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ORIGINAL RESEARCH

Knowledge Mapping of COVID-19 and Asthma/Allergic Rhinitis: A Visual and Bibliometric Analysis

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Objective: Numerous studies have highlighted a link between COVID-19 and respiratory allergic conditions such as asthma and allergic rhinitis (AR). Despite the growing volume of research, there remains a notable gap in the form of a comprehensive bibliometric analysis that consolidates the findings on this association. This study aims to fill that gap by systematically exploring how asthma and AR interact with COVID-19.

Methods: By using the Web of Science Core Collection, we selected publications from January 2020 to October 2024 that related to COVID-19 and asthma/AR. Analysis tools such as VOSviewer and CiteSpace were employed to perform network mappings and citation analyses, focusing on co-authorship networks, keyword co-occurrences, and citation impacts to understand the research dynamics and collaborative patterns within this field.

Results: A collection of 553 publications was obtained, revealing an upward trend in research volume over the study period. The United States, China, and the United Kingdom were predominant in the research output, demonstrating extensive international collaborations. The study highlighted key areas of impact, such as the influence of asthma types on COVID-19 severity and the protective effects of specific treatments like inhaled corticosteroids and biologics. Emerging trends identified included the significance of socioeconomic factors and obesity in disease outcomes, as well as evolving strategies in vaccination and interventions.

Conclusion: This bibliometric analysis highlights the significant role of global research in exploring the interactions between COVID-19 and asthma/AR. It points out the reported safety and effectiveness of COVID-19 vaccines for these conditions and acknowledges the challenges in vaccine uptake among minority and socioeconomically disadvantaged groups. The study also identifies unique risks for children and obese patients during the pandemic and underscores the need for increased international collaboration and more comprehensive clinical trials, to evaluate the efficacy of treatments like inhaled corticosteroids and biologics.

Keywords: COVID-19, asthma, allergic rhinitis, bibliometric analysis, vaccine

Introduction

Asthma and allergic rhinitis (AR) are prevalent chronic respiratory diseases globally, impacting the quality of life of hundreds of millions of adults and children.[1] The incidence of AR is on the rise, affecting 10–40% of the global population.[2] Similarly, over 330 million people worldwide suffer from asthma.[3] The increasing prevalence of these allergy-related illnesses imposes significant burdens on healthcare systems.[1,4] The coronavirus disease 2019 (COVID-19) outbreak has escalated into an international crisis.[5] Research presents mixed findings regarding asthma's role in COVID-19 severity; some studies suggest that asthma is associated with increased severity and mortality in COVID-19 cases, while others find no worsening of outcomes.[6] Although typically considered a risk factor for respiratory diseases, AR might confer some protection against COVID-19 due to the lower expression of angiotensin-converting enzyme 2(ACE2) receptors in these patients, potentially reducing severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2)

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invasion.[7] Additionally, recent studies suggest allergen immunotherapy in AR patients reduces COVID-19 symptom severity and illness duration, likely via immune modulation.[8–10] Asthma patients are at a significantly higher risk of severe COVID-19 outcomes compared to non-asthmatics.[11] Moreover, the type of asthma, such as eosinophilic versus non-eosinophilic, can influence the severity of COVID-19 infections and their clinical outcomes.[12]

Building upon the mixed findings regarding asthma and AR's roles in COVID-19 severity, substantial research has focused on exploring their interplay with SARS-CoV-2 infection outcomes.[13] Notably, a multinational cohort study involving South Korea, Japan, and the UK reported a significant increase in the incidence of allergic diseases post-COVID-19, including heightened risks for asthma and AR, highlighting the long-term consequences of the infection on pre-existing conditions.[14] Despite these insights, several critical questions remain unresolved, including variations in immune responses among patients with AR or asthma following SARS-CoV-2 infection, and how the trajectory of COVID-19 influences these immune reactions.[15] While some studies suggest that diminished ACE2 receptor expression may reduce viral entry likelihood, the precise mechanisms and effectiveness of this potential protective effect continue to be debated.[16] Further, the role of allergen immunotherapy in modulating the severity and recovery from COVID-19 symptoms warrants additional investigation.[17] The impact of different asthma types, such as eosinophilic versus non-eosinophilic asthma, on SARS-CoV-2 infection is varied and not fully understood.[18] Research has predominantly focused on adult populations, leaving gaps in our understanding of these conditions in children, who are similarly affected by these respiratory diseases. Moreover, most studies have not considered racial and geographical variations, which may limit the generalizability of their findings. Although bibliometrics cannot fill these research gaps directly, it offers a structured methodology for organizing and quantitatively assessing the literature, enabling researchers to pinpoint trends, hotspots, and geographic distributions. This approach is crucial in guiding more precise and in-depth future research efforts.Therefore, addressing these unresolved questions and complex clinical interactions requires a comprehensive, systematic analysis of existing studies. Bibliometric analysis offers precisely such a structured and quantitative approach.

Bibliometric analysis assesses research trends within specific domains by statistically analyzing a vast array of publications. This methodology examines the quantity and distribution of documents, publication trends, core journals, and research hotspots, thereby offering a macroscopic view of the primary research topics and distribution characteristics across various fields.[19,20] In the realms of AR, asthma, and COVID-19, bibliometrics is instrumental. It provides insights into global advancements and regional variances, as illustrated by Zyoud's study on COVID-19 and liver dysfunction. This research showcases the use of bibliometric methods to catalog extensive literature and pinpoint key contributors and themes.[21] Additionally, bibliometric analysis identifies the most prolific countries, regions, institutions, and journals, thus delineating how these chronic conditions impact COVID-19. Shekhar's work on schizophrenia and COVID-19 highlights the value of bibliometrics in mapping out research trends and themes within specialized areas, shedding light on significant patterns and psychiatric comorbidities influenced by the pandemic.[22] Moreover, Chen et al's examination of global research on RNA vaccines for COVID-19 demonstrates how bibliometric techniques can monitor scientific output and collaborations, reflecting robust progress and international cooperation in vaccine development.[23] As a vital analytical tool, bibliometrics plays a crucial role in evaluating and characterizing research outputs and trends across the medical field.[24]

This study aims to systematically evaluate and analyze the literature on the correlation between AR, asthma, and COVID-19 using bibliometric methods, to reveal research trends, hotspots, geographic distributions, and developmental directions in this field. By analyzing major publishing countries, core research institutions, active authors, and high-impact journals, this research will identify the key research forces in this domain. Furthermore, by exploring recent hot topics and the evolution of themes, this study will uncover the research dynamics and existing knowledge gaps related to the interactions between AR, asthma, and COVID-19 during and after the pandemic. Ultimately, the outcomes of this analysis will provide a scientific foundation for future research directions, enhancing the exploration of the interactions between COVID-19 and allergic diseases such as AR and asthma.

Materials and Methods

Data Retrieval

This study was conducted using the Web of Science Core Collection (WoSCC) database on November 1, 2024. The search applied the following terms: (TI=(COVID-19 OR Coronavirus OR SARS-CoV-2)) AND (TI=(asthma* OR allergic rhiniti*)), restricted to documents published between January 1, 2020, and October 31, 2024. The search yielded a total of 1127 publications. For inclusion in this study, we focused solely on English-language articles and reviews. We excluded 574 publications based on type, including editorials, letters, conference abstracts, etc. Finally, 553 publications were considered relevant for this analysis, comprising 452 research articles and 101 reviews. Figure 1 shows the detailed process of publications collection.

Data Analysis and Visualization

The collected data from 2020 to 2024 were analyzed using a range of software tools to reveal publication trends, collaborations, and thematic distributions in the field. Microsoft Excel 2019 facilitated the analysis of publication trends, while VOSviewer 1.6.20, developed by Nees Jan van Eck and Ludo Waltman[25] was utilized to examine national and institutional collaborations, author networks, and keyword co-occurrences, providing visual bibliometric networks. Geographic distributions of national publications were mapped using ArcGIS. Furthermore, CiteSpace 6.4.R1 was employed for dual-overlay journal analysis, reference co-citation analysis, and tracking emerging keywords and references, offering a comprehensive visualization and analysis of the research landscape, developed by Professor Chen Chaomei's team.[26]

Results

Analysis of Publications

The variation in publication numbers over time within a specific field can indicate its developmental trends and status. Figure 2A shows the annual publication trends in the field of asthma/AR and COVID-19 from 2020 to 2024, where initial low volume in 2020 reflects limited understanding of the virus at the pandemic's onset. As research deepened, publications increased, peaking in 2022. The study classified research into 79 distinct categories, as depicted in Figure 2B through an overlay analysis, which aggregated these into five primary domains: biology and medicine, chemistry and physics, ecology and environment, psychology and social sciences, and engineering and mathematics. Most research is concentrated within biology and medicine, with significant interdisciplinary collaboration enhancing understanding of immune responses and clinical impacts of COVID-19 on patients with asthma or AR. Less-represented domains like chemistry and physics, ecology

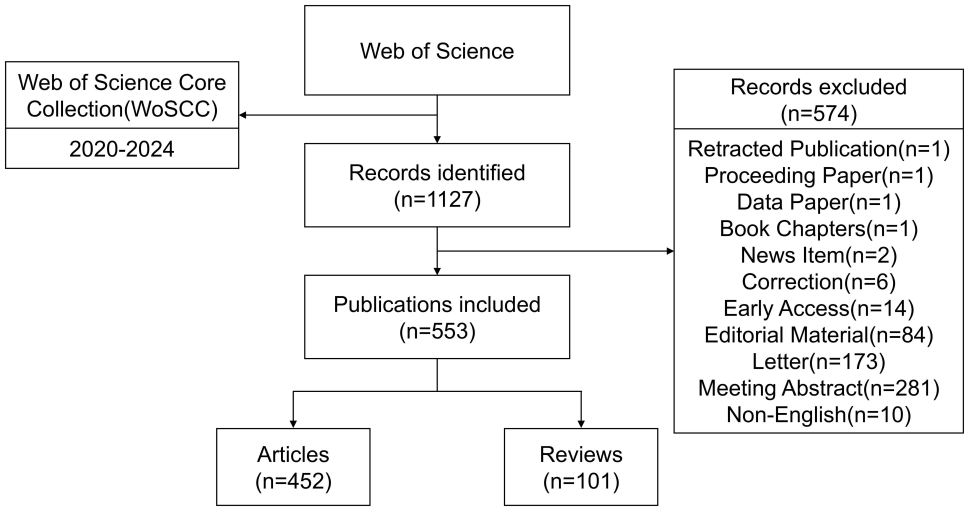

Figure 1 Flowchart for identifying and selecting publications.

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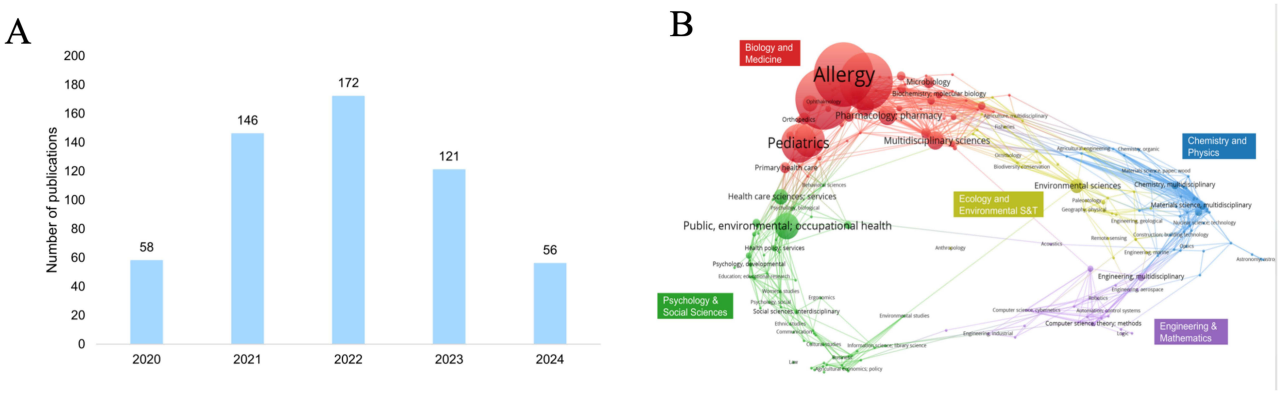

Figure 2 Annual publication volume and research fields. (**A**) The number of annual publication; (**B**) Research fields overlay.

and environment, psychology and social sciences, and engineering and mathematics offer valuable insights into transmission dynamics, environmental factors, psychological impacts, and disease modeling. Cross-disciplinary collaboration can enhance understanding of COVID-19 interactions with asthma and AR.

Analysis of Countries/Regions

Research contributions from 79 countries in the fields of asthma/AR and COVID-19 are substantial and geographically diverse, as shown in Figure 3A, which maps the publication output of each country. Table 1 ranks the top 10 countries by publication volume. The USA leads significantly with 148 papers, followed by China with 83, and the United Kingdom with 63. France stands out with the highest average citation frequency per paper, highlighting the global influence and recognition of its research. Furthermore, the USA boasts the highest H-index, indicating a robust and influential body of work that consistently delivers high-quality research. The international cooperation network depicted in Figure 3B reveals collaborative relationships among 79 countries in the research fields. The visualization clusters around major contributors such as the United States and China, which are central nodes indicating extensive collaborative links.

Analysis of Institutions and Authors

In the study of asthma/AR and COVID-19, 3637 authors and 1,440 institutions have showcased significant international cooperation and interdisciplinary research. Table 2 highlights the top 10 most prolific authors, with Sheikh Aziz leading at eight publications, followed by Mario Morais-Almeida and Ioana Agache. Akdis Cezmi stands out for high citation frequency, indicating high-quality, influential research. Sheikh Aziz also holds the highest H-index, underscoring his pivotal role in this field. Table 3 lists the top 10 institutions, with Imperial College London leading with 18 publications,

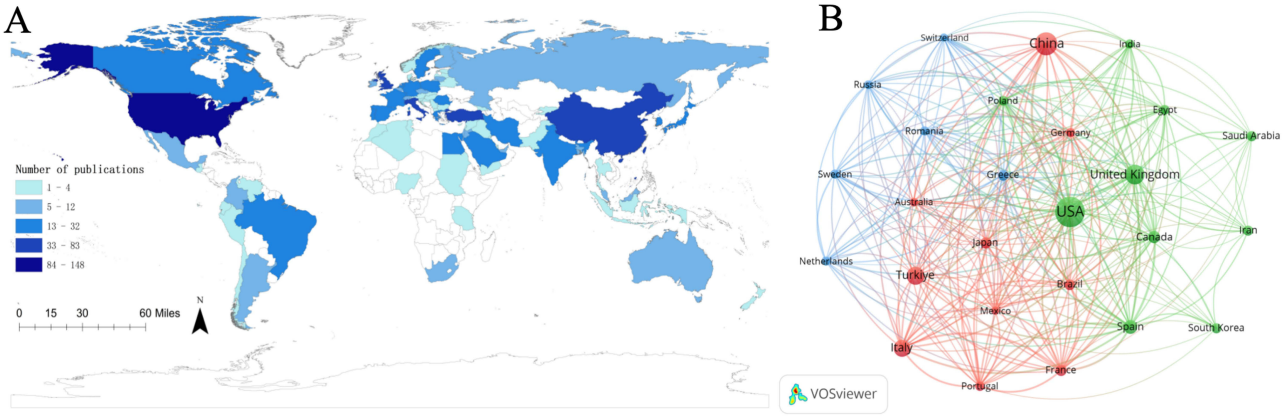

Figure 3 The global research collaboration network. (**A**) Geographic distribution of research collaborations; (**B**) Thematic clusters of global collaborations.

Table 1 The Top 10 Countries/Regions in Terms of Publications

Rank	Country	Counts	Average Citation	H-index
1	USA	148	24.90	27
2	China	83	22.12	19
3	United Kingdom	63	27.14	20
4	Turkiye	53	9.68	10
5	Italy	47	15.47	15
6	Spain	32	24.56	12
7	Canada	26	13.62	9
8	France	20	38.05	11
9	Japan	20	31.90	8
10	Brazil	18	24.50	8

Table 2 The Top 10 Authors in Terms of Publications

Rank	Author	Counts	Average Citation	H-index
1	Sheikh, Aziz	8	35.63	8
2	Morais-Almeida, Mario	7	35.00	4
3	Agache, Ioana	6	56.67	6
4	Canonica, Giorgio Walter	5	38.00	5
5	Jutel, Marek	5	35.80	5
6	Quint, Jennifer K.	5	69.60	5
7	Yang, Haiyan	5	11.40	3
8	Gemicioglu, Bilun	5	9.00	3
9	Akdis, Cezmi	4	127.75	4
10	Nadeau, Kari	4	112.75	4

Table 3 The Top 10 Institutions in Terms of Publications

Rank	Organization	Counts	Average Citation	H-index
1	IMPERIAL COLL LONDON	18	58.00	12
2	UNIV EDINBURGH	13	39.38	10
3	NATL & KAPODISTRIAN UNIV ATHENS	11	23.27	6
4	UNIV OXFORD	10	33.50	5
5	HARVARD MED SCH	9	70.22	7
6	KAROLINSKA INST	9	29.44	6
7	HACETTEPE UNIV	9	20.00	5
8	UNIV HLTH SCI	9	8.33	5
9	UNIV WISCONSIN	8	113.75	7
10	UNIV PITTSBURGH	8	72.88	5

evidencing its status as a research leader. It is followed by the University of Edinburgh and the National & Kapodistrian University of Athens. The University of Wisconsin, noted for the highest citation rate per publication, emphasizes the impactful nature of its research.

Through the analysis of VOSviewer, Figure 4A and B respectively show the cooperation network diagram of 34 authors who published no less than 4 articles and 54 institutions who published no less than 5 articles. These charts reveal the close collaborative relationships between researchers and institutions. Although some authors have formed independent research groups and there is relatively little direct collaboration between research groups, overall collaboration between institutions shows a closer network. structure. This structure helps promote knowledge innovation and the transformation of scientific

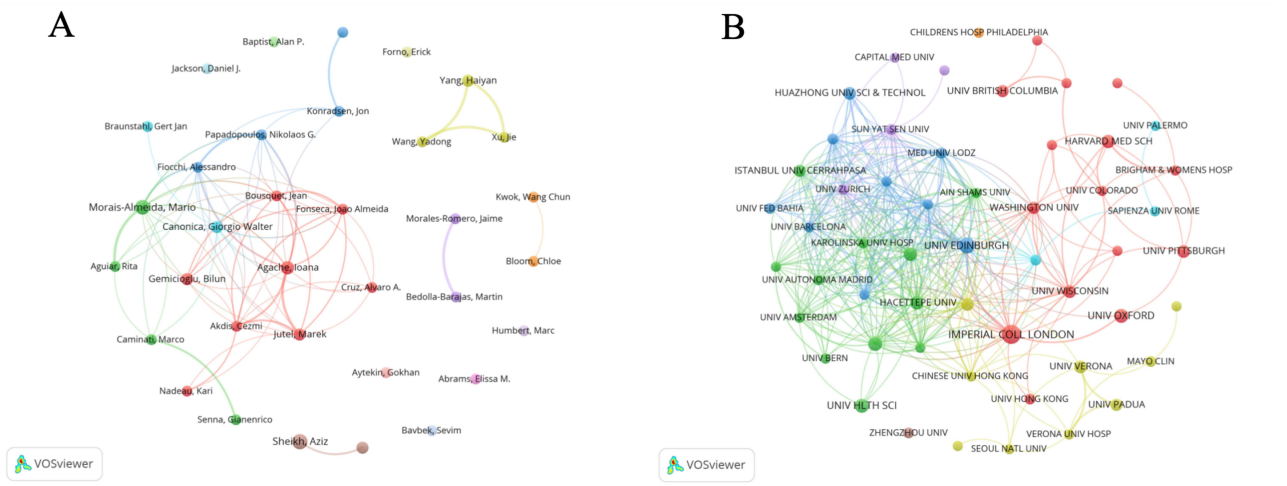

Figure 4 The network map of authors and institutions. (**A**) Author collaboration network; (**B**) Institutional collaboration network.

research results in the field. Leading authors and institutions are prominent likely due to substantial funding, active involvement in global research networks, and key roles in international clinical studies and guideline development during the pandemic.

Analysis of Journals and Co-Cited Journals

Table 4 lists the top 10 journals by publication volume on the left. The Journal of Asthma in the USA, with an impact factor (IF) of 1.7, leads with 36 publications. It is followed by the Journal of Allergy and Clinical Immunology-In Practice (IF=8.2) and Pediatric Pulmonology (IF=2.7), with 28 and 23 publications respectively. Among these, Allergy from the United Kingdom has the highest IF at 12.6. On the right side of Table 4, the top 10 journals by citation frequency are listed. The Journal of Allergy and

Table 4 The Top 10 Journals and Co-Cited Journals in Terms of Publications

Rank	Journals	Counts	Country	IF (2023)	Cited Journals	Citations	Country	IF (2023)
1	JOURNAL OF ASTHMA	36	USA	1.7	J ALLERGY CLIN IMMUN	1499	USA	11.4
2	JOURNAL OF ALLERGY AND CLINICAL IMMUNOLOGY-IN PRACTICE	28	Netherlands	8.2	ALLERGY	977	United Kingdom	12.6
3	PEDIATRIC PULMONOLOGY	23	USA	2.7	J ALLER CL IMM-PRACT	947	Netherlands	8.2
4	ANNALS OF ALLERGY ASTHMA & IMMUNOLOGY	16	USA	5.3	EUR RESPIR J	702	United Kingdom	17.0
5	JOURNAL OF ALLERGY AND CLINICAL IMMUNOLOGY	15	USA	11.4	AM J RESP CRIT CARE	535	USA	19.3
6	JOURNAL OF ASTHMA AND ALLERGY	15	New Zealand	3.7	LANCET	433	United Kingdom	98.4
7	RESPIRATORY MEDICINE	10	United Kingdom	3.5	NEW ENGL J MED	381	USA	96.3
8	CUREUS JOURNAL OF MEDICAL SCIENCE	10	USA	1	LANCET RESP MED	378	United Kingdom	38.7
9	ALLERGY	9	United Kingdom	12.6	JAMA-J AM MED ASSOC	325	USA	63.5
10	ALLERGY AND ASTHMA PROCEEDINGS	8	USA	2.6	ANN ALLERG ASTHMA IM	321	USA	5.3

Clinical Immunology from the USA, with an IF of 11.4, tops the list with 1,499 citations. It is followed by Allergy (IF=12.6) and Journal of Allergy and Clinical Immunology-In Practice (IF=8.2) with 977 and 947 citations, respectively. Among these, The Lancet from the United Kingdom has the highest IF at 98.4.

Figure 5 displays a dual-map overlay of the source journals and the citing journals for the 553 related articles, with the left side showing application fields and the right side indicating foundational disciplines. The colored lines represent citation pathways, highlighting the interrelationships between journals across different fields and revealing the connections between the applied (left) and cited (right) domains, which reflects the flow of knowledge at the journal level.[27,28] Clustering in the diagram was performed using the built-in Z-score algorithm, identifying two significant citation pathways, represented by the colors in the cited region, with line width proportional to the Z-scores of the citations. Z-score indicates the strength and significance of citation connections between journals. The primary citation pathways originate from "Molecular Biology, Genetics" and "Health, Nursing, Medicine", leading to the cutting-edge research areas of "Medicine, Medical, Clinical". Notably, the citation pathway from "Health, Nursing, Medicine" to "Medicine, Medical, Clinical" is particularly significant, with a Z-score of 4.97, highlighting its importance and influence in the field.

Analysis of Keywords

In this study, we used VOSviewer to extract keywords appearing at least three times, creating an initial set of 122 keywords. To refine the dataset, we merged synonymous terms—such as converting 'covid 19' to 'covid-19'—reducing the total by 32 keywords. We also eliminated 16 non-informative or redundant terms, like 'risk' and 'control'.

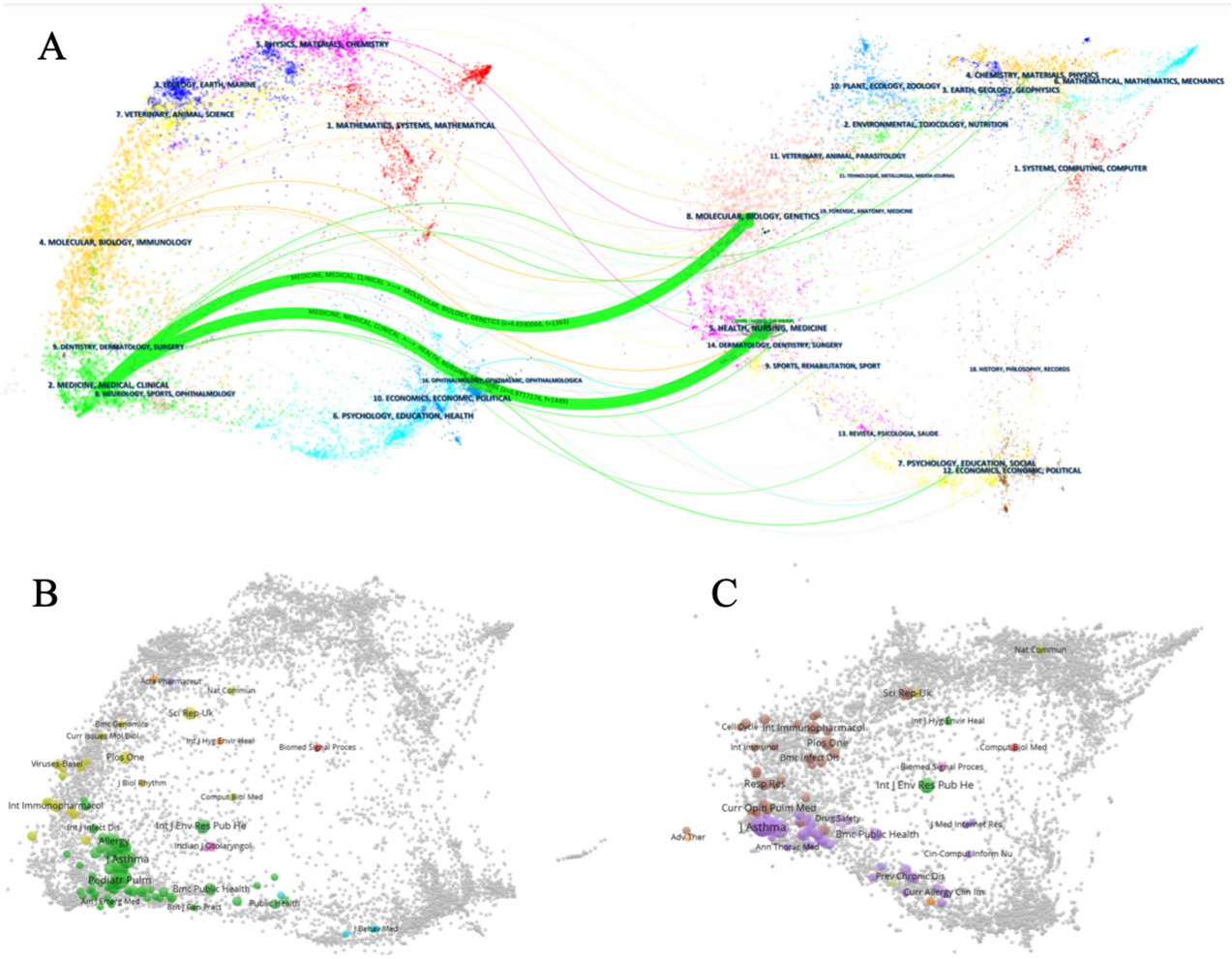

Figure 5 Journal overlay map. (**A**) Dual map overlay of journals; (**B**) Citing journals overlay; (**C**) Cited journals overlay.

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Co-occurrence analysis facilitated the visualization of these refined keywords, as depicted in Figure 6A. This analysis categorized the keywords into four clusters, each differentiated by color. These clusters represent distinct but interconnected research directions within the field. The size of each node within a cluster corresponds to the keyword's frequency, highlighting the most prominent terms—specifically, from left to right: 'covid-19', 'sars-cov-2', 'asthma', and 'omalizumab'. These keywords signify the primary research foci within their respective categories. To clarify keyword relationships within clusters, Cluster 1 primarily focuses on pathogenic mechanisms and viral characteristics, whereas Cluster 2 emphasizes clinical management and therapeutic strategies. Clusters 3 and 4 are oriented toward epidemiological research and immunological responses, respectively, further delineating the research directions within the field. Figure 6B builds on the insights from Figure 6A by analyzing the weighted years of keyword appearances, thereby illustrating the temporal progression of research themes. The color gradient transitions from blue to yellow, indicating a timeline from earlier to more recent years. Keywords such as 'vaccine', 'comorbidity', and 'epidemiology' have emerged as recent focal points, reflecting evolving research hotspots in the field of asthma/AR and COVID-19.

The analysis of keyword emergence is instrumental in identifying shifts in research hotspots within a field, understanding current trends, and predicting future areas of interest. Table 5 lists the top seven keywords based on their emergence scores. Emergence scores reflect the rapid growth in frequency of keywords, signaling their recent importance in the research field. Among these, "biologics" holds the highest score of 2.57, with its period of emergence spanning two years from 2020 to 2021. The keyword "biologics" had a high emergence score likely because biologic therapies, such as omalizumab, gained significant attention during the COVID-19 pandemic for effectively modulating immune-inflammatory responses in asthma and AR patients. These treatments demonstrated potential to reduce COVID-19 symptom severity, making biologics a notable recent research focus. The recent emergence of keywords such as "obesity", "inhaled corticosteroids", and "eosinophils" points to significant research hotspots at the intersection of asthma/AR and COVID-19. Obesity worsens COVID-19 outcomes by increasing inflammation, especially in those with asthma and AR. Inhaled corticosteroids could reduce COVID-19 severity by controlling this inflammation, while eosinophils, important in allergies, are studied for their potential impacts on the disease in respiratory cases.

Analysis of References

This study analyzed 553 publications and 407 citations, using co-citation and cluster analysis to trace the evolution of core knowledge and hotspots in this field. Figure 7A displays the co-citation network, highlighting the ten most-cited references. Notably, the paper by Jackson, Daniel J. et al, published in the Journal of Allergy and Clinical Immunology, stands out with 140 citations, highlighting its significant impact.[29] This study is highly cited by challenging previous assumptions and underscoring the protective potential of type 2 inflammatory responses, this research marks a pivotal advancement in the field. The analysis further employed the log-likelihood ratio (LLR) algorithm on titles to identify the

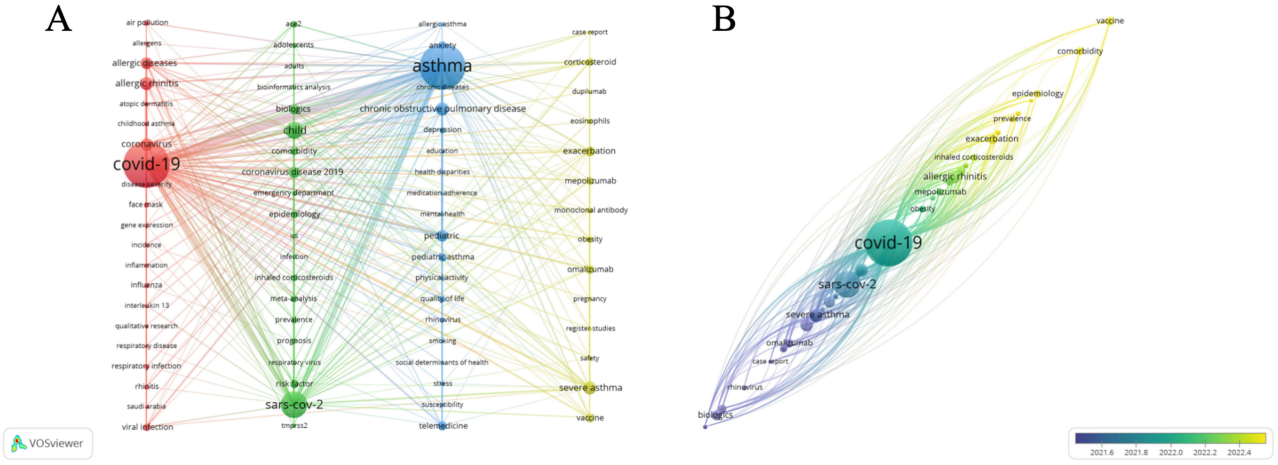

Figure 6 Visualization map of keywords. (**A**) Keywords co-occurrence network; (**B**) Average time the keyword appears.

Table 5 The Keywords with the Strong Citation Bursts

Keywords	Year	Strength	Begin	End	2020–2024
Biologics	2020	2.57	2020	2021	
Viral infection	2020	1.88	2020	2021	
Corticosteroid	2020	1.75	2020	2021	
ACE2	2020	1.12	2020	2021	
Obesity	2022	1.04	2022	2024	
Inhaled corticosteroids	2022	1.04	2022	2024	
Eosinophils	2022	1.04	2022	2024	

12 most significant clusters from these citations. The modularity (Q) score of 0.6367 and the silhouette (S) score of 0.8583 both exceed their respective thresholds, indicating a significant and reliable clustering structure. Figure 7B illustrates this network, with darker blue clusters representing earlier research and lighter blue indicating recent topics, such as #10 underlying asthma and #11 allergic rhinitis.

Reference emergence identifies trends by spotlighting rapidly growing research areas, with higher emergence values signaling significant influence within a field. Figure 7C, based on Figure 7A, highlights key emerging references with red nodes. One standout paper, the 2022 study by Sunjaya, Anthony P. et al from the Journal of Asthma,[30] features the highest emergence value. This study is crucial as it reveals that asthma does not elevate the risk of acquiring COVID-19 or suffering severe outcomes, challenging prior concerns about asthma as a risk factor for severe COVID-19. Figure 8 lists the top 19 emerging references, including notable research on pediatric populations such as "Pediatric asthma exacerbations during the COVID-19 pandemic: Absence of the typical fall seasonal spike in Washington, DC".[31] This study reports a significant decrease in asthma exacerbations among children during the fall of 2020, likely resulting from

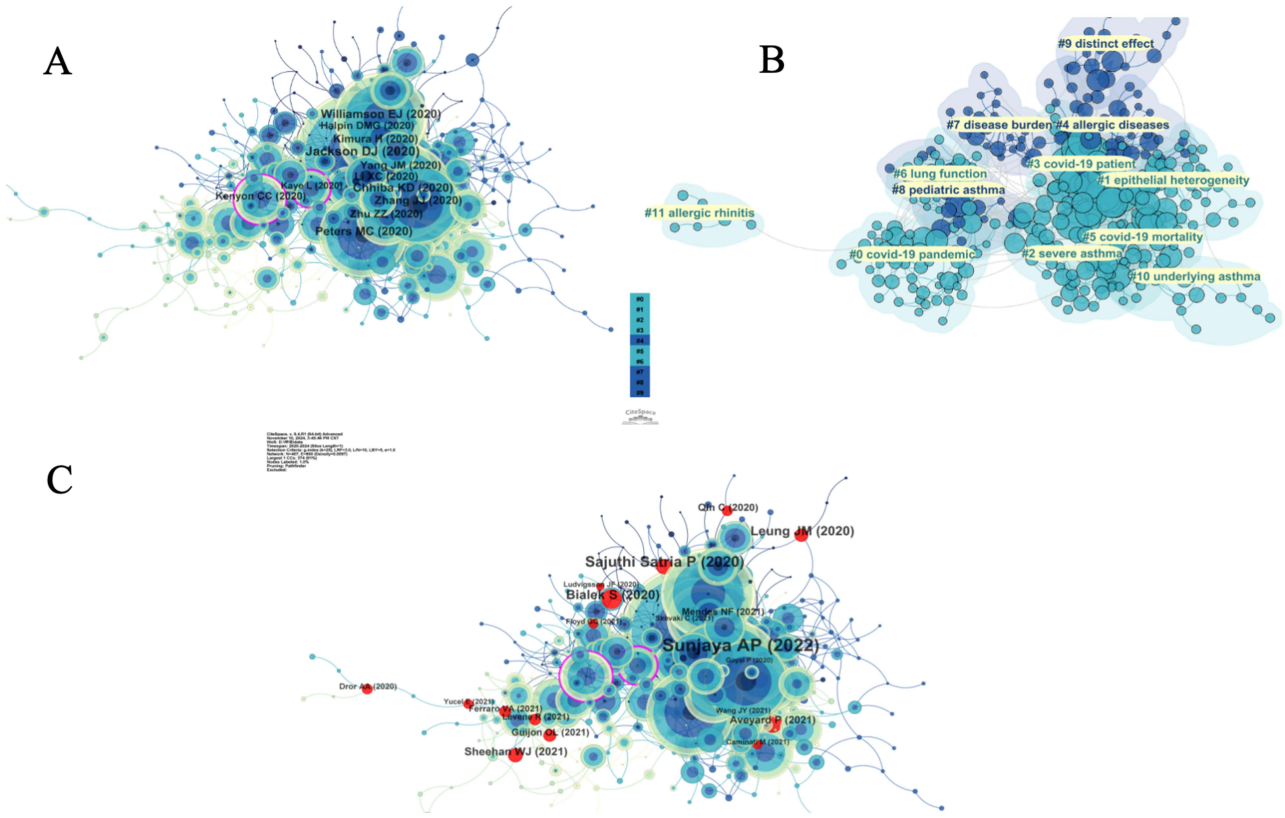

Figure 7 Visualization map of references.(**A**) Reference co-occurrence network; (**B**) Reference cluster map; (**C**) Reference bursts map.

https://doi.org/10.2147/JAA.S512175

Top 19 References with the Strongest Citation Bursts

References	Year	Strength	Begin	End	2020 - 2024
Sajuthi Satria P, 2020, BIORXIV, V0, P0, DOI 10.1101/2020.04.09.034454, DOI	2020	3.98	2020	2021	
Leung JM, 2020, EUR RESPIR J, V55, P0, DOI 10.1183/13993003.00688-2020, DOI	2020	3.48	2020	2021	
Bialek S, 2020, MMWR-MORBID MORTAL W, V69, P422, DOI 10.15585/mmwr.mm6914e4, DOI	2020	3.44	2020	2021	
Qin C, 2020, CLIN INFECT DIS, V71, P762, DOI 10.1093/cid/ciaa248, DOI	2020	2.73	2020	2021	
Ludvigsson JF, 2020, ACTA PAEDIATR, V109, P1088, DOI 10.1111/apa.15270, DOI	2020	1.98	2020	2021	
Goyal P, 2020, NEW ENGL J MED, V382, P2372, DOI 10.1056/NEJMc2010419, DOI	2020	1.84	2020	2021	
Sunjaya AP, 2022, J ASTHMA, V59, P866, DOI 10.1080/02770903.2021.1888116, DOI	2022	4.66	2022	2024	
Sheehan WJ, 2021, J ALLER CL IMM-PRACT, V9, P2073, DOI 10.1016/j.jaip.2021.02.008, DOI	2021	2.91	2022	2024	
Aveyard P, 2021, LANCET RESP MED, V9, P909, DOI 10.1016/S2213-2600(21)00095-3, DOI	2021	2.79	2022	2024	
Guijon OL, 2021, ANN ALLERG ASTHMA IM, V127, P91, DOI 10.1016/j.anai.2021.03.018, DOI	2021	2.52	2022	2024	
Mendes NF, 2021, ALLERGY ASTHMA CL IM, V17, P0, DOI 10.1186/s13223-020-00509-y, DOI	2021	2.52	2022	2024	
Ferraro VA, 2021, IMMUN INFLAMM DIS, V9, P561, DOI 10.1002/iid3.418, DOI	2021	2.32	2022	2024	
Levene R, 2021, AM J EMERG MED, V43, P109, DOI 10.1016/j.ajem.2021.01.072, DOI	2021	2.32	2022	2024	
Dror AA, 2020, J ALLER CL IMM-PRACT, V8, P3590, DOI 10.1016/j.jaip.2020.08.035, DOI	2020	2.13	2022	2024	
Wang JY, 2021, ALLERGY, V76, P565, DOI 10.1111/all.14480, DOI	2021	1.94	2022	2024	
Floyd GC, 2021, J ALLER CL IMM-PRACT, V9, P2077, DOI 10.1016/j.jaip.2021.02.038, DOI	2021	1.94	2022	2024	
Skevaki C, 2021, NAT REV IMMUNOL, V21, P202, DOI 10.1038/s41577-021-00516-z, DOI	2021	1.94	2022	2024	
Caminati M, 2021, VACCINES-BASEL, V9, P0, DOI 10.3390/vaccines9080853, DOI	2021	1.94	2022	2024	
Yucel E, 2021, PEDIAT ALLERG IMM-UK, V32, P963, DOI 10.1111/pai.13477, DOI	2021	1.94	2022	2024	

Figure 8 Top 19 most cited references based on the strength of the citation burst.

reduced exposure to respiratory viruses due to pandemic-related social distancing and school closures. Another significant paper, "Evaluating the impact of coronavirus disease 2019 on asthma morbidity",[32] discusses improved asthma management and decreased healthcare utilization during the pandemic, attributed to lower air pollution, reduced respiratory infections, and an uptick in telehealth services. These findings underscore the unique impact of the COVID-19 pandemic on asthma management, particularly in children.

Discussion

General Information

This study underscores the pivotal roles of specific geographic regions, particularly the United States, China, and the United Kingdom, in advancing research on asthma, AR, and COVID-19. The United States leads in terms of both publication volume and research impact, reflecting its significant investment in health research infrastructure and funding.[8,33,34] This prominence is demonstrated by institutions such as Harvard Medical School, which have been central in disseminating high-impact research. Major American journals like the Journal of Allergy and Clinical Immunology play a crucial role in setting research agendas and facilitating the rapid publication of significant findings.

China has rapidly expanded its research capabilities in recent years, particularly noticeable in the output from institutions like Peking University. This growth is closely tied to increased governmental focus on combating respiratory diseases.[35] The United Kingdom maintains a strong contribution through its longstanding tradition in epidemiology and clinical research. Leading institutions such as Imperial College London and the University of Edinburgh are supported by substantial funding and collaborative networks that enhance their global research impact. Prominent researchers based in the UK, such as Sheikh Aziz and Ioana Agache, are noted for their prolific contributions to the fields of allergy and respiratory diseases,[36–39] with extensive publications linking them to key research advancements.

Journals based in the UK, like Allergy and The Lancet, not only expedite the dissemination of emerging research but also influence global research priorities due to their high impact factors and international reach. By providing a detailed account of the geographical specifics of these contributions, this discussion highlights how regional characteristics and strategic priorities influence the global directions of medical research in asthma, AR, and their interactions with COVID-19.

However, while these leading countries and institutions contribute significantly to global research output, the generalizability of many findings remains limited by an underrepresentation of studies focused on ethnic and geographic diversity. Most research in asthma, AR, and COVID-19 has concentrated on Western populations, with relatively few studies examining the unique biological, environmental, and social factors affecting individuals from diverse ethnic backgrounds or those living in low- and middle-income regions. This gap poses a challenge in applying findings universally, as differing immune responses, healthcare access, and environmental exposures can lead to distinct disease presentations and treatment outcomes across populations. Despite significant contributions from high-income countries, research participation from low- and middle-income countries remains limited, likely due to barriers such as insufficient funding, inadequate research infrastructure, and fewer opportunities for international collaboration. To address these disparities, initiatives such as targeted funding programs, capacity-building projects, and cross-regional partnerships should be encouraged, enhancing global research inclusivity and improving the generalizability of findings.

Research Basis

The keyword co-occurrence analysis, identifying frequent terms such as “COVID-19”, “SARS-CoV-2”, “asthma”, and “omalizumab”, underscores the academic focus on the challenges faced by patients with asthma and AR after contracting the novel coronavirus. This includes exploring the mechanisms behind symptom exacerbation and evaluating the therapeutic impact of biological agents.

Research into the risks and treatment responses for asthma and AR patients during the COVID-19 pandemic has yielded varied and sometimes contradictory results. While some studies indicate that individuals with severe asthma may experience heightened risks of severe illness and hospitalization following infection—often linked to persistent airway inflammation and specific immune responses—other research suggests these patients might have a reduced susceptibility to SARS-CoV-2 due to lower ACE2 receptor expression.[40–42] The impact of medications for asthma and AR on COVID-19 also remains uncertain. For instance, corticosteroids and biologics like omalizumab are thought to modulate immune responses[43] and could theoretically alleviate COVID-19 symptoms, yet robust evidence supporting this effect is scarce. The current body of research, largely observational, falls short in establishing causal relationships. Future studies must more precisely assess how patients with various asthma and AR subtypes respond to COVID-19 and conduct extensive clinical trials to deepen our understanding of the specific benefits of anti-asthma and anti-allergy treatments.

Omalizumab, an anti-IgE monoclonal antibody, has attracted particular interest due to its effectiveness in managing severe asthma and AR.[44] This biologic not only inhibits the inflammatory response in asthma and AR but might also offer additional protection during the pandemic by reducing airway inflammation and modulating immune functions, potentially decreasing the risk of post-infection symptom exacerbation.[45] Although some studies suggest omalizumab may facilitate milder symptoms and quicker recovery in COVID-19 patients,[46] these findings are predominantly from observational studies and lack comprehensive validation through randomized controlled trials. Moreover, the potential risks associated with immune modulation by biological agents, such as inadvertently weakening natural viral defenses during the anti-inflammatory process, should be cautiously considered.[47] Current research on the effectiveness and safety of omalizumab across different ethnic and geographical groups is inadequate, limiting its worldwide applicability. Hence, future research should involve more rigorous clinical trials across a broader demographic to verify omalizumab’s specific impact on COVID-19 and to evaluate its long-term safety and efficacy. This will ensure that treatment strategies for asthma and AR are both scientifically sound and effective.

Overall, these high-frequency keywords illuminate three pivotal themes in the research fields of asthma/AR and COVID-19: the direct effects of the virus on respiratory diseases, the varied immune responses in different asthma types, and the role of biologics like omalizumab in managing these conditions. These focal points provide essential directions for future investigations into the relationship between respiratory diseases and COVID-19 and demonstrate the potential of biologics to address viral infections and regulate immune responses moving forward.

Reference co-occurrence analysis highlights foundational studies in asthma, AR, and COVID-19 research. Among the most cited, the study by Daniel J Jackson et al[48] suggests that asthma and AR may not substantially increase the risk for severe COVID-19, challenging previous assumptions about the vulnerability of these patients. This study, which primarily involved a cohort of children and adults with mild asthma not on regular treatment, emphasizes the need for broader research across varied demographics to validate these findings and to tailor treatment and prevention strategies effectively. While valuable, the study's focus on ACE2 receptor expression and its limited direct measurement of ACE2 protein levels means that further research is necessary to establish a more definitive link between ACE2 expression and susceptibility to SARS-CoV-2 infection. Future investigations should expand to include a diverse range of ages, ethnicities, and asthma severity levels to ensure comprehensive and applicable results.

While observational studies provide valuable insights, they are inherently limited by potential confounding factors, selection bias, and challenges in establishing causal relationships. These limitations must be carefully considered when interpreting the findings. To enhance the reliability of evidence, future research should prioritize randomized controlled trials and prospective cohort studies, which can help mitigate bias and provide stronger causal inferences.

Research Hotspots and Trends

Epidemiology and Management of Asthma and AR

The COVID-19 pandemic has significantly influenced the epidemiological landscape for patients with asthma and AR, yet interpreting these effects requires careful consideration. Preliminary data suggest that infection rates among asthmatic patients are comparable to those in the general population.[49–51] This observation could be partially attributed to more rigorous adherence to personal protective measures by asthmatic patients, such as frequent handwashing and mask-wearing. However, it is crucial to assess whether these findings accurately reflect the situation for asthmatic individuals worldwide, especially in low-income countries where access to protective measures and healthcare might be limited. Additionally, the variability in testing capabilities and reporting systems across different regions may introduce biases in reported case numbers.

The role of inhaled corticosteroids, a primary treatment for asthma and AR, in the context of COVID-19 infection remains contentious. While some research[52–54] indicates that inhaled glucocorticoids may diminish the expression of ACE2 receptors, potentially reducing SARS-CoV-2 entry, other studies raise concerns about their potential to suppress immune responses, thereby increasing infection risk.[55] Consequently, understanding the mechanisms behind these effects is currently a focal point of research. Many studies underpinnings these findings are observational and may be influenced by selection bias and confounding variables, such as the patients' pre-existing health conditions and other comorbidities. Eosinophils are significant in allergic diseases,[56] and although fluctuations in eosinophil counts have been associated with COVID-19 severity,[57] this relationship should not be interpreted as causal. Eosinophils' roles may differ across various types of inflammation and infections,[58] and their specific contributions to COVID-19 are not yet fully understood. Therefore, detailed mechanistic studies are imperative to clarify how eosinophils influence the progression of viral infections, which is essential before any eosinophil-based therapeutic strategies can be developed.

Specific Groups

Children represent a significant demographic affected by asthma and AR. A 2020 survey in the United States reported that the prevalence of asthma among children was 5.8%,[59] and the prevalence of AR was 40%.[60,61] Notably, there was a significant reduction in the typical seasonal peaks of acute asthma attacks among children during the pandemic.[62] This reduction is likely linked to public health interventions, such as school closures, which have also contributed to decreased transmission of influenza and other respiratory viruses.[63] However, it is important to consider that these findings might be influenced by a reduction in medical consultations during the pandemic.[64] For children with AR, the widespread use of masks has not only helped reduce the spread of COVID-19 but has also significantly decreased exposure to common allergens like pollen and dust mites, aiding symptom management.[65]

The role of COVID-19 vaccination in children with asthma and AR has also been a focal point of research. Studies confirm that the COVID-19 vaccine is safe for children with asthma, not exacerbating underlying lung function issues or causing severe adverse reactions.[66] Systematic reviews further support that asthma does not significantly increase the risk

for severe COVID-19 outcomes, underscoring the importance of vaccination.[67] For children with moderate to severe asthma, vaccination has been shown to notably decrease risks associated with COVID-19.[68] Nevertheless, vaccine hesitancy remains a barrier to achieving comprehensive protection, with about 19.1% of parents reluctant to vaccinate their children with asthma.[69]

Obesity is another critical area of concern in the intersection of COVID-19, asthma, and AR research. Current studies indicate that obesity not only serves as an independent risk factor for COVID-19 but also exacerbates the severity of asthma and AR, potentially leading to worse outcomes after infection.[70] Obesity is linked to higher expression of critical SARS-CoV-2 receptors such as ACE2 and CD147, which may facilitate the virus's entry into host cells.[71] Additionally, obesity is associated with elevated levels of pro-inflammatory markers[72] and is identified as a significant risk factor for long-term COVID syndrome (LCS), which can prolong and intensify the severity of the disease through metabolic imbalances and chronic inflammation.[73] Furthermore, obesity substantially increases the likelihood of COVID-19 hospitalization among patients with asthma, particularly those with metabolic comorbidities like hypertension and diabetes.[74] However, hospitalization rates among obese asthmatic patients on inhaled corticosteroids (ICS) remain relatively low, suggesting that ICS may offer some protective benefits.[75] Moreover, the combination of obesity and socioeconomic disadvantages, such as low education levels and immigrant status, significantly exacerbates the risk of severe COVID-19 infection and complications.[76] This intersection of factors poses substantial challenges to effective disease management in patients with asthma and AR, emphasizing the need for tailored treatment and prevention strategies that consider both medical and socioeconomic variables.

COVID-19 Vaccines

The European Academy of Allergy and Clinical Immunology (EAACI) provided guidelines for managing allergic diseases at the outset of the pandemic, emphasizing that the likelihood of allergic reactions from COVID-19 vaccines is comparatively lower than other vaccines, thus supporting their use in patients with asthma and AR.[77] Research indicates that in asthma patients with predominantly type 2 inflammation, vaccination does not trigger significant adverse immune reactions, affirming its safety in this sensitive group.[78] Studies, including those by McPhee et al, suggest that type 2 inflammation may offer some degree of protection against SARS-CoV-2 infection by diminishing ACE2 receptor expression. Additionally, the utilization of inhaled and intranasal corticosteroids may further decrease ACE2 receptor levels, potentially lowering infection risks. Importantly, vaccination is deemed safe for asthma patients undergoing allergy immunotherapy or biologic treatments, with substantial benefits noted.[79]

Clinically, vaccination significantly mitigates the risk of contracting COVID-19 and developing severe symptoms among asthma patients. A 2022 study highlighted that vaccination provides crucial protective effects, especially in patients requiring systemic corticosteroids, thereby reducing infection rates and enhancing overall disease management.[80] Research by Rosenberg et al supports these findings, demonstrating that vaccination does not induce eosinophil-related adverse inflammatory reactions, thereby ensuring its safety and applicability for asthma and AR patients.[81] Although generally safe, the willingness to vaccinate is markedly influenced by socioeconomic factors, such as employment status and concerns over vaccine side effects, particularly among ethnic minority groups with asthma. This underscores the need for tailored vaccine promotion strategies that address the diverse concerns of various demographic groups.[82] Further studies confirm that both mRNA and viral vector vaccines are safe, causing no serious adverse events or exacerbation of conditions in patients with asthma and AR, reaffirming the vaccine's safety profile.[83] Nevertheless, additional research is necessary to understand how severe asthma, complex cases with multiple comorbidities, and socioeconomic challenges affect vaccination decisions.

Limitations

This study has several limitations that merit consideration. Firstly, the exclusive use of the WoSCC as the data source may overlook relevant literature available in other databases such as PubMed and Scopus. This selection bias could impact the comprehensiveness and representativeness of the research findings. Secondly, the study's restriction to English-language literature introduces a linguistic bias, potentially omitting significant research from non-English-speaking regions. This limitation may restrict our understanding of global research trends in the field. Thirdly, the

bibliometric analysis conducted relies predominantly on quantitative metrics, such as publication counts and citation frequencies, which do not provide a deep evaluation of the research quality or its clinical relevance. High citation counts are not always indicative of high research quality and can be influenced by factors like self-citations or current popular topics. Lastly, the field of COVID-19 research is evolving rapidly, and the most recent studies might not yet be reflected in the analyzed data. As such, research hotspots and trends could shift quickly. Therefore, the findings of this study should be interpreted as preliminary and require ongoing updates and validation in light of new research publications.

Conclusion

This bibliometric analysis systematically reviews the major contributors, research hotspots, and developmental trends in the field of asthma/AR and COVID-19 globally. The United States, China, and the United Kingdom stand out for their significant scientific contributions. However, the bulk of research is concentrated in high-income countries, with scant studies from low and middle-income countries. The pandemic has markedly changed the disease patterns in patients with asthma and AR. Although their infection rates mirror those of the general population, ongoing airway inflammation and specific immune responses can exacerbate the severity of their infections. Inhaled corticosteroids and biologics such as omalizumab show promise in reducing the disease burden by modulating inflammation, but the prevailing evidence is primarily observational. COVID-19 vaccines have demonstrated safety and efficacy in patients with asthma and AR, yet challenges persist in promoting vaccination among minority and socioeconomically disadvantaged groups. Moreover, particular populations like children and obese patients encounter unique risks during the pandemic. Future research should increasingly focus on diverse populations and conduct cross-regional clinical trials to tailor and refine treatment strategies.

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Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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