBD study represents the most complete standardized analysis of asthma incidence and prevalence worldwide. To estimate the prevalence of asthma by continent, asthma prevalence values were used with World Bank estimates of country population using the following equation:[13]

$$\text{Asthma prevalence per Continent} = \left(\sum \text{Country populations}\right)\left(\sum \text{Country prevalence values}\right)/\left(\sum \text{Country populations}\right)$$

Please note that all equations used were adapted from the Centers for Disease Control and Prevention (CDC) guide to epidemiological statistics.[14]

Asthma Subgroup Prevalence

A targeted literature review was conducted in October of 2021 to calculate the prevalence of key subgroups of the asthma population. The search methodology is outlined in Figure S1. Nine key studies with prevalence estimates for clinical subgroups were identified using PubMed (Table S1).[15–23] The studies included primarily real-world evidence, along with several reviews, and formed the base of the pearl-growing (ie, snowballing) technique used to find additional sources of the same level of relevance and authority.[24] Publications were identified retrospectively (ie, bibliographic) and prospectively (ie, cited by) along with keywords from the nine studies; the process was repeated several times to amass a focused collection of evidence. Additional sources were obtained by using keyword searches of four journals known to publish many epidemiological studies related to asthma: Allergy, BMC Pulmonary Medicine, European Respiratory Journal, and Journal of Allergy and Clinical Immunology Practice. Where available, 10 or more studies were included per country/disease category. The evidence base was built using articles with a substantial discussion of asthma prevalence along with subgroup data. Data on both children and adults were considered. Papers published earlier than 2011, those that lacked extrapolation content, and those that used epidemiology data already encountered in literature were excluded. After gathering several sources for each country and disease category combination, the prevalence estimate (range or point estimate) from the study with the largest number of participants was included in the dataset; this approach was selected because within studies with a valid methodology, studies with a higher number of participants were less likely to report findings influenced by random effects and unmeasured confounders. Where country-specific values were not available, continental values were used.

The following equation was used to calculate the country-specific subgroup prevalence of EA, SA, AR, and NPs where direct prevalence estimates were not available:

$$\text{Country subgroup prevalence} = (\text{Country population x Asthma prevalence})(\text{Subgroup prevalence})$$

To calculate the average prevalence of each subgroup within the population of those with asthma, all ranged values were excluded. A crude average was taken of the remaining values by summing the prevalence values of countries within a continent and dividing them by the number of countries. Some subgroup prevalence values were inflated to match the 2020 country population, using the formula below and country-specific growth rates from the World Bank, where x denotes the year the prevalence value was published:[13]

$$\text{Prevalence in 2020} = (\text{Prevalence at x})(1 + \text{Country specific growth rate})^{2020-x}$$

Country-Specific Factors Affecting Global Prevalence Distributions

A qualitative analysis was conducted to better detect patterns in prevalence and reporting by country and region. Asthma prevalence values were aggregated according to 2020 Air Quality Index (AQI) values, 2022 World Bank economic status, and 2017 Institute for Health Metrics and Evaluation Healthcare Access and Quality (HAQ) values.[13,25,26] Scatterplots were generated to visually identify patterns of high and low prevalence using RStudio©.

Results

Asthma Prevalence

Reported asthma prevalence ranged from 1.43% in Bangladesh to 11.25% in the United States (US) (Figure 1, Table 1). Asia had the lowest reported asthma prevalence of any continental region at 3.44%, as well as the lowest country-specific prevalence value: Bangladesh, at 1.43%. Reported prevalence values in most of the other Asian countries fell between 2% and 4%, with the highest reported prevalence found in the United Arab Emirates (7.55%). Africa had the second-lowest reported prevalence of asthma, at 3.68%; most African countries had a reported asthma prevalence between 3% and 4.5%. South America had an asthma reported prevalence of 5.06%, with most countries reporting values quite close to the regional estimate. The European reported asthma prevalence was 5.86%, with considerable variation across countries; the lowest value was reported in Serbia (3.05%), while the highest was reported in the UK (10.07%). Australia and New Zealand both had relatively high reported asthma prevalence, at 9.66% and 7.00%, respectively. In North America, Canada's reported asthma prevalence was 5.32%, in line with many South American countries, while the US had the highest reported asthma prevalence in the dataset, at 11.25%.

Asthma Subgroup Prevalence

In total, 162 publications were identified using pearl-growing and targeted search techniques. Globally, of those with asthma, 25.71% reported SA, 30.70% EA, 49.01% AR, and 7.54% NPs (Table 2, Figures S2–S5). The reported prevalence of clinical subgroups was highly variable across countries, especially for AR and EA. The reported prevalence of SA was high in some countries that had a lower reported prevalence of general asthma, such as India (asthma: 2.75%, SA: 50.0%) and Nigeria (asthma: 3.68%, SA: 39.2%).

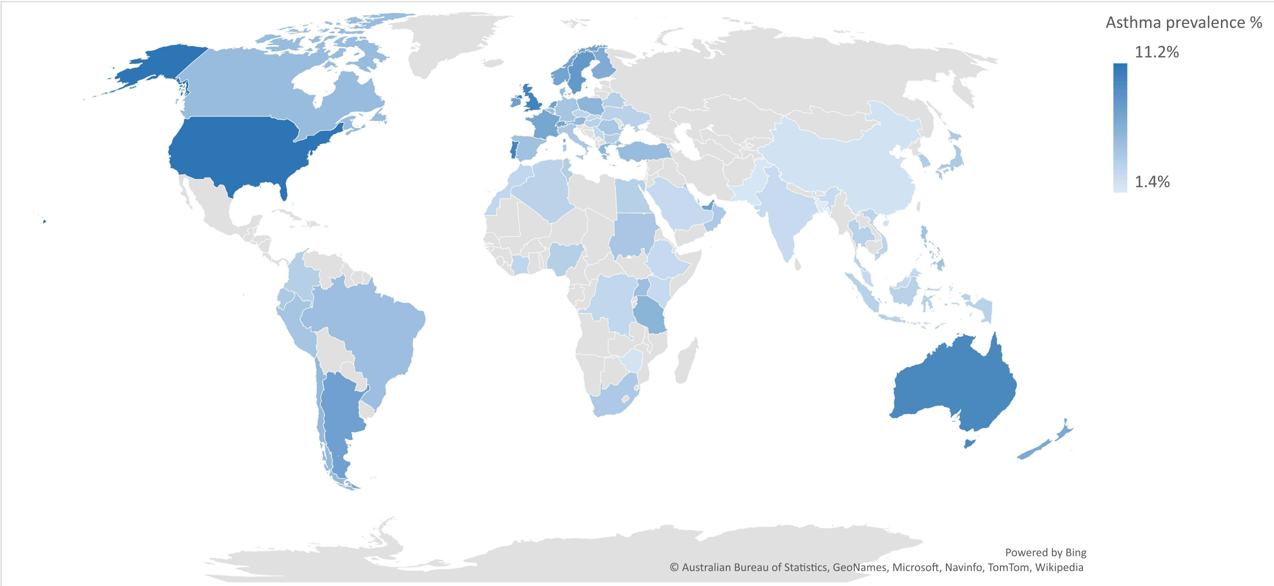

Figure 1 The global prevalence of asthma.

Country-Specific Factors Affecting Global Prevalence Distributions

AQI values (higher scores denote worse air quality) ranged from 5 for Finland and Sweden to 77.1 for Bangladesh. AQI values were not reported for 14 countries. HAQ values (higher scores denote better quality) ranged from 40.4 for the Democratic Republic of the Congo to 91.8 for Switzerland. World Bank economic status placed each nation into a discrete category: high (32 countries), upper-middle (16 countries), lower-middle (16 countries), and low (three

Table 1 Annual Asthma Prevalence Rates by Country

	Year	%	Rate per 100,000	Upper Interval	Lower Interval
North America	2019	8.29%	7608	8937	6517
United States of America	2019	11.25%	10,399	11,903	9140
Canada	2019	5.32%	4817	5971	3893
South America	2019	4.90%	4628	5877	3652
Brazil	2019	5.13%	4892	6352	3757
Colombia	2019	3.68%	3478	4428	2729
Argentina	2019	7.54%	7020	8448	5894
Peru	2019	4.56%	4336	5773	3190
Venezuela (Bolivarian Republic of)	2019	4.06%	3882	4893	3058
Chile	2019	5.64%	5196	6249	4391
Ecuador	2019	4.18%	3967	5332	2945
Bolivia (Plurinational State of)	2019	4.43%	4251	5536	3250
Europe	2019	5.69%	5211	6379	4257
United Kingdom	2019	10.07%	9167	11,035	7645

(*Continued*)

Table 1 (Continued).

	Year	%	Rate per 100,000	Upper Interval	Lower Interval
France	2019	7.22%	6555	7933	5357
Germany	2019	4.55%	4153	5081	3405
Italy	2019	4.33%	4028	5107	3174
Spain	2019	4.95%	4481	5512	3637
Poland	2019	5.88%	5413	6639	4414
The Netherlands	2019	7.66%	6942	8419	5703
Belgium	2019	5.07%	4610	5606	3792
Greece	2019	5.79%	5301	6546	4326
Portugal	2019	9.97%	9106	11,070	7500
Sweden	2019	8.24%	7586	9403	6047
Switzerland	2019	7.29%	6616	8052	5413
Denmark	2019	5.29%	4783	5846	3910
Finland	2019	6.70%	6103	7356	5043
Norway	2019	7.36%	6790	8270	5590
Ireland	2019	7.56%	6860	8348	5695
Ukraine	2019	3.48%	3227	4076	2528
Romania	2019	4.47%	4180	5181	3402
Czechia	2019	3.29%	3053	3781	2480
Hungary	2019	3.56%	3307	4083	2678
Belarus	2019	3.69%	3418	4293	2761
Austria	2019	5.72%	5220	6381	4281
Serbia	2019	3.05%	2849	3453	2358
Bulgaria	2019	3.87%	3613	4427	2919
Slovakia	2019	3.13%	2915	3589	2363
Asia	2019	3.44%	3256	3942	2726
China	2019	2.11%	1974	2565	1530
India	2019	2.75%	2681	3222	2190
Indonesia	2019	3.58%	3431	4055	2918
Japan	2019	4.22%	3865	4891	3119
Philippines	2019	4.81%	4628	5595	3916
Thailand	2019	3.59%	3412	4142	2864
Republic of Korea	2019	3.91%	3705	4373	3216
Singapore	2019	4.02%	3667	4565	3012

(*Continued*)

Table 1 (Continued).

	Year	%	Rate per 100,000	Upper Interval	Lower Interval
Gulf States (calculated values)	2019	4.54%	4302	5228	3541
United Arab Emirates	2019	7.55%	7180	8345	6188
Oman	2019	4.22%	4054	5014	3279
Saudi Arabia	2019	2.77%	2642	3207	2155
Qatar	2019	3.69%	3461	4306	2794
Kuwait	2019	4.47%	4174	5265	3291
Pakistan	2019	1.77%	1702	1975	1448
Bangladesh	2019	1.43%	1391	1574	1217
Vietnam	2019	3.23%	3093	3714	2613
Turkey	2019	5.38%	5103	6041	4402
Malaysia	2019	2.78%	2625	3254	2178
Africa	2019	3.67%	3552	4292	2941
Nigeria	2019	3.68%	3627	4366	3066
Ethiopia	2019	2.85%	2792	3414	2299
Egypt	2019	3.65%	3487	4200	2903
Democratic Republic of the Congo	2019	3.03%	3003	3545	2583
South Africa	2019	4.27%	4124	5399	2788
Kenya	2019	2.81%	2730	3321	2259
Uganda	2019	5.03%	4953	5882	4217
United Republic of Tanzania	2019	6.07%	5923	7128	5048
Algeria	2019	3.41%	3219	3924	2633
Sudan	2019	4.35%	4175	4976	3493
Morocco	2019	3.05%	2915	3486	2453
Côte d'Ivoire	2019	3.22%	3154	3761	2691
Tunisia	2019	3.85%	3640	4394	3020
Zimbabwe	2019	2.08%	1990	2287	1728
Oceania	2019	8.33%	7547	9347	6160
Australia	2019	9.66%	8768	10,822	7162
New Zealand	2019	7.00%	6326	7871	5157

countries). The economic status of Venezuela was unclassified and no status was reported for Indonesia. The country-specific qualitative analysis of AQI, economic status, and HAQ revealed a pattern of high asthma prevalence in countries with higher income status, better air quality, and better healthcare access and quality (Table 3, Figure 2). The US, United

Table 2 Global Prevalence Estimates for Key Clinical Subgroups Within Asthma

	Allergic Rhinitis (AR) %	Eosinophilic Asthma (EA) %	Severe Asthma (SA) %	Nasal Polyps (NPs) %
North America	39.37%	47.72%	15.00%	6.35%
United States of America	38.8%*	50%*	15%*	6.7%*
Canada	50%*	5.3%	11.4–22.8%	7.1–25.7%
South America	61.60%	45.06%	46.26%	7–25.4%
Brazil	79.6%	46.5%*	62%*	7.1–25.6%
Colombia	5.9%*	39.7%	10.8–21.6%	7.6–27.7%
Argentina	15%*	52%*	11.2–22.5%	7.6–27.4%
Peru	66.4%*	40.2%	11.2–22.4%	7.8–28.4%
Venezuela (Bolivarian Republic of)	93.3%*	37.6%	9.8–19.6%	6.8–24.8%
Chile	55.6%*	39.3%	10.7–21.4%	7.5–27.2%
Ecuador	82.3%	39%*	32.5%*	7.9–28.7%
Bolivia (Plurinational State of)	81.8%	40.1%	33.6%*	7.8–28.3%
Europe	27.58%	26.1%	7.05%	21.53%
United Kingdom	82–90%*	0.7%*	3.6%*	3.3%*
France	19.8%	9.8%*	3.6–9.8%*	33.0%
Germany	24.2%*	16%*	8.7%*	33.0%
Italy	18.5%*	58.7%*	5–10%	30.2%*
Spain	20.0%	85%*	7.7%*	12%*
Poland	19.6%	75.4%*	5–10%	6%*
The Netherlands	42.7%*	5%*	3.6%*	23.2%*
Belgium	20.1%	55%*	5–10%	19%*
Greece	80.7%*	86%*	5–10%	32.9%
Portugal	52.3%*	5.0%	3.6%*	33.0%
Sweden	25%*	47.8%*	3.6–6.1%*	2.7%*
Switzerland	20.2%	5.2%	5–10%	33.1%
Denmark	19.9%	93%*	8.1%*	10%*
Finland	7.2%*	21.8%*	7.4%*	17%*
Norway	20.1%	5.1%	5–10%	33.1%
Ireland	80%*	5.3%	5–10%	33.3%
Ukraine	49.1%*	4.9%	5–10%	32.7%
Romania	19.3%	4.9%	5–10%	42.5%*
Czechia	19.8%	10%*	5–10%	33.0%
Hungary	66.8%*	4.9%	0.9%*	32.8%

(*Continued*)

Table 2 (Continued).

	Allergic Rhinitis (AR) %	Eosinophilic Asthma (EA) %	Severe Asthma (SA) %	Nasal Polyps (NPs) %
Belarus	50%*	4.9%	5–10%	32.8%
Austria	20.0%	45.5%*	5–10%	1.8%*
Serbia	19.2%	4.9%	5–10%	32.7%
Bulgaria	19.1%	76%*	5–10%	32.7%
Slovakia	19.7%	5.0%	5–10%	32.9%
Asia	52.47%	17.52%	32.28%	6.85%
China	50%*	6.2%*	14.8%*	7.2–26%
India	65.2%*	26%*	50%*	6.9%*
Indonesia	29.2%*	5.3%	7–11%	7.6–27.6%
Japan	50%*	34.5%*	31%*	7–25.4%
Philippines	50%*	5.3%	7–11%	7.8–28.3%
Thailand	50%*	62%*	2%*	7.1–25.9%
Republic of Korea	50%*	28.3%*	6.1%*	4.9%*
Singapore	50%*	4.9%	7–11%	6.8–24.8%
Gulf States (calculated values)	50%*	5.4%	7–11%	8–29.1%
United Arab Emirates	50%*	5.3%	7–11%	7.7–28%
Oman	50%*	5.7%	7–11%	8.6–31.2%
Saudi Arabia	50%*	5.4%	7–11%	7.9–28.8%
Qatar	50%*	5.4%	7–11%	8–29.1%
Kuwait	50%*	85%*	7–11%	7.9–28.6%
Pakistan	20.6%*	5.5%	7–11%	8.2–29.7%
Bangladesh	50%*	5.3%	7–11%	7.6–27.5%
Vietnam	50%*	5.2%	7–11%	7.5–27.3%
Turkey	50%*	45%*	21.3%*	7–25.4%
Malaysia	50%*	5.3%	2.7%*	7.8–28.2%
Africa	61.38%	11.14%	23.47%	7–25.4%
Nigeria	86.5%*	5.7%	39.2%*	8.6–31.1%
Ethiopia	50%*	5.7%	30.8%*	8.6–31%
Egypt	44%*	5.5%	28.8%*	8.2–29.6%
Democratic Republic of the Congo	49%*	5.8%	10.8%*	9–32.5%
South Africa	50%*	5.3%	5.7%*	7.7–28.1%
Kenya	50%*	5.6%	4.8%*	8.4–30.4%

(*Continued*)

Table 2 (Continued).

	Allergic Rhinitis (AR) %	Eosinophilic Asthma (EA) %	Severe Asthma (SA) %	Nasal Polyps (NPs) %
Uganda	77.3%*	76.3%*	21.6%*	9.1–32.9%
United Republic of Tanzania	50%*	5.8%	9.6%	8.8–32%
Algeria	83.4%*	18.6%*	12.9%*	8.1–29.4%
Sudan	52.9%*	5.6%	4%*	8.5–30.7%
Morocco	59.7%*	5.3%	52.1%*	7.7–27.9%
Côte d'Ivoire	50%*	5.7%	61.9%*	8.6–31%
Tunisia	40.7%*	5.3%	1.9%*	7.6–27.6%
Zimbabwe	50%*	5.4%	8.1%	7.9–28.6%
Oceania	50.00%	39.28%	30.52%	7–25.4%
Australia	50%*	44.2%*	11.1–22.1%	7.7–28.1%
New Zealand	50%*	4.9%*	30.5%*	8.3–30%

Note: *Values were not able to be adjusted for 2020.

Table 3 Qualitative Comparison of Air Quality (AQI), World Bank Income Status, and Healthcare Quality and Access (HAQ) to Global Asthma Prevalence

	Asthma Prevalence %	AQI (2020) (13)	Income Status (2022) (11)	HAQ Index (2017) (10)
North America	8.29%			
United States of America	11.25%	9.6	High	81.3
Canada	5.32%	7.3	High	87.6
South America	4.90%			
Argentina	7.54%	14.2	Upper-middle	68.4
Chile	5.64%	19.3	Upper-middle	76.0
Brazil	5.13%	14.2	Upper-middle	64.9
Peru	4.56%	17.9	Upper-middle	69.6
Bolivia (Plurinational State of)	4.43%	NR	Upper-middle	59.2
Ecuador	4.18%	7.6	Upper-middle	61.2
Venezuela (Bolivarian Republic of)	4.06%	NR	Temporarily unclassified in July 2021 pending release of revised national accounts statistics	64.7
Colombia	3.68%	15.6	Upper-middle	67.8
Europe	5.69%			
United Kingdom	10.07%	8.3	High	84.6
Portugal	9.97%	9.1	High	84.5

(*Continued*)

Table 3 (Continued).

	Asthma Prevalence %	AQI (2020) (13)	Income Status (2022) (11)	HAQ Index (2017) (10)
Sweden	8.24%	5	High	90.5
The Netherlands	7.66%	9.7	High	89.5
Ireland	7.56%	8.6	High	88.4
Norway	7.36%	5.7	High	90.5
Switzerland	7.29%	9	High	91.8
France	7.22%	11.1	High	87.9
Finland	6.70%	5	High	89.6
Poland	5.88%	16.9	High	79.6
Greece	5.79%	18.4	High	87.0
Austria	5.72%	10.9	High	88.2
Denmark	5.29%	9.4	High	85.7
Belgium	5.07%	8.9	High	87.9
Spain	4.95%	10.4	High	89.6
Germany	4.55%	10.1	High	86.4
Romania	4.47%	15.8	Upper-middle	74.4
Italy	4.33%	18.5	High	88.7
Bulgaria	3.87%	27.5	Upper-middle	71.4
Belarus	3.69%	NR	Upper-middle	74.4
Hungary	3.56%	14.3	High	79.6
Ukraine	3.48%	19.2	Lower-middle	72.7
Czechia	3.29%	NR	High	84.8
Slovakia	3.13%	15.3	High	78.6
Serbia	3.05%	24.3	Upper-middle	75.4
Asia	3.44%			
United Arab Emirates	7.55%	NR	High	72.2
Turkey	5.38%	18.7	Upper-middle	76.2
Philippines	4.81%	12.8	Lower-middle	52.0
Kuwait	4.47%	34	High	82.0
Oman	4.22%	44.4	High	77.1
Japan	4.22%	9.8	High	89.0
Singapore	4.02%	11.8	High	86.3
Republic of Korea	3.91%	19.5	High	85.8

(*Continued*)

Table 3 (Continued).

	Asthma Prevalence %	AQI (2020) (13)	Income Status (2022) (11)	HAQ Index (2017) (10)
Qatar	3.69%	44.3	High	85.2
Thailand	3.59%	21.4	Upper-middle	70.8
Indonesia	3.58%	40.7	NR	49.2
Vietnam	3.23%	28	Lower-middle	66.3
Malaysia	2.78%	15.6	Upper-middle	66.6
Saudi Arabia	2.77%	23.3	High	79.4
India	2.75%	51.9	Lower-middle	44.8
China	2.11%	34.7	Upper-middle	74.2
Pakistan	1.77%	59	Lower-middle	43.1
Bangladesh	1.43%	77.1	Lower-middle	51.7
Africa	3.67%			
United Republic of Tanzania	6.07%	NR	Lower-middle	49.9
Uganda	5.03%	26.1	Low	42.9
Sudan	4.35%	NR	Low	50.1
South Africa	4.27%	18	Upper-middle	52.0
Tunisia	3.85%	NR	Lower-middle	70.1
Nigeria	3.68%	NR	Lower-middle	51.3
Egypt	3.65%	NR	Lower-middle	61.0
Algeria	3.41%	20.2	Lower-middle	63.7
Côte d'Ivoire	3.22%	NR	Lower-middle	42.4
Morocco	3.05%	NR	Lower-middle	61.3
Democratic Republic of the Congo	3.03%	NR	Lower-middle	40.4
Ethiopia	2.85%	14.7	Low	44.2
Kenya	2.81%	14.2	Lower-middle	48.7
Zimbabwe	2.08%	NR	Lower-middle	48.7
Oceania	8.33%			
Australia	9.66%	7.6	High	89.8
New Zealand	7.00%	7	High	86.2

Abbreviation: NR, not reported.

Kingdom (UK), and Australia were strong examples of this trend; all had high asthma prevalence (11.25%, 10.07%, and 9.66% for the US, UK, and Australia, respectively), better air quality scores (AQIs of 9.6, 8.3, and 7.6 respectively), HAQ (81.3, 84.6, and 86.2, respectively), and higher economic status (all high).

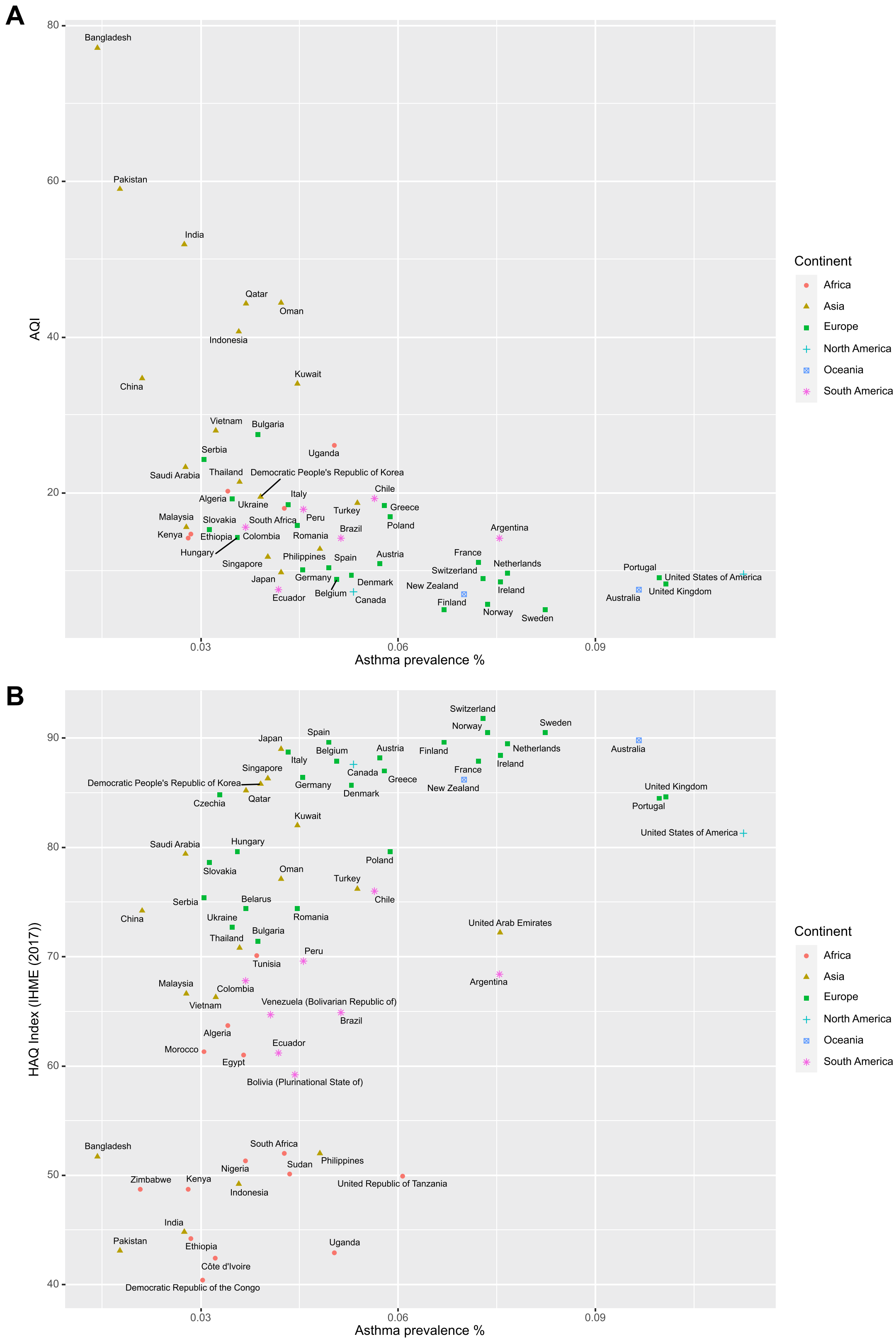

Figure 2 Country-specific asthma prevalence by AQI and HAQ. Asthma prevalence is visualized by country AQI (**A**) and HAQ (**B**). For (**A**), AQI values were available for 55 countries. Note that lower values of AQI represent higher air quality. In (**B**), A total of 69 countries are shown by asthma prevalence and HAQ. A higher HAQ value represents a healthcare system with a higher level of quality and access.

Discussion

This study presents the available evidence for the reported prevalence of asthma and its key clinical subgroups, adding to the existing epidemiological knowledge of respiratory conditions and revealing variation in the country-specific prevalence of disease.

Data Quality and Asthma Underreporting

The studies included in this review are highly relevant to the topic of reported asthma subgroup prevalence, but it should be noted that most studies had a low sample size (1000 participants or fewer), and some patient populations represented subgroups within the variables of interest—for example, children or adolescents. Furthermore, nearly all the included studies did not have an epidemiological focus, but rather reported the prevalence of clinical subgroups within asthma patients as part of a healthcare-related study. While the identified studies represent the best evidence for the prevalence of key subgroups, they do not represent a methodical sampling. Despite the uncertainty present in our findings, several known factors are likely to have influenced the observed prevalence distribution.

The Role of Healthcare, Access, and Quality (HAQ)

A possible explanation for the reported distribution of asthma prevalence is the level of HAQ across countries. HAQ can be measured using the amenable mortality rate; that is, the rate of mortality from causes that are preventable by effective and available medical treatment. The level of quality and access within healthcare systems is strongly relevant to the understanding of asthma prevalence, as each step of the treatment pathway is complicated by the condition itself. Adequate training in taking patient history, identifying symptom presentation, and selecting and administering clinical tests in practice is required to properly diagnose asthma, yet diagnostic methods are heterogeneous with poor asthma and subgroup reporting. This is especially true in LMICs that often have a lower quality of healthcare and access.[27,28] Asia and Africa—both continents with many LMICs—had the lowest asthma prevalence, at 3.44% and 3.67%, respectively. These estimates may be the result of diagnostic and reporting procedures, rather than a smaller population of people with asthma, as described by a recent, large-scale study in Vietnam that found that 27.3% of school children presented with one or more asthma symptoms, but only 8.5% had an asthma diagnosis from a doctor.[29] Agarwal et al studied the diagnosis of asthma in four Asian LMICs through a cross-sectional survey and reported that language was a barrier to healthcare access in diverse regions and that the quality of spirometry measurements was difficult to assess in the field.[30] The study also found that evaluating patient history, along with the presence of key symptoms (wheezing and chest tightness) was the most reliable method for diagnosing asthma.[30] These findings illustrated the difficulty of diagnosing asthma in a low-resource environment, while pointing toward evidence-based clinical adaptations to meet patient needs.

Even in countries with a higher HAQ, clinicians may struggle to diagnose asthma and provide care. A 2014 report from the Royal College of Physicians reviewed 195 asthma deaths that occurred from 2012 to 2013 in the UK, a country with an HAQ of 84.6.[12,31] Of the 155 individuals whose asthma severity could be determined, more than half (58%) were being treated for mild or moderate asthma. The study concluded that it was likely that they actually had SA, but were not categorized appropriately by their physician.[31] This interpretation is especially troubling as many nations in the current dataset have SA estimates over 20%, and those with SA are at risk for asthma-related death and reduced quality of life. Other studies have reported that the proportion of those with SA appeared to be higher in LMICs; this may be due to the underutilization and inaccessibility of controller medication.[32] The highest proportions of people with SA in the current study were Brazil (62.0%), Côte d'Ivoire (61.9%), and Morocco (52.1%).

The Role of Air Quality

Many studies have noted the impact of air quality on respiratory disease on a smaller scale, including Freid et al, who found a positive relationship between childhood asthma incidence and road pollution.[33] Although air quality was often noted as an important driver of asthma and other respiratory conditions, the results of the current study did not directly link air quality to asthma prevalence. The country with the highest reported asthma prevalence—the US (11.25%)—had good air quality (9.6 AQI), compared with the country with the lowest reported asthma prevalence—Bangladesh (1.43%)

—which had poor air quality (77.1 AQI). This may be due to fine-scale geographical variations in air quality that are not captured by the AQI.[34] Additionally, AQI does not capture the presence of household pollution due to the unsafe cooking conditions that are extremely common in many countries.[35,36] The discrepancy between reported asthma prevalence and air quality observed in our results may be due in part to the imprecise nature of country-level data.

Potential Connection to the Hygiene Hypothesis

The hygiene hypothesis is a potential explanation for the observed relationship between asthma prevalence and higher AQI, income status, and HAQ. The hygiene hypothesis proposes that early, mild infections are required for optimal development of the immune system and that when children are raised in sterilized environments, away from livestock, soil, and other microbiota, there will be a higher incidence of childhood asthma.[37] Since the presence of microbiota in the childhood environment is not commonly measured, country-specific comparisons of asthma and hygiene are difficult to evaluate. Ardura-Garcia et al analyzed 45 studies of the hygiene hypothesis in Latin American cities and found contradictory conclusions—studies that addressed respiratory infections instead of asthma, and others that did not accurately measure childhood exposure.[38]

Implications of Subgroup Prevalence Distributions

The complexities of asthma likely impacted the prevalence estimates of key clinical subgroups. There was a wide range of reported subgroup prevalence values, particularly for EA and AR. These results reflect the differences in testing and disease definitions across studies, which complicate the interpretation of observed patterns. For example, studies determining the proportion of asthma patients with EA will typically use the blood eosinophil count as a determining factor but may use different cutoffs to differentiate between EA and other asthma phenotypes. Lima-Matos et al used a cutoff of ≥260 cells/mm^3 to define EA in Brazil, while a global study by Heaney et al used a complex algorithm that incorporated blood eosinophil count, corticosteroid use, and other factors to detect EA in patient records.[15,39] Even within countries, there may be a need to standardize patient diagnosis, as demonstrated by a 2018 study of the diagnosis of allergic disease in the US, which showed that there were highly differential diagnostic practices across US states.[2] In particular, AR was diagnosed more frequently in southern states that used less testing and more immunotherapies.[2] This variation in diagnosis hinders the identification of key clinical subgroups and obscures the country-specific burden of disease. More accurate prevalence estimates would provide opportunities to improve healthcare infrastructure, for example, identifying areas with extreme unmet need that may be mitigated by environmental or public health initiatives.

Despite the observed variation in subgroup prevalence, some generalizations can be made. AR is a significant subgroup, with regional reported prevalence rates of approximately 20% to 50% across all continents except Africa and South America, which have an estimated AR prevalence of 60%. Global SA reported prevalence is approximately 10% to 20%, with a higher prevalence in some countries with low patient access to controller medication. The reported prevalence of EA was around 5% to 10% globally. The reported global prevalence of NPs was estimated at 6% to 15%.

Improving Asthma Healthcare and Reporting in LMICs

By identifying inadequacies in current healthcare systems, change can be planned and implemented. A systematic literature review of studies conducted in Nigeria, South Africa, and Uganda outlined common reasons for asthma underreporting.[40] These included the lack of accessible healthcare, including spirometry testing, low levels of asthma knowledge in the general population, and the lack of healthcare education for clinicians on asthma and relevant clinical guidelines.[40] Many of these underlying causes affect similar patterns of underreporting for other chronic diseases, including tuberculosis.[41]

Several initiatives have been developed to address the need for improved access to asthma care in LMICs. Costa Rica's National Asthma Program (NAP) was enacted in 2003, and provided training to healthcare practitioners throughout the country.[42,43] Following NAP, hospitalizations decreased by 53%, and mortality decreased by 80%.[42,43] More recent programs include the Practical Approach to Care Kit (PACK),[44] which provides a decisions support tool for clinicians and aims to standardize patient care, and several initiatives sponsored by WHO that include assessment algorithms and reporting tools.[45,46]

Strengths and Limitations

This study brought together information on the reported prevalence of asthma and asthma subgroups, as well as country-specific variables of AQI, HAQ, and economic status. The targeted searches adhered to the methodical pearl-growing technique to identify the most relevant sources of reported asthma subgroup prevalence.

The main limitation of this study was the paucity of reliable and accurate data, especially for clinical subgroups of asthma in LMICs. These data were based on generally small sample sizes rather than thorough epidemiological sampling. Although the data showed a pattern of less prevalent asthma in LMICs, more research is needed to determine the drivers of this trend.

Conclusion

This study showed that there was a pattern of low reported asthma prevalence values in LMICs, which potentially indicate health system deficiencies resulting in low diagnosis and reporting. The reported prevalence of the EA and SA asthma phenotypes was high in many countries, although the prevalence estimates of all asthma subgroups were quite variable. Existing efforts to standardize healthcare practices, increase access to care, and boost reporting have the potential to reduce the burden of illness in LMICs.

Data Sharing Statement

The corresponding author had access to all data in the study.

Funding

This study was funded by AstraZeneca (Cambridge, UK). AstraZeneca reviewed the publication, without influencing the opinions of the authors, to ensure medical and scientific accuracy, and the protection of intellectual property.

Disclosure

Professor Adrian Paul J Rabe was an employee of AstraZeneca during the conduct of the study. Dr Wei Jie Loke is an external research consultant who received personal fees from AstraZeneca UK, during the conduct of the study. Miss Khushboo Gurjar and Dr Allison Brackley were employees of Cytel Inc at the time of manuscript writing, which was hired by AstraZeneca to perform study analyses and development of this manuscript. The authors report no other conflicts of interest in this work.

References

1. Global Initiative for Asthma – GINA. Global strategy for asthma management and prevention, 2023; 2023. Available from: https://ginasthma.org/wp-content/uploads/2023/07/GINA-2023-Full-report-23_07_06-WMS.pdf. Accessed September 26, 2023.
2. Arianpour K, Svider PF, Yuhan B, Hooda Z, Eloy JA, Folbe AJ. Evolving patterns in the diagnosis and management of allergy-mediated disorders. *Int Forum Allergy Rhinol*. 2018;8(8):928–933. doi:10.1002/alr.22111
3. Menzies-Gow A, Bafadhel M, Busse WW, et al. An expert consensus framework for asthma remission as a treatment goal. *J Allergy Clin Immunol*. 2020;145(3):757–765. doi:10.1016/j.jaci.2019.12.006
4. Bakakos P, Loukides S, Bakakos P. Severe eosinophilic asthma. *J Clin Med*. 2019;8(9):1375. doi:10.3390/jcm8091375
5. Pavord ID. Eosinophilic phenotypes of airway disease. *Ann Am Thorac Soc*. 2013;10(Suppl):S143–9. doi:10.1513/AnnalsATS.201306-168AW
6. Tota M, Lacwik J, Laska J, Sedek L, Gomulka K. The role of eosinophil-derived neurotoxin and vascular endothelial growth factor in the pathogenesis of eosinophilic asthma. *Cells*. 2023;12(9):1326. doi:10.3390/cells12091326
7. Holguin F, Cardet JC, Chung KF, et al. Management of severe asthma: a European Respiratory Society/American Thoracic Society guideline. *Eur Respir J*. 2020;55(1):1900588. doi:10.1183/13993003.00588-2019
8. Czira A, Turner M, Martin A, et al. A systematic literature review of burden of illness in adults with uncontrolled moderate/severe asthma. *Respir Med*. 2021;191:106670. doi:10.1016/j.rmed.2021.106670
9. Dierick BJH, van der Molen T, Flokstra-de Blok BMJ, et al. Burden and socioeconomics of asthma, allergic rhinitis, atopic dermatitis and food allergy. *Expert Rev Pharmacoecon Outcomes Res*. 2020;20(5):437–453. doi:10.1080/14737167.2020.1819793
10. Marseglia G, Caimmi S, Marseglia A, et al. Rhinosinusitis and asthma. *Int J Immunopathol Pharmacol*. 2010;23(1 Suppl):29–31. doi:10.1177/03946320100230S108
11. Toro ED, Portela J. Nasal Polyps. In: *StatPearls*. StatPearls; 2021.
12. IHME. Global Burden of Disease Study 2019 (GBD 2019) Data Resources. Institute for health metrics and evaluation at the University of Washington; 2021. Available from: http://ghdx.healthdata.org/gbd-2019. Accessed October, 2021.
13. World Bank Group. World bank open data. Available from: https://data.worldbank.org/. Accessed February 11, 2022.
14. Centers for Disease Control and Prevention (CDC). Lesson 3: measures of risk; 2023. Available from: https://www.cdc.gov/csels/dsepd/ss1978/lesson3/section2.html#Incidence%20Proportion%20Or%20Risk. Accessed September 26, 2023.

15. Heaney LG, Perez de Llano L, Al-Ahmad M, et al. Eosinophilic and noneosinophilic asthma: an expert consensus framework to characterize phenotypes in a global real-life severe asthma cohort. *Chest*. 2021;160(3):814–830. doi:10.1016/j.chest.2021.04.013
16. Csoma Z, Gál Z, Gézsi A, Herjavecz I, Szalai C. Prevalence and characterization of severe asthma in Hungary. *Sci Rep*. 2020;10(1):9274. doi:10.1038/s41598-020-66445-4
17. Dhar R, Ip M, Kulkarni T, et al. Challenges faced in managing adult asthma: a perspective from Asian countries. *Respirology*. 2020;25 (12):1235–1242. doi:10.1111/resp.13935
18. Pembrey L, Brooks C, Mpairwe H, et al. Asthma inflammatory phenotypes on four continents: most asthma is non-eosinophilic. *Int J Epidemiol*. 2022;52(2):611–623. doi:10.1093/ije/dyac173
19. Sullivan AA, Kushnir NM, Scarupa MD, Chase C, Kaliner MA, Faaaai M. In-depth review of allergic rhinitis. World Allergy Organization; 2020. Available from: https://www.worldallergy.org/education-and-programs/education/allergic-disease-resource-center/professionals/in-depth-review-of-allergic-rhinitis. Accessed September 26, 2023.
20. Bedolla-Barajas M, Raúl Ortiz-Peregrina J, Daniel Hernández-Colín D, Morales-Romero J, Ramses Bedolla-Pulido T, Larenas-Linnemann D. The characterization of asthma with blood eosinophilia in adults in Latin America. *J Asthma*. 2019;56(11):1138–1146. doi:10.1080/02770903.2018.1520863
21. Selroos O, Kupczyk M, Kuna P, et al. National and regional asthma programmes in Europe. *Eur Respir J*. 2015;24(137):474–483. doi:10.1183/16000617.00008114
22. Adeloye D, Chan KY, Rudan I, Campbell H. An estimate of asthma prevalence in Africa: a systematic analysis. *Croat Med J*. 2013;54(6):519–531. doi:10.3325/cmj.2013.54.519
23. Ahmadiafshar A, Farjd HR, Moezzi F, Mousavinasab N. Nasal polyposis in patients with asthma and allergic rhinitis. *J Laryngol Otol*. 2012;126 (8):780–783. doi:10.1017/S0022215112000771
24. Booth A. Searching for qualitative research for inclusion in systematic reviews: a structured methodological review. *Syst Rev*. 2016;5(1):74. doi:10.1186/s13643-016-0249-x
25. IQAir. World's most polluted countries 2020. Available from: https://www.iqair.com/ca/world-most-polluted-countries. Accessed February 11, 2022.
26. Global Burden of Disease Collaborative Network. *Data From: Global Burden of Disease Study 2015 (GBD 2015) Healthcare Access and Quality Index Based on Amenable Mortality 1990–2015*. United States: Seattle; 2017.
27. Devi R, Kanitkar K, Narendhar R, Sehmi K, Subramaniam K. A narrative review of the patient journey through the lens of non-communicable diseases in low- and middle-income countries. *Adv Ther*. 2020;37(12):4808–4830. doi:10.1007/s12325-020-01519-3
28. Meghji J, Mortimer K, Agusti A, et al. Improving lung health in low-income and middle-income countries: from challenges to solutions. *Lancet*. 2021;397(Mar 6):928–940. doi:10.1016/S0140-6736(21)00458-X
29. Le HHTC, Le An P, Vinh NN, et al. Burden of asthma-like symptoms and a lack of recognition of asthma in Vietnamese children. *J Asthma*. 2023;60(3):516–524. doi:10.1080/02770903.2022.2066002
30. Agarwal D, Hanafi NS, Khoo EM, et al. Predictors for detecting chronic respiratory diseases in community surveys: a pilot cross-sectional survey in four South and South East Asian low- and middle-income countries. *J Glob Health*. 2021;11:04065. doi:10.7189/jogh.11.04065
31. The National Review of Asthma Deaths (NRAD). Why asthma still kills; 2014. Available from: https://www.asthma.org.uk/globalassets/campaigns/nrad-executive-summary.pdf. Accessed September 26, 2023.
32. Cruz AA, Stelmach R, Ponte EV. Asthma prevalence and severity in low-resource communities. *Curr Opin Allergy Clin Immunol*. 2017;17 (3):188–193. doi:10.1097/ACI.0000000000000360
33. Freid RD, Qi YS, Espinola JA, et al. Proximity to major roads and risks of childhood recurrent wheeze and asthma in a severe bronchiolitis cohort. *Int J Environ Res Public Health*. 2021;18(8):4197. doi:10.3390/ijerph18084197
34. IQAir. World air quality report; 2021. Available from: https://www.iqair.com/assets/svg/ic-download.svg. Accessed September 26, 2023.
35. Simkovich SM, Goodman D, Roa C, et al. The health and social implications of household air pollution and respiratory diseases. *NPJ Prim Care Respir Med*. 2019;29(1):12. doi:10.1038/s41533-019-0126-x
36. Smith K, Pillarisetti A. *Household Air Pollution from Solid Cookfuels and Its Effects on Health. Chapter 7: Injury Prevention and Environmental Health*. The International Bank for Reconstruction and Development / The World Bank; 2017.
37. Weber J, Illi S, Nowak D, et al. Asthma and the hygiene hypothesis. Does cleanliness matter? *Am J Respir Crit Care Med*. 2015;191(5):522–529. doi:10.1164/rccm.201410-1899OC
38. Ardura-Garcia C, Garner P, Cooper PJ. Is childhood wheeze and asthma in Latin America associated with poor hygiene and infection? A systematic review. *BMJ Open Respir Res*. 2018;5(1):e000249. doi:10.1136/bmjresp-2017-000249
39. Lima-Matos A, Ponte EV, de Jesus JPV, et al. Eosinophilic asthma, according to a blood eosinophil criterion, is associated with disease severity and lack of control among underprivileged urban Brazilians. *Respir Med*. 2018;145:95–100. doi:10.1016/j.rmed.2018.10.025
40. Magwenzi P, Rusakaniko S, Sibanda EN, Gumbo FZ. Challenges in the diagnosis of asthma in children, what are the solutions? A scoping review of 3 countries in sub Saharan Africa. *Respir Res*. 2022;23(1):254. doi:10.1186/s12931-022-02170-y
41. Linn AR, Dubois MM, Steenhoff AP. Under-reporting of tuberculosis disease among children and adolescents in low and middle-income countries: a systematic review. *Trop Med Infect Dis*. 2023;8(6):300.
42. Soto-Martinez ME, Soto-Quiros ME, Custovic A. Childhood asthma: low and middle-income countries perspective. *Acta Med Acad*. 2020;49 (2):181–190. doi:10.5644/ama2006-124.296
43. Soto-Martínez M, Avila L, Soto N, Chaves A, Celedón JC, Soto-Quiros ME. Trends in hospitalizations and mortality from asthma in Costa Rica over a 12- to 15-year Period. *J Allergy Clin Immunol*. 2014;2(1):85–90. doi:10.1016/j.jaip.2013.09.010
44. Cornick R, Picken S, Wattrus C, et al. The Practical Approach to Care Kit (PACK) guide: developing a clinical decision support tool to simplify, standardise and strengthen primary healthcare delivery. *BMJ Glob Health*. 2018;3(Suppl 5):e000962. doi:10.1136/bmjgh-2018-000962
45. World Health Organization. WHO Package of Essential Noncommunicable (PEN) disease interventions for primary health care; 2020. Available from: www.who.int/publications/i/item/who-package-of-essential-noncommunicable-(pen)-disease-interventions-for-primary-health-care. Accessed September 26, 2023.
46. World Health Organization. IMAI district clinician manual: hospital care adolescents and adults: guidelines for the management of illnesses with limited-resources; 2012. Available from: https://apps.who.int/iris/handle/10665/77751. Accessed September 26, 2023.