Original Article

A bibliometric analysis of acute respiratory distress syndrome (ARDS) research from 2010 to 2019

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Background: Thousands of papers on acute respiratory distress syndrome (ARDS) have been published in the last decade. This study aimed to evaluate the research hotspots and future trends in ARDS research using bibliometric analysis.

Methods: All relevant literature on ARDS published between 2010 and 2019 was retrieved from the Web of Science Core Collection database, and the retrieval strategy was TS = (ARDS OR acute respiratory distress syndrome). Bibliometric analysis was conducted using VOSviewer and the online bibliometric analysis platform based on retrieved data. Bibliographic Item Co-occurrence Matrix Builder (BICOMB) and gCLUTO software were used to evaluate and visualize the results, and to explore the hotspots in the field of ARDS.

Results: A total of 9,858 ARDS research articles dated between 2010 and 2019 were included. The dominant position of the United States in global ARDS research throughout this 10-year period was evident, and it was also the country most frequently involved in international cooperation. The University of Toronto was the most productive institution and a leader in research collaboration. *Critical Care Medicine* was the most productive journal in terms of the number of publications on ARDS. Further, Matthay MA, Pelosi P, Slutsky AS, and Thompson BT all made significant contributions to ARDS research. A total of 37 most frequent keywords were identified and belonged to 5 hotspots: (I) adult and pediatric ARDS; (II) life-support monitoring parameters and therapy in severe patients with ARDS; (III) molecular mechanisms of acute lung injury; (IV) influenza-related pneumonia; and (V) severe complications of ARDS. Also, in the last 5 years, the keywords "biomarkers", "pathway", "NF-κB", "epidemiology", "life-support", and "ECMO" began to appear in the ARDS research field.

Conclusions: In the decade from 2010 to 2019, the United States was a global leader in ARDS research, and hotspots included epidemiology, mechanisms, monitoring parameters, and therapy, especially mechanical ventilation. Our results suggest that the mechanisms of ARDS and novel life-support therapies will remain research hotspots in the future. International collaboration is also expected to widen and deepen in the field of ARDS research.

Keywords: Acute respiratory distress syndrome (ARDS); bibliometric analysis; VOSviewer; hotspots

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Introduction

Acute respiratory distress syndrome (ARDS) is a life-threatening clinical syndrome characterized by acute respiratory failure, refractory hypoxemia, and non-cardiogenic pulmonary edema (1,2). ARDS affects 10.4% of all patients in intensive care units across the globe, and is associated with high risks of morbidity and mortality (1,3,4). There are numerous risk factors associated with the development of ARDS, including pneumonia, sepsis, aspiration of gastric contents, major trauma, pulmonary contusion, inhalational injury, acute pancreatitis, severe burns, non-cardiogenic shock, multiple transfusions or transfusion-associated acute lung injury, drug overdose, pulmonary vasculitis, and drowning (5,6). ARDS imposes an immense disease burden on patients and, being costly to treat, consumes a large proportion of health care resources (7,8). ARDS was first described by Ashbaugh and colleagues in 1967 (9). During the past 50 years, especially in the last decade, great progress has been made in the field of ARDS research regarding epidemiology, diagnostics, pathology, pathophysiology, and therapeutics (2,10-13). However, there is still a lack of comprehensive reports that can assist researchers in obtaining an intuitive overview and reveal research trends in the ARDS research field.

Bibliometric analysis is a novel scientific method used to evaluate contributions to a research field, including those by countries, institutions, authors, and journals. Further, bibliometric analysis can predict the hotspots and trends within a certain research area through information visualization (14-16). However, few bibliometric studies have been performed in the field of ARDS research.

In the present study, we performed a comprehensive bibliometric analysis of ARDS research literature from 2010 to 2019, taking into account the number of annual publications, countries, international cooperation, institutions, journals, authors, and keyword co-occurrence visualization analysis. Furthermore, perspectives on progress in the field of ARDS research over the past decade were considered. Overlay visualization maps of co-occurring keywords and double-clustering analysis were also performed in order to confirm the trends and hotspots in ARDS research. We hope that this study will provide new perspectives and a basis for future ARDS research.

Methods

Data sources and search strategy

The Web of Science is one of the most influential databases of scientific literature. In this study, all data were retrieved from the Web of Science Core Collection (WoSCC) via the China Medical University library website. The retrieval strategy was TS = (ARDS OR acute respiratory distress syndrome).

Screening criteria and data downloads

The publication period in the present study was limited to the period from 2010 to 2019. Non-English language, non-article, and non-review publications were excluded. WoSCC data including titles, author information, abstracts, keywords, journals, and references were downloaded in .txt format. To avoid the bias caused by frequent database updates, all literature retrieval and data downloads were completed on the same day (August 9, 2020). Two investigators (Xinyu Zhang and Chengyuan Wang) independently performed the search and had an agreement of 98% [kappa = (P0–Pe)/(n–Pe) =0.98>0.75], showing significant consistency (17).

Statistical analysis

In the present study, a comprehensive description of various publishing characteristics is provided, including authors, institutions, countries, journals, keywords, impact factor (IF), and Hirsch index (h-index). IFs were obtained from the 2019 Journal Citation Reports (JCR) to assess the scientific value of research (18). The value of the h-index was defined as the number of papers with citation number ≥ h and is considered to be an important indicator for assessing both the productivity and impact of the published work of scientists, journals, or countries (19). The filtered data from WoSCC was imported into the online analysis platform of literature metrology (http://bibliometric.com/) and VOSviewer 1.6.15 (Leiden University, Leiden, The Netherlands) for bibliometric analysis. Apache ECharts (https://echarts.apache.org/), a JavaScript-based data visualization tool, was used to visualize the annual number of publications and the number of cumulative publications in different countries/regions. The online bibliometric analysis platform was used to visualize international collaboration between countries. VOSviewer was used for analysis and visualization of bibliometric networks such as authors, institutions, journals, co-citations, and the keywords used in the articles (20). Network visualization maps and overlay visualization maps were generated using VOSviewer. The online bibliometric analysis platform

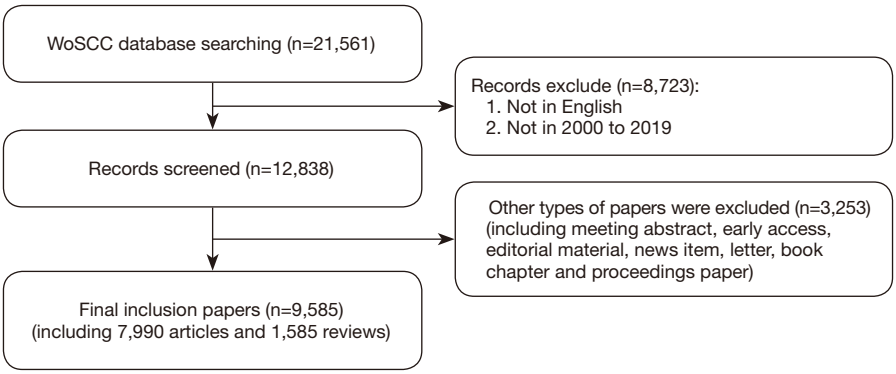

Figure 1 Flowchart of data filtration processing and excluding publications. WoSCC, Web of Science Core Collection.

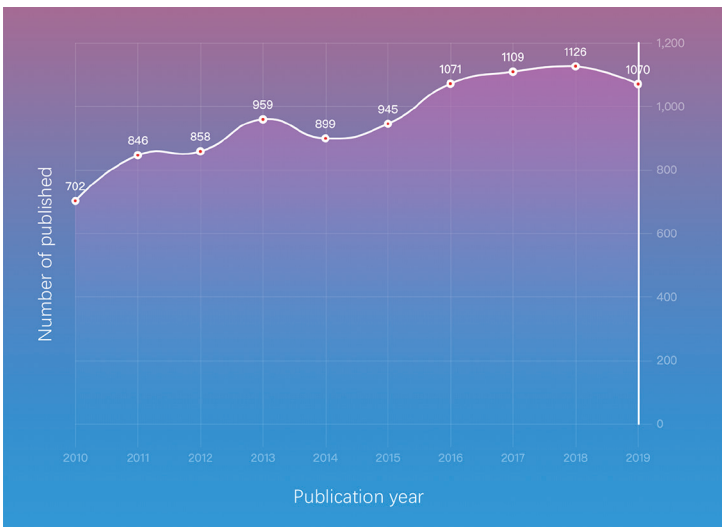

Figure 2 Annual number of the published publications in ARDS research from 2010 to 2019. ARDS, acute respiratory distress syndrome.

and Microsoft Excel 2016 were used to assess the impact of authors, institutions, and journals. The filtered data from WoSCC were imported into Bibliographic Item Co-occurrence Matrix Builder (BICOMB) to construct a keyword-article binary matrix (21). The rows of the matrix represented publications, while the columns represented highly frequent keywords. Additionally, gCLUTO software 1.0 was used to perform double-clustering analysis, and to build mountain maps and heat maps based on the results of the clustering analysis (21).

Results

Trends and annual publications

As shown in *Figure 1*, a total of 21,561 papers were identified, and 9,585 papers (7,990 articles and 1,595 reviews) from 2010 to 2019 were ultimately included according to the screening criteria. *Figure 2* shows the growth trend of the annual publications related to ARDS, from 702 in 2010 to 1,070 in 2019. Based on the WoSCC database, the 9,585 papers were cited 211,730 times, and each paper was cited an average of 22.09 times.

Contribution of countries and institutions

According to the WoSCC database, 117 countries or regions contributed to publications on ARDS between 2010 and 2019. The top 22 countries or regions in terms of the number of publications (n≥60) on ARDS are presented on a world map in *Figure 3A*, and the top 10 are presented

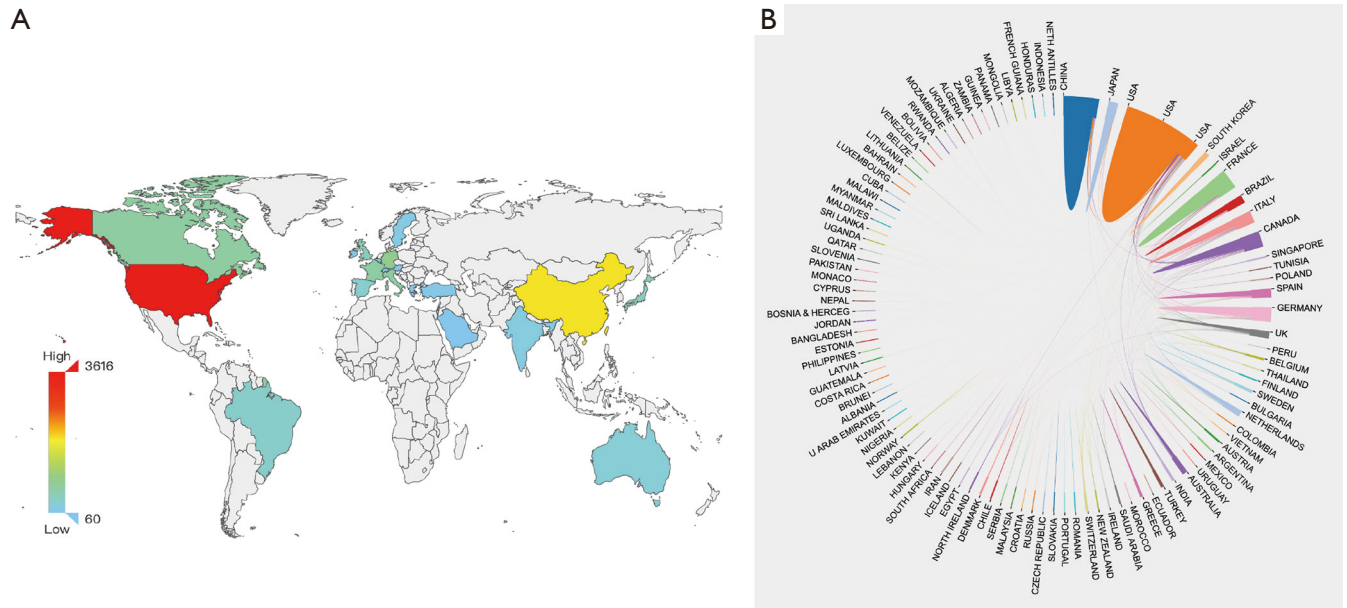

Figure 3 The distribution of countries or regions in ARDS research. (A) Distribution of ARDS literatures in the world map. The color of each country or region on the world map represents the amount of literature published, according to the color gradient in the lower left corner. (B) The network map of cooperation between countries or regions. Different colors represent different countries or regions, the area of each color represents the amount of literature published in each country or regions, and the thickness of the connecting line indicates the cooperation frequency. ARDS, acute respiratory distress syndrome.

Table 1 The top 10 countries or regions contributing to publications in ARDS research

Rank	Country/region	Records	Percentage (N/9,585), %
1	USA	3,616	37.726
2	China	1,936	20.198
3	Germany	868	9.056
4	Canada	715	7.46
5	Italy	697	7.272
6	France	671	7.001
7	UK	517	5.394
8	Japan	465	4.851
9	Brazil	372	3.881
10	Spain	345	3.599

ARDS, acute respiratory distress syndrome.

as numbers in *Table 1*. The United States was the largest contributor, with 3,616 papers published, followed by China (n=1,936), Germany (n=868), Canada (n=715), Italy (n=697), France (n=671), the United Kingdom (n=517), Japan (n=465), Brazil (n=372), and Spain (n=345). The United States and China contributed many more papers to the number of publications on ARDS than other countries or regions (*Figure 3A*, *Table 1*). Within the survey period, close cooperation between countries or regions around the world was extremely common. International cooperation analysis indicated that the United States was the country most frequently involved in international cooperation (*Figure 3B*).

The most productive institutions were also evaluated in our study. As shown in *Table 2*, with 788 papers published, the University of Toronto was the most productive institution, and was followed by the University of California, San Francisco (n=656), Johns Hopkins University (n=422), University of Pittsburgh (n=383), Mayo Clinic (n=372), University of Pennsylvania (n=355), Vanderbilt University (n=306), University of Washington (n=299), University of Michigan (n=284), and Harvard University (n=282). Among the top 10 most productive institutions, the University of Toronto was in Canada and the rest were from the United States. The collaboration network was generated using VOSviewer software, and the threshold was set to 66 as the minimum number of documents of an institution, while

Table 2 The top 10 most productive institutions in ARDS research

Rank	Institutions	Article counts	Total number of citations	Average number of citations	Total number of first author	Total number of first author citations	Average number of first author citations
1	Univ Toronto	788	23,458	29.77	104	3,240	31.15
2	Univ Calif San Francisco	656	13,350	20.35	127	2,885	22.72
3	Johns Hopkins Univ	422	7,052	16.71	76	930	12.24
4	Univ Pittsburgh	383	2,131	5.56	86	355	4.13
5	Mayo Clin	372	3,394	9.12	103	981	9.52
6	Univ Penn	355	3,175	8.94	83	590	7.11
7	Vanderbilt Univ	306	4,674	15.27	69	802	11.62
8	Univ Washington	299	4,192	14.02	70	274	3.91
9	Univ Michigan	284	2,902	10.22	88	702	7.98
10	Harvard Univ	282	8,649	30.67	52	596	11.46

ARDS, acute respiratory distress syndrome.

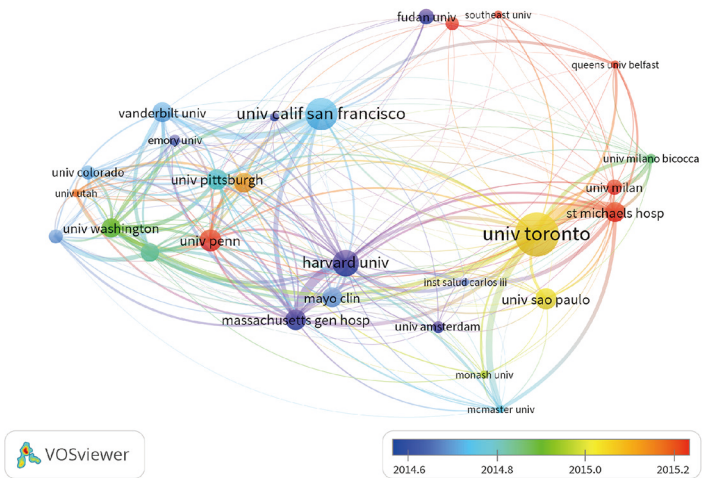

Figure 4 Co-authorship overlay visualization map of institutions. The color of each circle corresponds to the average publication year, the size of a circle is proportional to the number of literatures, and the thickness of the connecting line indicates the cooperation frequency.

2,000 was set as the minimum number of citations of an institution. Finally, 28 out of the 7,443 institutions were identified (*Figure 4*). During this decade, the University of Toronto published 788 papers, which were cited 23,458 times (*Table 2*), and cooperated with almost all influential scientific institutions in studies on ARDS (*Figure 4*).

Contribution of journals

In the present study, a comprehensive analysis of the contribution of journals with journal characteristics was provided, including journal titles, article counts, total citations, citations per article, CiteScore [2019], IF [2019], quartile in category [2019], and h-index. The top 10 most productive journals in the field of ARDS research are listed in *Table 3*; in total, these journals published 2,155 papers, accounting for 22.48% of the total publications. *Critical Care Medicine* (n=384), *Critical Care* (n=321), and *PloS One* (n=249) were the top 3 journals in terms of the number of publications on ARDS (*Table 3*). The *American Journal of*

Table 3 The top 10 most active journals that published articles in ARDS research

Rank	Journal title	Article counts	Total number of citations	Average number of citations	CiteScore	IF [2019]	Quartile in category [2019]	H-index
1	*Critical Care Medicine*	384	4,199	10.93	10.6	7.414	Q1	33
2	*Critical Care*	321	2,465	7.68	10.7	6.407	Q1	32
3	*PLoS One*	249	848	3.41	5.2	2.74	Q2	NA
4	*Intensive Care Medicine*	211	4,203	19.92	14	17.679	Q1	35
5	*Respiratory Care*	202	936	4.63	3.4	2.066	Q4	13
6	*American Journal of Respiratory and Critical Care Medicine*	188	4,494	23.9	21.6	17.452	Q1	48
7	*American Journal of Physiology-Lung Cellular and Molecular Physiology*	177	954	5.39	7.2	4.406	Q1	22
8	*Journal of Critical Care*	162	552	3.41	4.9	2.685	Q2	19
9	*Current Opinion in Critical Care*	143	956	6.69	4.8	2.92	Q3	16
10	*Shock*	118	456	3.86	6.2	2.96	Q2	19

ARDS, acute respiratory distress syndrome; IF, impact factor; H-index, Hirsch index; JCR, Journal Citation Reports.

Respiratory and *Critical Care Medicine*, *Intensive Care Medicine*, and *Critical Care Medicine* were the top 3 journals in terms of the highest total number of citations (4,494 *vs.* 4,203 *vs.* 4,199 citations, respectively), and they were also the top 3 journals with the highest average number of citations per paper (23.9 *vs.* 19.92 *vs.* 10.93 times, respectively). *Intensive Care Medicine*, the *American Journal of Respiratory* and *Critical Care Medicine*, and *Critical Care Medicine* also had the highest IFs of any journals in 2019 (17.679 *vs.* 17.452 *vs.* 7.414, respectively). The highest CiteScore and the highest h-index belonged to the *American Journal of Respiratory* and *Critical Care Medicine* (21.67 and 48, respectively). Among the top 10 most productive journals, *Critical Care Medicine*, *Critical Care*, *Intensive Care Medicine*, the *American Journal of Respiratory* and *Critical Care Medicine*, and the *American Journal of Physiology-Lung Cellular and Molecular Physiology* were classified as Q1 according to the JCR 2019 standards (*Table 3*). The top 10 most highly cited publications are listed in *Table 4*.

Contributions of authors

The top 10 most productive authors in the field of ARDS research are presented in *Table 5*. Among them, Matthay MA from the Department of Medicine and Anesthesia, Cardiovascular Research Institute, University of California, San Francisco in the United States ranked first (n=149). Pelosi P from the Department of Surgical Sciences and Integrated Diagnostics, University of Genoa in Italy was the second most productive author (n=104) (*Table 5*). Furthermore, Slutsky AS, Thompson BT, and Matthay MA were the top 3 authors with the highest total number of citations (5,055 *vs.* 5,038 *vs.* 3,736 times, respectively, *Table 5*). A co-authorship overlay visualization map was generated using VOSviewer software, and the threshold for the minimum number of documents by an author was set to 35. Finally, 31 authors who met the threshold were identified, and Matthay MA, Thompson BT, Calfee CS, and Ware LB were shown to have cooperated closely (*Figure 5A*). A citation overlay visualization map was also generated using VOSviewer software, and the threshold for the minimum number of citations of an author was set to 2,000. Finally, 37 authors who met the threshold were identified, and it could be seen that Matthay MA, Pelosi P, Slutsky AS, and Thompson BT had made significant contributions to the field of ARDS research (*Figure 5B* and *Table 5*).

Analysis of research hotspots

With an appearance of more than 47 times, 37 of the most frequent keywords were extracted from the included publications and are displayed in *Table 6*. Five clusters were sorted through double-clustering using gCLUTO. The relationship between publications and high-frequency

Table 4 The top 10 high-cited papers in ARDS research during 2010 to 2019

Rank	Title	Authors	Year	Journal	Total citations
1	Surviving Sepsis Campaign: International Guidelines for Management of Severe Sepsis and Septic Shock: 2012	Dellinger, R. Phillip. *et al.*	2013	*Critical Care Medicine*	5,031
2	Acute Respiratory Distress Syndrome: The Berlin Definition	Ranieri, V. Marco. *et al.*	2012	*JAMA*	3,149
3	Surviving Sepsis Campaign: International Guidelines for Management of Sepsis and Septic Shock: 2016	Rhodes, Andrew. *et al.*	2017	*Intensive Care Medicine*	1,543
4	Human Infection with a Novel Avian-Origin Influenza A (H7N9) Virus	Gao, Rongbao. *et al.*	2013	*New England Journal of Medicine*	1,542
5	Epidemiology, Patterns of Care, and Mortality for Patients with Acute Respiratory Distress Syndrome in Intensive Care Units in 50 Countries	Bellani, Giacomo. *et al.*	2016	*JAMA*	1,136
6	Neuromuscular Blockers in Early Acute Respiratory Distress Syndrome.	Papazian, Laurent. *et al.*	2010	*New England Journal of Medicine*	1,122
7	Functional Disability 5 Years after Acute Respiratory Distress Syndrome	Herridge, Margaret S. *et al.*	2011	*New England Journal of Medicine*	1,101
8	Prone Positioning in Severe Acute Respiratory Distress Syndrome	Guerin, Claude. *et al.*	2013	*New England Journal of Medicine*	1,088
9	Surviving Sepsis Campaign: International Guidelines for Management of Sepsis and Septic Shock: 2016	Rhodes, Andrew. *et al.*	2017	*Critical Care Medicine*	1,035
10	Surviving Sepsis Campaign: International Guidelines for Management of Severe Sepsis and Septic Shock, 2012	Dellinger, R. P. *et al.*	2013	*Intensive Care Medicine*	903

ARDS, acute respiratory distress syndrome.

Table 5 The top 10 most productive authors in ARDS research

Rank	Author	Article counts	Total number of citations	Average number of citations	First author counts	First author citation counts	Corresponding author counts	Corresponding author citation counts
1	Matthay, MA	149	3,736	25.07	10	1,015	24	1,417
2	Pelosi, P	104	903	8.68	5	48	14	66
3	Schultz, MJ	87	956	10.99	1	2	5	160
4	Thompson, BT	82	5,038	61.44	4	140	6	186
5	Slutsky, AS	80	5,055	63.19	1	14	10	82
6	Calfee, CS	79	1,568	19.85	8	461	15	675
7	Brochard, L	78	2,918	37.41	2	15	14	126
8	Gajic, O	77	1,474	19.14	1	213	12	514
9	Pesenti, A	73	1,933	26.48	2	26	17	302
10	Ware, LB	73	2,034	27.86	6	223	20	358

ARDS, acute respiratory distress syndrome.

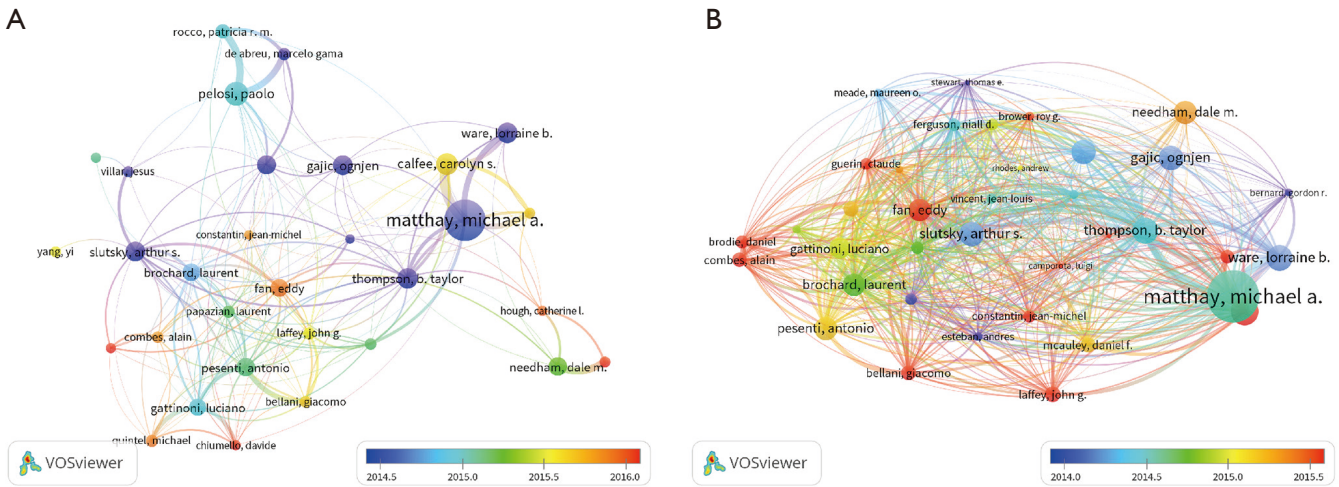

Figure 5 The distribution of authors in ARDS research. (A) Author co-authorship overlay visualization map. Notes: the color of each circle corresponds to the average publication year of the author, the size of a circle is proportional to the number of literatures published by the author, and the thickness of the connecting line indicates the cooperation frequency. (B) Author co-citation overlay visualization map. Notes: the color of each circle corresponds to the average publication year of the author, the size of a circle is proportional to the total number of citations of the author, and the thickness of the connecting line indicates the strength of the co-citation link. ARDS, acute respiratory distress syndrome.

keywords was visualized using a volcano map and matrix map (*Figure 6*). The matrix map is shown in *Figure 6A*, in which column labels represent articles, while row labels represent keywords. To combine similar rows in a single cluster, the rows of the initial matrix were reset and each cluster was partitioned by black horizontal lines. In the matrix map, the upper dendrogram represents article associations, while the left represents high-frequency keyword associations. The results of the volcano map in *Figure 6B* directly show the high-dimensional character of the data. In this 3-dimensional image, 5 different mountains represent 5 different clusters, numbered from 0 to 4.

The above 37 high-frequency keywords were divided into 5 clusters. All representative articles involved in each cluster were mined to further summarize hotspots in the field of ARDS. Finally, 5 hotspots were identified using BICOMB and gCLUTO software packages:

- Cluster 0: adult and pediatric ARDS.
- Cluster 1: life-support monitoring parameters and therapy in severe patients with ARDS.
- Cluster 2: molecular mechanisms of acute lung injury.
- Cluster 3: influenza-related pneumonia.
- Cluster 4: severe complications of ARDS.

To explore the changes of hotspots over a period of time, a network visualization map of keyword co-occurrence was generated using VOSviewer software, and the results showed that the keywords “biomarkers”, “pathway”, “NF-κB”, “epidemiology”, “life-support”, and “ECMO” began to appear in the last 5 years (*Figure 7*).

Discussion

In the era of the information explosion, bibliometric analysis can help scientific researchers to manage their knowledge and visualize knowledge structures more intuitively. By presenting visual results, bibliometric analysis can help new researchers in a specific field to grasp the overall trends in the field being investigated. It can also reveal milestone manuscripts, the most productive authors and institutions, and current research hotspots, as well as future trends (22-24). In our study, a comprehensive bibliometric analysis of global scientific publications in the field of ARDS research from 2010 to 2019 was performed.

The number of publications in a particular research field can reflect the productivity and developments in the field over time (25). In the present study, a total of 9,585 publications, including 1,070 articles in 2019, were included (*Figures 1,2*). The results showed that the number of publications in the field of ARDS was maintained at a

Table 6 Keywords of ARDS research hotspots

Number	Keywords	Frequency	Percent (%)	Accumulate percent (%)
1	Acute respiratory distress syndrome	2,456	7.8743	7.8743
2	Acute lung injury	1,334	4.2770	12.1513
3	Mechanical ventilation	550	1.7634	13.9147
4	Extracorporeal membrane oxygenation	415	1.3306	15.2453
5	Inflammation	396	1.2696	16.5149
6	Lipopolysaccharide	303	0.9715	17.4864
7	Sepsis	302	0.9683	18.4546
8	Lung injury	222	0.7118	19.1664
9	Mortality	221	0.7086	19.8750
10	Pneumonia	168	0.5386	20.4136
11	Respiratory failure	153	0.4905	20.9041
12	Critical care	146	0.4681	21.3722
13	Respiratory distress syndrome	146	0.4681	21.8403
14	Acute respiratory failure	142	0.4553	22.2956
15	Ventilator-induced lung injury	131	0.4200	22.7156
16	Intensive care	117	0.3751	23.0907
17	Apoptosis	116	0.3719	23.4626
18	Cytokines	111	0.3559	23.8185
19	Intensive care unit	109	0.3495	24.1680
20	Lung	102	0.3270	24.4950
21	Outcome	98	0.3142	24.8092
22	Critical illness	97	0.3110	25.1202
23	NF-kappa B	94	0.3014	25.4216
24	Biomarker	93	0.2982	25.7198
25	Children	82	0.2629	25.9827
26	Acute kidney injury	76	0.2437	26.2264
27	Oxidative stress	76	0.2437	26.4700
28	Prognosis	72	0.2308	26.7009
29	Epidemiology	69	0.2212	26.9221
30	Pediatrics	66	0.2116	27.1337
31	Adult	65	0.2084	27.3421
32	Pulmonary edema	60	0.1924	27.5345
33	Septic shock	57	0.1828	27.7172
34	Peep	49	0.1571	27.8743
35	H1N1	48	0.1539	28.0282
36	Prone position	48	0.1539	28.1821
37	Influenza	47	0.1507	28.3328

ARDS, acute respiratory distress syndrome.

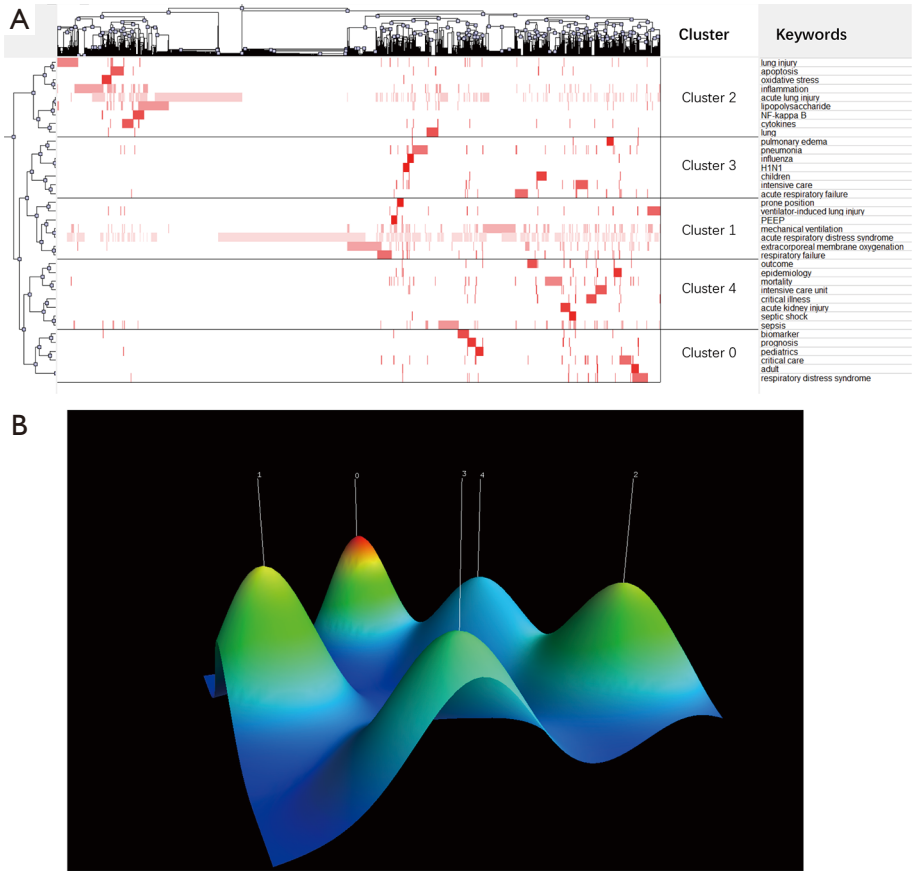

Figure 6 Research hotspots in the field of ARDS. (A) Visualized matrix of biclustering of highly frequent keywords in the research field of ARDS. Color of each blot represented the frequency of occurrence of keywords in all literatures. (B) Mountain visualization of biclustering of highly frequent keywords in the research field of ARDS. The height and color of the mountain is proportional to internal similarity and standard deviation of cluster (Blue: high deviation; Red: low deviation). ARDS, acute respiratory distress syndrome.

substantial level in the decade from 2010 to 2019, which suggests that ARDS remains a hot research field, and more and more scholars may participate in ARDS research.

The number of publications in a research field is an important indicator for evaluating the scientific research level of a country or institution (22,25,26). Our study showed that the United States and China were the 2 largest contributors to the number of publications on ARDS (*Figure 3A*, *Table 1*), highlighting their impact in the ARDS research field. The value of international collaboration in supporting innovation and addressing unmet challenges is well recognized worldwide (27). From 2010 to 2019, many countries or regions around the world collaborated on studies in the research field of ARDS. Furthermore, our results demonstrated that the United States had the highest collaboration performance, especially with Canada and China (*Figure 3B*). Meanwhile, the University of Toronto was identified as the most productive institution, with the highest total citation number during the 10-year period (*Table 2*), and cooperated with almost all influential scientific institutions in the ARDS research field, including Harvard University and St. Michael's Hospital (*Figure 4*). These results showed that highly collaborative countries or institutions generally had a high academic level, suggesting that international cooperation will remain a future trend in the field of ARDS research.

Journal indicators obtained from bibliometric analysis can provide a reliable reference for researchers to search documents or submit manuscripts (28,29). Our results showed that 8 of the top 10 journals publishing literature on ARDS were included in the category of "critical care medicine", while *PLoS One* was listed in the category of

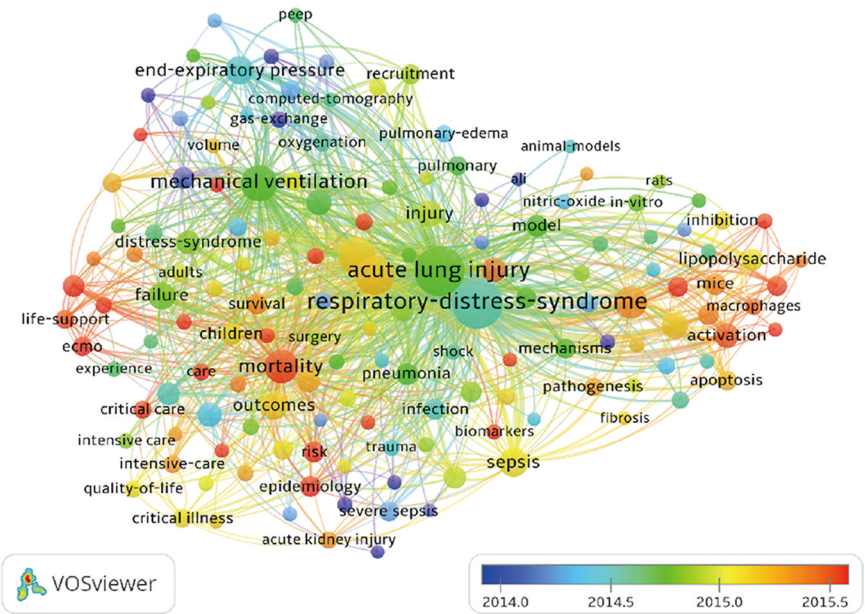

Figure 7 Keywords co-occurrence overlay visualization map. Notes: the color of each circle corresponds to the average publication year. The size of a circle is proportional to the frequency of occurrence of the keyword, and the thickness of the connecting line indicates the strength of the keywords co-occurrence link.

"multidisciplinary sciences" and the *American Journal of Physiology-Lung Cellular and Molecular Physiology* was listed in the category of "physiology". *Critical Care Medicine* published the highest number of ARDS-related papers, while the *American Journal of Respiratory and Critical Care Medicine* had the highest number of total citations (*Table 3*), which suggests that ARDS plays an important role in the fields of critical care and intensive care medicine. Our results also showed that the most frequently cited publication was a practice guideline written by the Surviving Sepsis Campaign Guidelines Committee, and that "The Acute Respiratory Distress Syndrome: the Berlin Definition", written by the ARDS Definition Task Force, was a milestone in the ARDS research field in the decade from 2010 to 2019 (1) (*Table 4*). These results suggest that these active journals and highly cited papers can provide a reliable reference for scholars concerned with the progress of ARDS research.

Based on the WoSCC database, Matthay MA published the highest number of ARDS-related papers, while Thompson BT had the highest number of total citations (*Table 5*). Furthermore, Matthay MA, Thompson BT, Slutsky AS, Brochard L, Ware LB, and Gajic O cooperated closely and published a considerable number of highly cited publications, as evidenced in the co-authorship overlay network visualization map and citation overlay visualization map (*Figure 5A,B*). Therefore, they can be regarded as the leaders in the ARDS research field.

Because of the heterogeneity of the ARDS research field, we divided the keywords in our study into 5 clusters via double-clustering analysis (*Figure 6*). Keyword co-occurrence network visualization analysis is a widely accepted method for determining research hotspots and predicting research trends (30). Our results indicated that the early stage of ARDS research was focused on severe sepsis and monitoring parameters. Subsequently, keywords such as "epidemiology", "life-support", "ECMO", "biomarker", "activation", and "mice" appeared frequently in the last 5 years, suggesting that the study of the mechanisms of ARDS and therapeutic strategies will remain research hotspots over the next few years. Our analysis also suggests that scientists are still trying to gain a comprehensive understanding of ARDS, and we expect scientists to make breakthroughs in the pathogenesis and treatment of this condition in the near future.

However, there were some limitations in our study. Firstly, the WoSCC database is updated continuously and dynamically. Therefore, our results are temporary in nature.

Secondly, non-English publications were excluded. Hence, a discrepancy may exist between our results and the real publication characteristics.

In conclusion, the annual number of publications on ARDS grew in the decade between 2010 and 2019. The United States was the leading country in this research field, while the University of Toronto also achieved important research results and played a certain role in promoting the development of ARDS research. Furthermore, Matthay MA, Pelosi P, Slutsky AS, and Thompson BT made significant contributions to this research field. The hotspots over the decade were epidemiology, mechanisms, monitoring parameters, and therapy, especially mechanical ventilation. Our results suggest that the mechanisms of ARDS and novel life-support therapies will remain research hotspots in the future. International collaboration was also prevalent, and it is expected to widen and deepen in the future. These results provide new perspectives for the study of ARDS and may have a beneficial effect on further study regarding the etiology, diagnosis, and treatment of this condition.

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Footnote

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at http://dx.doi.org/10.21037/apm-20-2050). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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