The top 100 most influential articles in allergic rhinitis from 1970 to 2018: A bibliometric analysis

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Abstract
Objective: This study aimed to identify the top 100 most influential articles in the field of allergic rhinitis (AR).
Methods: Web of Science was queried for 1970 to 2018. Articles were sorted in descending order of the citation count. All titles and abstracts were screened to identify the top 100 articles.
Results: The top 100 most influential articles in AR were identified. The earliest article was published in 1975, and the most recent in 2015. The most prolific decade was the 2000s, with 59 articles published. Twenty-nine journals contributed to the top 100 articles, with the Journal of Allergy and Clinical Immunology contributing most of the articles (n = 34). The top three countries of article origin were the United States (n = 34), followed by the United Kingdom and France (n = 14 each). The type of article covered clinical research (n = 68), reviews (n = 22), and basic research (n = 10). For the clinical research articles, there were 6 studies with level 1 evidence, 25 with level 2 evidence, 11 with level 3 evidence, and 26 with level 4 evidence.
Conclusions: This study identified the top 100 most influential articles in the area of AR. Recognition of important historical contributions to this field may guide future investigations into AR.

Keywords
Allergic rhinitis, bibliometric, citation analysis, immunity therapy, influential article, landmark study

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Introduction

Allergic rhinitis (AR) represents a global health problem for all age groups. To improve our understanding of AR and our ability to manage and control it effectively, a great number of articles have been published on the epidemiology, pathogenesis, diagnosis, and treatment of AR. However, it is difficult to identify the most influential articles among numerous publications.

Bibliometrics are statistical and quantitative analyses that are designed to analyze the academic impact and publication characteristics within a certain field. Citation analysis is one method of bibliometric analysis that evaluates the influence and importance of an article by analyzing the citation count. It is widely recognized in various disciplines, such as medicine, respiratory medicine, and neurosurgery.

To the best of our knowledge, there has been no citation analysis performed in the field of AR. Therefore, we performed a citation analysis to identify the top 100 most influential articles on AR and analyzed their characteristics.

Methods

Search strategy

We used the advanced search “TI = ((allergi* rhiniti*) OR (pollen allerg*) OR (pollinos*) OR (hay fever) OR (hayfever))” in the Web of Science (WoS) core collection. The publication range was from January 1970 to August 2018 and the document types were original articles and reviews. Conference proceedings and Letters to the Editor were excluded. We also excluded some studies that did not involve AR, such as chronic idiopathic urticaria, chronic sinusitis, and grass sensitization. No language was restricted in this search. Two researchers (Q.-W.W. and R.Z.) reviewed and screened the titles and abstracts of the articles. The retrieved articles were ranked from the highest to the lowest based on the number of citations. Because no human subjects were enrolled, ethics approval was not required in this study.

Data extraction

After the articles were screened, we extracted the contents including the title of each article, the number of citations, the source of the journal, and the first author and their country. Next, based on the type of article, the publications were further divided into basic research, clinical research, and review article groups. Levels of evidence for clinical research articles were based on The Oxford 2011 Levels of Evidence. The Levels of Evidence Table focuses on the issues of prevalence, diagnosis, prognosis, treatment and screening, and has been frequently used in bibliometric research. For example, a systematic review of randomized trials that is graded level 1 represents the highest level.

Statistical analysis

The data were analyzed using IBM SPSS 22.0 package (IBM Corp., Armonk, NY, USA). Descriptive statistics were quantified as counts or percentages of parameters. This study did not involve statistically significant differences.

Results

Our literature search yielded 14,270 articles between 1970 and 2018, which were further screened for the top 100 articles (Table 1).

Number of articles published

Among the top 100 articles, the oldest article was published in 1975 and the most recent was published in 2015 (Figure 1). Among these 100 articles, the most prolific
| Rank | Title                                                                 | Journal                                           | Year | First Author       | Institute                          | Citation | Class   |
|------|------------------------------------------------------------------------|---------------------------------------------------|------|--------------------|------------------------------------|----------|---------|
| 1    | Allergic rhinitis and its impact on asthma (ARIA) 2008 update (in collaboration with the World Health Organization, GA(2)LEN and AllerGen) | Allergy                                           | 2008 | Bousquet J         | Hospital Arnaud de Villeneuve      | 2130     | review  |
| 2    | Allergic rhinitis and its impact on asthma                             | Journal of Allergy and Clinical Immunology         | 2001 | Bousquet J         | Hospital Arnaud de Villeneuve      | 1624     | review  |
| 3    | Allergic Rhinitis and its Impact on Asthma (ARIA) guidelines: 2010 Revision | Journal of Allergy and Clinical Immunology         | 2010 | Brozek Jan L       | McMaster University                | 684      | review  |
| 4    | Prevalence and rate of diagnosis of allergic rhinitis in Europe        | European Respiratory Journal                      | 2004 | Bauchau V          | UCB Pharma S.A.                    | 499      | 4       |
| 5    | Immunolocalization of cytokines in the nasal-mucosa of normal and perennial rhinitic subjects - the mast-cell as a source of IL-4, IL-5, and IL-6 in human allergic mucosal inflammation | Journal of Immunology                             | 1993 | Bradding P         | Southampton University              | 470      | technology |
| 6    | Sublingual immunotherapy for allergic rhinitis: systematic review and meta-analysis | Allergy                                           | 2005 | Wilson DR          | University Hospital Birmingham     | 459      | 1       |
| 7    | Consensus statement on the treatment of allergic rhinitis             | Allergy                                           | 2000 | van Cauwenberge P  | Ghent University Hospital          | 396      | review  |
| 8    | Allergic rhinitis: Definition, epidemiology, detection, and pathophysiology, diagnosis | Journal of Allergy and Clinical Immunology         | 2001 | Skoner DR          | University of Pittsburgh School of Medicine | 384      | review  |

(continued)
| Rank | Title                                                                 | Journal                                | Year | First Author          | Institute                                      | Citation | Class |
|------|----------------------------------------------------------------------|----------------------------------------|------|-----------------------|------------------------------------------------|----------|-------|
| 9    | Immunotherapy with a ragweed-toll-like receptor 9 agonist vaccine for allergic rhinitis | New England Journal of Medicine        | 2006 | Creticos Peter S      | Johns Hopkins University School of Medicine     | 372      | 2     |
| 10   | Intranasal corticosteroids versus oral H-1, receptor antagonists in allergic rhinitis: systematic review of randomised controlled trials | British Medical Journal                | 1998 | Weiner JM             | Monash University                               | 365      | 1     |
| 11   | Assessment of quality-of-life in patients with perennial allergic rhinitis with the French version of the SF-36 health-status questionnaire | Journal of Allergy and Clinical Immunology | 1994 | Bousquet J           | Hospital Arnaud of Villeneuve                    | 334      | 4     |
| 12   | Optimal dose, efficacy, and safety of once-daily sublingual immunotherapy with a 5-grass pollen tablet for seasonal allergic rhinitis | Journal of Allergy and Clinical Immunology | 2007 | Didie Alain           | Larrey Hospital                                  | 333      | 2     |
| 13   | Epidemiology of physician-diagnosed allergic rhinitis in childhood | Pediatrics                             | 1994 | Wright AL            | The Steele Memorial Children’s Research Center   | 305      | 4     |
| 14   | Immediate and late airway response of allergic rhinitis patients to segmental antigen challenge - characterization of Eosinophil and mast-cell mediators | American Review of Respiratory Disease | 1991 | Sedgwick JB          | University of Wisconsin                          | 288      | technology |
| 15   | The burden of allergic rhinitis                                       | Allergy and Asthma Proceedings          | 2007 | Nathan Robert A.      | University of Colorado Health Sciences Center   | 287      | review |
| 16   | Seasonal allergic rhinitis and antihistamine effects on children’s learning | Annals of Allergy                       | 1993 | Vuurman EF           | University of Limburg                            | 267      | 4     |
| Rank | Title                                                                 | Journal                                                                 | Year | First Author | Institute                                      | Citation | Class |
|------|-----------------------------------------------------------------------|-------------------------------------------------------------------------|------|--------------|------------------------------------------------|----------|-------|
| 17   | Allergic Rhinitis and its Impact on Asthma (ARIA): Achievements in 10 years and future needs | Journal of Allergy and Clinical Immunology                              | 2012 | Bousquet J   | Hospital Arnaud of Villeneuve                   | 262      | review |
| 18   | Drug-therapy - allergic rhinitis                                       | New England Journal of Medicine                                         | 1991 | Naclerio RM  | Johns Hopkins University School of Medicine     | 252      | review |
| 19   | Allergen injection immunotherapy for seasonal allergic rhinitis       | Cochrane Database of Systematic Reviews                                 | 2007 | Calderon MA  | Royal Brompton Hospital                         | 246      | 1     |
| 20   | Obstructive apneas during sleep in patients with seasonal allergic rhinitis | American Review of Respiratory Disease                                  | 1982 | McNicholas WT | Queen Elizabeth Hospital                        | 245      | 3     |
| 21   | Segmental bronchial provocation induces nasal inflammation in allergic rhinitis patients | American Journal of Respiratory and Critical Care Medicine              | 2000 | Braunstahl GJ | Erasmus University Medical Center Rotterdam     | 244      | 3     |
| 22   | Nasal mast cells in perennial allergic rhinitics exhibit increased expression of the Fc epsilon RI, CD40L, IL-4, and IL-13, and can induce IgE synthesis in B cells | Journal of Clinical Investigation                                      | 1997 | Pawankar R   | Juntendo University School of Medicine          | 244      | technology |
| 23   | Inhibition of mediator release in allergic rhinitis by pretreatment with topical glucocorticosteroids | New England Journal of Medicine                                         | 1987 | Pipkorn U    | Johns Hopkins University School of Medicine     | 244      | 2     |

(continued)
| Rank | Title                                                                 | Journal                                      | Year | First Author      | Institute                                      | Citation | Class |
|------|-----------------------------------------------------------------------|----------------------------------------------|------|-------------------|------------------------------------------------|----------|-------|
| 24   | A survey of the burden of allergic rhinitis in Europe                 | Allergy                                      | 2007 | Canonica GW       | University of Genoa                             | 238      | 4     |
| 25   | Efficacy of sublingual immunotherapy in the treatment of allergic rhinitis in pediatric patients 3 to 18 years of age: a meta-analysis of randomized, placebo-controlled, double-blind trials | Annals of Allergy Asthma & Immunology       | 2006 | Penagos Martin    | University of Genoa                             | 236      | 1     |
| 26   | Local production of specific IgE antibodies in allergic rhinitis patients with negative skin-tests | Lancet                                       | 1975 | Huggins KG        | Middlesex Hospital Medical School               | 231      | 3     |
| 27   | Use of an anti-IgE humanized monoclonal antibody in ragweed-induced allergic rhinitis | Journal of Allergy and Clinical Immunology   | 1997 | Casale TB         | University of Iowa                              | 229      | 3     |
| 28   | Effect of omalizumab on symptoms of seasonal allergic rhinitis - A randomized controlled trial | Jama-Journal of the American Medical Association | 2001 | Casale TB         | Creighton University                            | 223      | 2     |
| 29   | Recombinant humanized mAb-E25, an anti-IgE mAb, in birch pollen-induced seasonal allergic rhinitis | Journal of Allergy and Clinical Immunology   | 2000 | Adelroth E        | Umea University Hospital                        | 219      | 2     |
| 30   | Concomitant montelukast and loratadine as treatment for seasonal allergic rhinitis: A randomized, placebo-controlled clinical trial | Journal of Allergy and Clinical Immunology   | 2000 | Meltzer EO        | Allergy and Asthma Medical Group and Research Center (San Diego) | 217      | 2     |
| 31   | Burden of allergic rhinitis: Results from the Pediatric Allergies in America survey | Journal of Allergy and Clinical Immunology   | 2009 | Meltzer EO        | Allergy and Asthma Medical Group and Research Center (San Diego) | 215      | 4     |

(continued)
### Table 1. Continued.

| Rank | Title                                                                 | Journal                                      | Year | First Author         | Institute                                                | Citation | Class |
|------|-----------------------------------------------------------------------|----------------------------------------------|------|----------------------|----------------------------------------------------------|----------|-------|
| 32   | Efficacy of combination treatment with anti-IgE plus specific immunotherapy in polysensitized children and adolescents with seasonal allergic rhinitis | Journal of Allergy and Clinical Immunology   | 2002 | Kuehr J              | University Children's Hospital                            | 209      | 2     |
| 33   | Allergic rhinitis                                                     | Lancet                                       | 2011 | Greiner Alexander N  | Allergy and Asthma Medical Group and Research Center (San Diego) | 207      | technology |
| 34   | Omalizumab pretreatment decreases acute reactions after rush immunotherapy for ragweed-induced seasonal allergic rhinitis | Journal of Allergy and Clinical Immunology   | 2006 | Casale TB            | the Creighton University School of Medicine               | 205      | 2     |
| 35   | A cost of illness study of allergic rhinitis in the United States      | Journal of Allergy and Clinical Immunology   | 1997 | Malone DC            | University of Colorado Health Sciences Center             | 202      | 4     |
| 36   | Airway hyperresponsiveness in allergic rhinitis - a risk factor for asthma | Chest                                        | 1987 | Braman SS            | Rhode Island Hospital and Brown University                | 201      | 4     |
| 37   | Seasonal allergic rhinitis is associated with a detrimental effect on examination performance in United Kingdom teenagers: Case-control study | Journal of Allergy and Clinical Immunology   | 2007 | Walker Samantha      | University of Edinburgh                                    | 199      | 4     |

(continued)
| Rank | Title                                                                 | Journal                                                                 | Year | First Author | Institute                                      | Citation | Class  |
|------|-----------------------------------------------------------------------|-------------------------------------------------------------------------|------|--------------|------------------------------------------------|----------|--------|
| 38   | Immunohistology of the nasal-mucosa in seasonal allergic rhinitis - increases in activated eosinophils and epithelial mast-cells | Journal of Allergy and Clinical Immunology                               | 1992 | Bentley AM   | Royal Brompton Hospital                        | 198      | technology |
| 39   | Quality of life in adults and children with allergic rhinitis       | Journal of Allergy and Clinical Immunology                               | 2001 | Meltzer EO   | The Allergy and Asthma Medical Group and Research Center | 196      | review |
| 40   | Allergic rhinitis and its impact on asthma update: Allergen immunotherapy | Journal of Allergy and Clinical Immunology                               | 2007 | Passalacqua Giovanni | University of Genoa                              | 194      | review |
| 41   | Absence of growth retardation in children with perennial allergic rhinitis after one year of treatment with mometasone furoate aqueous nasal spray | Pediatrics                                                               | 2000 | Schenkel EJ  | Easton                                         | 185      | 2      |
| 42   | Nasal congestion secondary to allergic rhinitis as a cause of sleep disturbance and daytime fatigue and the response to topical nasal corticosteroids | Journal of Allergy and Clinical Immunology                               | 1998 | Craig TJ     | Penn State University                           | 184      | 3      |
| 43   | Severity and impairment of allergic rhinitis in patients consulting in primary care | Journal of Allergy and Clinical Immunology                               | 2006 | Bousquet J   | Hospital Arnaud of Villeneuve                    | 167      | 3      |
| 44   | Montelukast for treating seasonal allergic rhinitis: a randomized, double-blind, placebo-controlled trial performed in the spring | Journal of Allergy and Clinical Immunology                               | 2002 | Philip G      | Merck Research Laboratories                     | 167      | 2      |

(continued)
| Rank | Title                                                                 | Journal                                | Year | First Author   | Institute                               | Citation | Class |
|------|----------------------------------------------------------------------|----------------------------------------|------|----------------|-----------------------------------------|----------|-------|
| 45   | Low-dose sublingual therapy in patients with allergic rhinitis due to house dust mite | Clinical Allergy                       | 1986 | Scadding GK    | Middlesex Hospital Medical School       | 163      | 3     |
| 46   | Exhaled and nasal NO levels in allergic rhinitis: relation to sensitization, pollen season and bronchial hyperresponsiveness | European Respiratory Journal           | 1999 | Henriksen AH   | Norwegian University of Science and Technology | 161      | 3     |
| 47   | Epidemiological characterization of the intermittent and persistent types of allergic rhinitis | Allergy                                | 2005 | Bauchau V      | UCB Pharma S.A                         | 148      | 4     |
| 48   | Economic impact and quality-of-life burden of allergic rhinitis       | Current Medical Research and Opinion   | 2004 | Schoenwetter WF | Park Nicollet Clinic                    | 148      | review |
| 49   | Economic impact of workplace productivity losses due to allergic rhinitis compared with select medical conditions in the United States from an employer perspective | Current Medical Research and Opinion   | 2006 | Lamb Charles   | PCA Occupational Medicine               | 146      | 4     |
| 50   | Levocetirizine improves quality of life and reduces costs in long-term management of persistent allergic rhinitis | Journal of Allergy and Clinical Immunology | 2004 | Bachert C      | Ghent university Hospital               | 146      | 2     |
| 51   | Characteristics of intermittent and persistent allergic rhinitis: DREAMS study group | Clinical and Experimental Allergy      | 2005 | Bousquet J     | Hospital Arnaud of Villeneuve           | 142      | 4     |
| 52   | Prevalence, classification and perception of allergic and nonallergic rhinitis in Belgium | Allergy                                | 2006 | Bachert C      | Ghent University Hospital               | 141      | 4     |

(continued)
| Rank | Title                                                                                                                                                                                                 | Journal                                  | Year | First Author | Institute                        | Citation | Class |
|------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------|------|--------------|-----------------------------------|----------|-------|
| 53   | The economic burden of allergic rhinitis - A critical evaluation of the literature                                                                                                                    | Pharmacoeconomics                        | 2004 | Reede SD Duke University Medical Center |          |       |
| 54   | Efficacy and tolerability of montelukast alone or in combination with loratadine in seasonal allergic rhinitis: a multicenter, randomized, double-blind, placebo-controlled trial performed in the fall | Annals of Allergy Asthma & Immunology    | 2002 | Nayak AS University of Illinois |          | 138    |
| 55   | Once daily intranasal fluticasone propionate (200 μg) reduces nasal symptoms and inflammation but also attenuates the increase in bronchial responsiveness during the pollen season in allergic rhinitis | Journal of Allergy and Clinical Immunology | 1996 | Foresi A Serbizio di Fisiopatologia Respiratoria |          | 138    |
| 56   | Leukotriene receptor antagonists for allergic rhinitis: A systematic review and meta-analysis                                                                                                           | American Journal of Medicine             | 2004 | Wilson AM McMaster University |          | 137    |
| 57   | Intranasal corticosteroids versus topical H-1 receptor antagonists for the treatment of allergic rhinitis: a systematic review with meta-analysis                                                                 | Annals of Allergy Asthma & Immunology    | 2002 | Yanez A Hospital Aerona Útico Central |          | 134    |
| 58   | The expression of leukocyte-endothelial adhesion molecules is increased in perennial allergic rhinitis                                                                                                    | American Journal of Respiratory Cell and Molecular Biology | 1992 | Montefort S Southampton General Hospital |          | 134    |
| Rank | Title                                                                 | Journal                                                                 | Year | First Author          | Institute                                      | Citation | Class |
|------|----------------------------------------------------------------------|------------------------------------------------------------------------|------|-----------------------|------------------------------------------------|----------|-------|
| 59   | Omalizumab, an anti-IgE antibody, in the treatment of adults and adolescents with perennial allergic rhinitis | Annals of Allergy Asthma & Immunology                                  | 2003 | Chervinsky P          | Northeast Medical Research Associates          | 133      | 2     |
| 60   | The leukotriene D4-receptor antagonist, ICI-204,219, relieves symptoms of acute seasonal allergic rhinitis | American Journal of Respiratory and Critical Care Medicine             | 1995 | Donnelly AL           | University of Iowa College of Medicine          | 133      | 2     |
| 61   | A survey of the burden of allergic rhinitis in the USA                | Allergy                                                                | 2007 | Schatz M              | Kaiser Permanente Medical Center               | 131      | 4     |
| 62   | Allergen drives class switching to IgE in the nasal mucosa in allergic rhinitis | Journal of Immunology                                                  | 2005 | Takhar P              | King's College London                           | 131      | technology |
| 63   | Double-blind, placebo-controlled study comparing the efficacy and safety of fexofenadine hydrochloride (120 and 180 mg once daily) and cetirizine in seasonal allergic rhinitis | Journal of Allergy and Clinical Immunology                             | 1999 | Howarth PH            | Southampton General Hospital                     | 131      | 2     |
| 64   | Allergic rhinitis and its consequences on quality of sleep - An unexplored area | Archives of Internal Medicine                                          | 2006 | Leger Damien          | Assistance Public Hospital of Paris             | 127      | 4     |
| 65   | Validation of the classification of ARIA (allergic rhinitis and its impact on asthma) | Allergy                                                                | 2003 | Demoly P              | Hospital Arnaud de Villeneuve                   | 127      | 4     |
| 66   | Allergen-induced release of sulfido-peptide leukotrienes (SRS-A) and LTB4 in allergic rhinitis | Allergy                                                                | 1985 | Shaw RJ               | Brompton Hospital                              | 127      | technology |

(continued)
| Rank | Title                                                                 | Journal                                      | Year | First Author | Institute                              | Citation Class |
|------|----------------------------------------------------------------------|----------------------------------------------|------|--------------|-----------------------------------------|----------------|
| 67   | Nasal nitric oxide is increased in allergic rhinitis                  | Clinical and Experimental Allergy            | 1997 | Arnal JF     | Hospital Rangueil                      | 124 technology |
| 68   | Evaluation of impermeable covers for bedding in patients with allergic rhinitis | New England Journal of Medicine              | 2003 | Terreehorst I | Erasmus Medical Center                  |                |
| 69   | The role of leukotriene-D4 in allergic rhinitis                       | Annals of Allergy                            | 1988 | Okida M      | Nippon Medical School                   |                |
| 70   | Quality of life in patients with allergic rhinitis                   | Annals of Allergy                            | 2000 | Thompson, AK | McMaster University                    | 122 review     |
| 71   | Prevalence of allergic rhinitis in the United States                  | Allergy & Asthma & Immunology                | 1997 | Nathan RA    | Colorado Springs                        | 122            |
| 72   | An intranasal Syk-kinase inhibitor (R112) improves the symptoms of seasonal allergic rhinitis in a park environment | Journal of Allergy and Clinical Immunology   | 2005 | Meltzer EO   | Allergy & Asthma & Immunology (San Diego) | 121 2          |
| 73   | The cost of productivity losses associated with allergic rhinitis    | American Journal of Managed Care            | 2000 | Crystal-Peters J | Washington                        | 120 4         |
| 74   | Segmental bronchoprovocation in allergic rhinitis patients affects mast cell and basophil numbers in nasal and bronchial mucosa | American Journal of Respiratory and Critical Care Medicine | 2001 | Braunstahl Gj | Erasmus University Medical Center Rotterdam | 119 3         |

(continued)
| Rank | Title                                                                 | Journal                        | Year | First Author        | Institute                                         | Citation | Class |
|------|----------------------------------------------------------------------|--------------------------------|------|---------------------|---------------------------------------------------|----------|-------|
| 75   | Clinical Practice Guideline: Allergic Rhinitis                       | Otolaryngology-Head and Neck Surgery | 2015 | Seidman Michael D  | Henry Ford West Bloomfield Hospital West Bloomfield | 118      | review |
| 76   | Implementation of guidelines for seasonal allergic rhinitis: a randomized controlled trial | Allergy                         | 2003 | Bousquet J          | Hospital Arnaud de Villeneuve                      | 115      | 2     |
| 77   | Comparison of the efficacy, safety and quality of life provided by fexofenadine hydrochloride 120 mg, loratadine 10 mg and placebo administered once daily for the treatment of seasonal allergic rhinitis | Clinical and Experimental Allergy | 2000 | Van Cauwenberge P   | Ghent University Hospital                          | 115      | 2     |
| 78   | Seasonal and perennial allergic rhinitis: is this classification adherent to real life? | Allergy                         | 2005 | Ciprandi G          | S. Martino Hospital                                | 114      | 4     |
| 79   | Allergic rhinitis: A disease remodeling the upper airways?          | Journal of Allergy and Clinical Immunology | 2004 | Bousquet J          | Hospital Arnaud de Villeneuve                      | 114      | review |
| 80   | Breathing disorders in sleep associated with microarousals in patients with allergic rhinitis | Acta Otolaryngologica            | 1981 | Lavie P             | Rothschild University Hospital                     | 114      | 4     |
| 81   | A placebo-controlled trial of immunotherapy with 2 extracts of Dermatophagoides pteronyssinus in allergic rhinitis, comparing clinical outcome with changes in antigen-specific IgE, IgG, and IgG subclasses | Journal of Allergy and Clinical Immunology | 1990 | McHugh SM           | University of Cambridge Clinical School            | 113      | 2     |

(continued)
| Rank | Title                                                                 | Journal                                         | Year | First Author        | Institute                                      | Citation | Class |
|------|-----------------------------------------------------------------------|-------------------------------------------------|------|---------------------|------------------------------------------------|----------|-------|
| 82   | Allergic rhinitis: Direct and indirect costs                          | Allergy and Asthma Proceedings                  | 2010 | Blaiss Michael S    | University of Tennessee Health Science Center | 112      | review|
| 83   | Inflammatory mediators in allergic rhinitis                           | Journal of Allergy and Clinical Immunology      | 2004 | Gelfand Erwin W     | National Jewish Medical and Research Center    | 112      | review|
| 84   | Bronchial hyperresponsiveness and airway inflammation markers in nonasthmatics with allergic rhinitis | European Respiratory Journal                   | 2000 | Polosa R            | University of Catania                           | 112      | 4     |
| 85   | Learning impairment and allergic rhinitis                             | Allergy and Asthma Proceedings                  | 1996 | Simons FER          | University of Manitoba                          | 112      | review|
| 86   | Plasma kallikrein during experimentally induced allergic rhinitis - role in kinin formation and contribution to taseesterase activity in nasal secretions | Journal of Immunology                           | 1986 | Baumgarten CR       | The Johns Hopkins University School of Medicine | 111      | technology|
| 87   | Comparison of a nasal glucocorticoid, antileukotriene, and a combination of antileukotriene and antihistamine in the treatment of seasonal allergic rhinitis | Journal of Allergy and Clinical Immunology      | 2002 | Pullerits T         | Göteborg University                              | 110      | 2     |
| 88   | Effects of monotherapy with intra-nasal corticosteroid or combined oral histamine and leukotriene receptor antagonists in seasonal allergic rhinitis | Clinical and Experimental Allergy               | 2001 | Wilson AM           | University of Dundee                           | 110      | 3     |

(continued)
Table 1. Continued.

| Rank | Title                                                                 | Journal                                      | Year | First Author     | Institute                      | Citation | Class |
|------|------------------------------------------------------------------------|----------------------------------------------|------|------------------|--------------------------------|----------|-------|
| 89   | Different effects of nasal and bronchial glucocorticosteroid           | American Review of Respiratory Disease       | 1992 | Aubier M         | Hospital Bichat                | 110      | 3     |
|      | administration on bronchial hyperresponsiveness in patients with allergic rhinitis |                                              |      |                  |                                |          |       |
| 90   | Molecular spreading and predictive value of preclinical IgE response   | Journal of Allergy and Clinical Immunology    | 2012 | Hatzler Laura    | Charite University Medical Centre | 108      | 4     |
|      | to Phleum pratense in children with hay fever                         |                                              |      |                  |                                |          |       |
| 91   | Requirements for medications commonly used in the treatment of allergic rhinitis - European Academy of Allergy and Clinical Immunology (EAACI) allergic rhinitis and its impact on asthma (ARIA) | Allergy                                      | 2003 | Bousquet J       | Hospital Arnaud de Villeneuve  | 107      | review|
| 92   | Overview of comorbid associations of allergic rhinitis                 | Journal of Allergy and Clinical Immunology    | 1997 | Spector SL       | University of California       | 106      | review|
| 93   | Randomised controlled trial of homoeopathy versus placebo in perennial allergic rhinitis with overview of four trial series | British Medical Journal                      | 2000 | Taylor MA        | Glasgow Royal Infirmary        | 104      | 2     |
| 94   | Lower airways remodeling in nonasthmatic subjects with allergic rhinitis | Laboratory Investigation                     | 1996 | Chakir J         | University Laval               | 104      | 4     |
| 95   | Changes in daytime sleepiness, quality of life, and objective sleep   | Journal of Allergy and Clinical Immunology    | 2004 | Stuck BA         | University Hospital Mannheim   | 103      | 4     |
|      | patterns in seasonal allergic rhinitis: A controlled clinical trial   |                                              |      |                  |                                |          |       |

(continued)
| Rank | Title                                                                 | Journal                                      | Year | First Author | Institute                                      | Citation | Class |
|------|----------------------------------------------------------------------|----------------------------------------------|------|--------------|------------------------------------------------|----------|-------|
| 96   | Treatment of perennial allergic rhinitis with lactic acid bacteria  | Pediatric Allergy and Immunology             | 2004 | Wang MF      | China Medical University Hospital               | 103      | 2     |
| 97   | Local production and detection of (specific) IgE in nasal B-cells and plasma cells of allergic rhinitis patients | European Respiratory Journal                 | 2000 | Kleinjan A   | Erasmus University Medical Centre Rotterdam     | 103      | 4     |
| 98   | A dose-ranging study of fluticasone propionate aqueous nasal spray for seasonal allergic rhinitis assessed by symptoms, rhinomanometry, and nasal cytology | Journal of Allergy and Clinical Immunology   | 1990 | Meltzer EO   | Allergy and Asthma Medical Group and Research Center (San Diego) | 103      | 4     |
| 99   | Local allergic rhinitis: Concept, pathophysiology, and management | Journal of Allergy and Clinical Immunology   | 2012 | Rondon Carmen | Carlos Haya Hospital                             | 102      | review|
| 100  | Fluticasone furoate nasal spray: A single treatment option for the symptoms of seasonal allergic rhinitis | Journal of Allergy and Clinical Immunology   | 2007 | Kaiser Harold B | Minneapolis                                    | 102      | 2     |
decade was the 2000s (n = 59), followed by the 1990s (n = 25), the 1980s (n = 8), the 2010s (n = 7), and the 1970s (n = 1).

**Number of citations**

Among these 100 articles, the highest citation count was 2130 and the lowest was 102. The average citation count for a single article in the 1970s, 1980s, 1990s, 2000s, and 2010s was 231.0, 166.0, 197.2, 238.0, and 227.6, respectively.

**Published journals**

The 100 most influential articles were published in 29 journals. Among these journals, those with more than one article published and its impact factor are listed in Table 2. The top journals were *Journal of Allergy and Clinical Immunology* (n = 34), *Allergy*...
(n = 12), Clinical and Experimental Allergy (n = 5), and Annals of Allergy Asthma & Immunology (n = 5).

**Origins**

These articles were mainly from 17 countries. Among these countries (Figure 2), the top three were the USA (n = 34), the UK (n = 14), and France (n = 14). The second tier of countries included Italy (n = 6), which was followed by Canada (n = 6), Belgium (n = 6), The Netherlands (n = 4), Germany (n = 3), Sweden (n = 2), and Japan (n = 2). An equal number of articles originated from Spain, Norway, Israel, The Netherlands, China, Australia, and Argentina (n = 1, each).

**First authors**

There were 80 first authors who contributed to these articles. There were nine first authors who had published more than 1 article (Table 3). The top three authors included Bousquet J (n = 9), Meltzer EO (n = 5), and Casale TB (n = 3). The number of publications for Bachert C, Bauchau V, Braunstahl GJ, Nathan RA, van Cauwenberge P, and Wilson AM were the same (n = 2, each).

**Institutions**

These articles came from 71 different institutions. There were 13 institutions with >1 published article (Table 4). Among them, the top three were Hospital Arnaud de Villeneuve (n = 10), Allergy and Asthma Medical Group and Research Center of San Diego (n = 5), and Ghent University Hospital (n = 4).

**Table 3.** First authors with more than one published article

| First Author     | No. of Articles |
|------------------|-----------------|
| Bousquet J       | 9               |
| Meltzer EO       | 5               |
| Casale TB        | 3               |
| Bachert C        | 2               |
| Bauchau V        | 2               |
| Braunstahl GJ    | 2               |
| Nathan RA        | 2               |
| van Cauwenberge P| 2               |
| Wilson AM        | 2               |

![Figure 2. Article counts by origin with >1 published article.](image-url)
The type of articles

Among these articles, the number of articles on clinical research, reviews, and basic research was 68, 22, and 10, respectively. Among the reviews, there were six articles about guidelines. Most of the basic research articles focused on immune response.

The level of evidence

Among the clinical research articles, 6, 25, 11, and 26 were graded as having Level 1, Level 2, Level 3, and Level 4 evidence, respectively, based on The Oxford 2011 Levels of Evidence.\(^7\)

Study types of clinical articles

The study types of clinical articles mostly included case-series/retrospective studies (n = 26), followed by randomized controlled trials (n = 25), non-randomized controlled cohort studies (n = 11), and systematic reviews/meta-analyses (n = 6). There were 27 of 68 articles that used a questionnaire, such as health-related quality of life (HRQoL) or the rhinoconjunctivitis quality of life questionnaire (RQLQ).

Based on the treatment modalities for clinical research articles, most were immunity therapy (n = 22), followed by intranasal corticosteroids and quality of daily life (n = 10, each).

Discussion

In our study, bibliometric analysis was used to identify the top 100 most influential articles in AR. These articles are representative of the many landmarks in AR over the past decades.

The top three articles were guidelines on Allergic Rhinitis and its Impact on Asthma (ARIA). The results demonstrate that guidelines are the most cited articles, but this is different from other bibliometric studies. These bibliometric studies often reported that basic research articles and clinical research articles are the most cited articles.\(^5,6,8\) Because of the time-dependent citation analysis,\(^9\) recent important articles might not have sufficient citations. For example, the ARIA guidelines 2016 revision\(^10\) and the ARIA score for AR using mobile technology that correlates with the quality of life\(^11\) was not in this top 100 list. This indicates that the number of citations that a paper has received may not reflect its overall historical importance.

### Table 4. Institutions with more than one published article

| Institution                                                   | No. of Articles (n = 43) |
|---------------------------------------------------------------|--------------------------|
| Hospital Arnaud de Villeneuve                                 | 10                       |
| Allergy and Asthma Medical Group and Research Center (San Diego) | 5                        |
| Ghent University Hospital                                     | 4                        |
| Erasmus University Medical Center Rotterdam                   | 3                        |
| Johns Hopkins University School of Medicine                   | 3                        |
| McMaster University                                           | 3                        |
| University of Genoa                                            | 3                        |
| Middlesex Hospital Medical School                             | 2                        |
| Royal Brompton Hospital                                       | 2                        |
| Southampton General Hospital                                  | 2                        |
| UCB Pharma S.A                                                 | 2                        |
| University of Colorado Health Sciences Center                  | 2                        |
| University of Iowa                                            | 2                        |

\(\text{Table 4. Institutions with more than one published article}\)
With the exception of the 2010s, the number of articles increased by decade. Thus, more than half of the articles in our study were published in the 2000s. The mean number of citations also tended to increase by decade except for the 1970s. These findings are consistent with those of other bibliometric studies. The results demonstrate that new articles with novel discoveries and advanced technologies continue to be published and receive more citations than previous articles.

Some bibliometric studies reported that journals with high impact factors, such as NEJM and The Lancet, were the leading journals. However, we found that the Journal of Allergy and Clinical Immunology was the most productive journal, despite its impact factor of 13.3. Other bibliometric studies also reported that specialized journals were the leading journals. The results showed that highly influential articles are also published in specialized journals, and these influential articles are not limited to the most well-known general medical journal.

Among the top 100 list, most articles originated from developed countries in Europe and North America. Only one article on the list came from Taiwan China. Another important article on the list came from mainland China and reported the prevalence of self-reported AR in China. Because biomedical research output is largely dependent on a country’s gross national product (GNP) and the expenditure allotted for research and development (R&D), authors in China will have an increasingly important place in the field of AR because of their increasing GNP and expenditure on R&D.

Some bibliometric articles reported that the most productive authors and institutions always came from the USA. In our study, although authors from the USA contributed most of the studies in the top 100 list, it is notable that Bousquet J was the first author who contributed 9 articles and his affiliated institution, Hospital Arnaud de Villeneuve in France, was the most prolific institution. Examination of the articles showed that he contributed most of the guidelines on ARIA. This finding is consistent with the bibliometric article on asthma.

Throughout the top 100 list, most articles were clinical research articles, and basic research articles only accounted for 10% of these publications. This finding is similar to a bibliometric article on asthma. The results may show that referring to clinical evidence is more favored compared with referring to basic research. Some bibliometric articles on surgical tumors reported that more than half of the articles were low-quality Level 4 and there were many challenges for conducting randomized controlled surgical trials, such as multicenter collaborations, a large number of personnel, and a large funding requirement. In our study, nearly half of the clinical articles were Level 1 and Level 2 based on the level-of-evidence grading. This result shows that high-quality level of studies for internal medicine is relatively easy to conduct and that these studies will receive more citations compared with low-quality studies.

There are various therapies for AR. In our study, most treatments for clinical research articles are immunity therapy and intranasal corticosteroids. Additionally, the questionnaires, such as HRQoL and RQLQ, were chosen to assess the clinical symptoms in most of the clinical research articles. To some extent, these findings reflect the performance of the guidelines in clinical practice.

Some limitations of this paper must be mentioned. First, the citation count used for citation analysis did not include self-citations and conference reports. Second, because of the influence of certain time factors, most recently published articles would
be unfavorably affected in the citation analysis. Third, because of the limitations of our search formula and WoS, some well-known papers may have been missed.\(^\text{18}\)

**Conclusions**

To the best of our knowledge, this is the first bibliometric study to identify the most influential articles in the area of AR and to provide a historical perspective on the progress of research on AR. The findings indicate that guidelines and articles with novel discoveries, advanced technologies, and high-quality evidence will receive more citations. Recognition of important historical contributions to this field may guide future investigations into AR.

**Author contributions**

All authors were involved in the study. Q.-T. Yang conceived and designed the study. Q.-W. Wu analyzed the data and wrote the paper. R. Zheng performed the search strategy and wrote the paper. W.-H. Wang performed the search strategy. H.-J. Qiu and X.-K. Huang collected the data.

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**Declaration of conflicting interest**

The authors declare that there is no conflict of interest.

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