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Bibliometric Analysis of Research Trends in Pulmonary Rehabilitation of Respiratory Tract Neoplasms

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ABSTRACT
Pulmonary rehabilitation of respiratory tract neoplasms has attracted increasing attention from researchers in recent years. This study aims to identify current research hotspots and status in this field through bibliometric and visualization analysis. Literature on pulmonary rehabilitation of respiratory tract neoplasms, meeting the inclusion criteria, was collected from the Core Collection. Bibliometric analysis and visualization were performed using CiteSpace. Our study included 1,410 documents on pulmonary rehabilitation of respiratory tract neoplasms, authored by 7,595 researchers from 2,327 institutions across 79 countries/regions, and published in 636 journals. The USA emerged as the most productive and influential country in this field, with 355 publications and 16,748 citations. The University of California System and University of London were recognized as the most productive institution and the institution with the highest citation count, respectively. Medical Physics was the leading journal. Irene Julie Higginson and Sara Booth were identified as the most productive and most cited authors, respectively. Cluster analysis identified 17 key areas, focusing on the diseases, treatments, clinical trials and interventions. The relationship between rehabilitation of pulmonary neoplasms remains a contentious and frequently discussed topic. Our findings indicate that research primarily focuses on cancer, interventions, complications, exercises, outcomes.

KEYWORDS
Rehabilitation; Pulmonary neoplasms; Bibliometric; CiteSpace; Clinical Interventions

1 Introduction

The American Thoracic Society and the European Respiratory Society have adopted the following new definition of pulmonary rehabilitation in 2013(1): "Pulmonary rehabilitation is a comprehensive intervention based on a thorough patient assessment followed by patient-tailored therapies that include, but are not limited to, exercise training, education, and behavior change, designed to improve the physical and psychological condition of people with chronic respiratory disease and to promote the long-term adherence to health-enhancing behaviors". Pulmonary rehabilitation provided to individuals with lung cancer has demonstrated improvements in symptoms, exercise tolerance, and quality of life.

There is increased evidence for use and efficacy of a variety of forms of exercise training as part of pulmonary rehabilitation; these include interval training, strength training, upper limb training, and transcutaneous neuromuscular electrical stimulation. Exercise training is considered to be the cornerstone of pulmonary rehabilitation(2). Those patients with severe chronic respiratory disease can often sustain the necessary training intensity and duration for skeletal muscle adaptation to occur(3,4). Exercise training improves strength, well-being, and health status among individuals with lung cancer who are undergoing chemotherapy(5 – 7). Low exercise tolerance is associated with poor thoracic surgical outcomes and reduced survival among individuals with lung disease. Preoperative pulmonary rehabilitation can optimize individuals' exercise tolerance and overall medical stability before lung cancer resection surgery(8–11).

Rehabilitation education now emphasizes collaborative self-management over traditional didactic methods, focusing on goal-setting, problem-solving, and action plans applicable to all chronic respiratory conditions(12). Body composition abnormalities are probably common to lung cancer, weight loss and underweight status are most prevalent in advanced disease(13). Weight loss and fat wasting may be caused by a negative energy balance due to either elevated energy requirements, reduced dietary intake, or both; muscle wasting is the consequence of an imbalance between muscle protein synthesis and breakdown(14).

Recent years have seen a surge in studies exploring the relationship between lung neoplasms and pulmonary rehabilitation(15,16). The surge in publications could overwhelm researchers interested in this relationship. As a discipline within literature and information science, bibliometric analysis can identify publication characteristics and assess study trends through qualitative and quantitative methods(17). Bibliometric analyses in this field have been scarce. This study aims to offer researchers insights into the current structure and development of studies in pulmonary rehabilitation of respiratory tract neoplasms through bibliometric and visual analysis. We collected and summarized studies published from 1999 to 2023 in pulmonary rehabilitation of respiratory tract neoplasms, analyzing and visualizing their knowledge

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structure and research trends.

2 Materials and methods

Data source

The Web of Science (WoS, Clarivate Analytics, Philadelphia, PA, USA) ranks among the most extensive scientific databases, frequently utilized in bibliometric analyses(18). The Web of Science Core Collection (WoSCC) comprises leading scholarly journals, books, and conference proceedings across sciences, social sciences, arts, and humanities, offering a comprehensive citation network. To minimize potential biases from article updates, two independent researchers jointly conducted the search, concluding it on July 20th, 2024.

Search strategies

Search terms for pulmonary rehabilitation included: restoration of human respiratory functions to the maximum degree possible in a person or persons suffering from disease or injury. Respiratory tract neoplasms search terms included: Tumors or cancer of the respiratory system. The search formula is presented as follows: TS= (((lung OR PULMONARY OR Bronchial OR THORA* OR PLEURAL OR TRACHEAL) AND (TUMOR* OR NEOPLASM* OR CANCER* OR CARCINOMA* OR Adenocarcinoma* OR BLASTOMA*)) OR Mesothelioma) AND (rehabilit* OR EXERCISE* OR TRAIN*) AND (BREATH* OR RESPIRAT*).

Retrieval strategies

Inclusion criteria for this study were: (a) articles examining the relationship between pulmonary rehabilitation and respiratory tract neoplasms; (b) documents classified as articles or reviews; (c) publications dated between January 1st, 1999, and December 31st, 2023. Exclusion criteria included: (a) non-English publications; (b) documents lacking sufficient information. Studies that met the inclusion criteria and did not fall under the exclusion criteria were included in this study.

Documents extraction

The full records of the identified documents were extracted from the WoS database. The information contained in the records included: title, authors, keywords, journals, abstract, year of publication, countries/regions, affiliations, research direction, and funding agencies.

Bibliometric and visualized analysis

A predicted publication curve, based on annual publication counts, was generated. Network maps showcasing collaborative and citation relationships among countries/regions, institutes, and authors were created using CiteSpace 6.2. R3(19). In the CiteSpace-generated maps, various nodes represent different entities, including authors, countries/regions. Lines between nodes indicate the relationships among entities. We conducted burst detection on keywords and literature and used the Timeline method for visual analysis of the keywords.

3 Results

Overview information and trends of publications

Our study included 1,410 documents exploring pulmonary rehabilitation of respiratory tract. These articles were authored by 7,595 individuals from 2,327 institutions across 79 countries/regions, appearing in 636 journals. Between 1999 and 2023, publications in this field saw slow growth, while citations witnessed rapid growth. In 2010, 44 articles were published and cited 943 times, with the number of citations significantly increasing in subsequent years. The number of annual publications didn't run exceeded 100 until 2019. Since 2018, publications were cited over 2,500 times annually, surpassing 4,000 times in 2021, and exceeding 5,500 times just two years later. (Figure 1).

Analysis of countries/regions

Table 1 summarizes the publication output of the top ten most productive countries/regions. The USA, leading in both documents and citations, dominates the field, significantly outpacing other countries/regions. China were the next most productive. Undoubtedly, the USA was the most influential country in studying pulmonary rehabilitation of respiratory tract neoplasms, owing to its highest number of publications and citations. Figure 2 visualizes the collaboration relationships between countries/regions. In this map, colored shapes indicate each country's publication count, while lines denote inter-country collaborations.

Analysis of institutions

A total of 2,327 institutions conducted research on the relationship between pulmonary rehabilitation and respiratory tract neoplasms. Table 2 summarizes the top 10 institutions by publication count. With 50 publications, the University of California System ranked as the most productive institution in this field. Figure 3 visualizes the collaborative relationships between institutions.

Analysis of journals

A total of 636 journals have published research on pulmonary rehabilitation of respiratory tract neoplasms. Table 3 ranks the top 10 journals by the number of studies published in this field. Medical Physics (48 publications) ranked the first. Chest was the most cited journal, with 1,450 citations. Figure 4 depicts the citation relationships among journals. Chest, American Journal of Respiratory And Critical Care Medicine, and The European Respiratory Journal were the most cited journals in this field.

Analysis of influential studies

Table 4 lists the top 10 most-cited publications. All were published between 2004 and 2016, each receiving over 420 citations. The article from New England Journal of Medicine, cited 2,714 times, was the most-cited publication. Figure 5 illustrates burst detection within this field's literature, with time points showing burst characteristics highlighted in red.

Analysis of Keywords

Keywords were extracted from each publication included in our study. Figure 6 displays the keywords with most occurrences. The five most frequent keywords were "lung cancer (377 occurrences)", "quality of life (206 occurrences)", "obstructive pulmonary disease (163 occurrences)", "cancer (160 occurrences)", and "exercise (113 occurrences)". During the early to mid-term stages, research focused on observing breathlessness as a symptom of patients with lung disease, particularly terminal lung cancer. This phase emphasized the effect of breathlessness to lung disease patients. Currently, research hotspots focus on the positive intervention and more intensive studies in the classification of breathlessness were conducted.

A total of 17 clusters were generated from keywords related to pulmonary rehabilitation of respiratory tract neoplasms in English literature. The clustering results indicate a Q value of 0.81 and an S value of 0.9323, attesting to the reliability of the clusters(20) (Table 5 and Figure 7). In the timeline chart, keywords from the same cluster are aligned on the same horizontal line, with the timeline displayed at the top of the chart. The further to the right a keyword is, the more recent it is. Figure 7 clearly illustrates the number of keywords in each cluster and the duration of the research period. A higher number of keywords in a cluster signifies the importance of that research area, while a larger time span indicates the longer duration of that cluster.

4 Discussion

Our study utilized the WoSCC database to gather publication data on pulmonary rehabilitation of respiratory tract neoplasms, taking advantage of its comprehensive and authoritative academic resources(21). The WoSCC database search results likely provide a comprehensive representation of the current research status in this field. This study indicated that the United States has consistently been the most influential country in advancing research on the relationship between frailty and cancer. The United States not only contributed the most publications on this topic but also received the highest number of citations, underscoring the significance and impact of its research contributions. Additionally, an examination of institutional productivity revealed that four of the top ten most productive institutions in this field were located in the United States. The concentration of leading research institutions in the U.S. highlighted the country's dominant role in shaping the discourse and progress in pulmonary rehabilitation of respiratory tract neoplasms studies. A journal analysis in this field reviewed the top 10 journals with the highest number of publications. Among them, four journals were dedicated to lung. This distribution underscored the importance of pulmonary rehabilitation of respiratory tract neoplasms.

The collective of academically influential authors highlight the trend of research collaboration within a specific discipline. By studying these high-impact authors, we can grasp the hotspots and developments in international pulmonary rehabilitation research, aiding clinicians and researchers in finding potential collaborators. Our study revealed that the top 10 prolific and highly-cited authors predominantly hail from developed countries/regions. Notably, no author possessed both high productivity and citation impact. The top three prolific authors were Irene Julie Higginson (19 publications, cited 1,484 times), Sara Booth (17 publications, cited 1,787 times), and Matthew Maddocks (25 publications, cited 395 times), with their research primarily focused on clinical interventions and outcome assessments for frailty syndrome(22 – 24). The top three highly-cited authors were Sara Booth (17 publications, cited 1,787 times), Irene Julie Higginson (19 publications, cited 1,484 times), and Claudia Bausewein (10 publications, cited 1,093 times). Their research delves into cutting-edge areas such as palliative care and biomarkers of aging(25–28). Although their publication volumes are not all among the highest, their work is widely cited due to significant contributions to the field. This highlighted hospice care and interventions research as academic hotspots receiving more attention. This analysis indicated that in the field of pulmonary rehabilitation of respiratory tract neoplasms research, highly-cited and prolific authors have different focal points, each playing a unique role in advancing academic development.

In recent years, pulmonary rehabilitation of respiratory tract neoplasms has been a significant topic of discussion, reflecting the crucial impact of pulmonary rehabilitation on lung cancers patients(29 – 31). Current research explores various methods on pulmonary rehabilitation of respiratory tract neoplasms. Not confined to lung neoplasms, scholars

focus on others lung diseases such as chronic obstructive pulmonary disease (COPD) (32), asthma(33), idiopathic pulmonary fibrosis(34), pulmonary embolism(35), COVID-19(36), and pneumonia(37). Pulmonary rehabilitation, applied in COPD first, was found useful in lung cancer as well(38). A single-center, assessor-blinded, prospective, three-arm randomized controlled trial was conducted with primary non-small cell lung cancer patients who scheduled for thoracoscopic surgery were randomly allocated to the combined intervention group, the mindful breathing group or the control group(39). Pulmonary rehabilitation demonstrated notable enhancements in cardiopulmonary function, exertional symptoms, exercise capacity, and health-related quality of life in patients with lung cancer(40). However, physicians' knowledge of pulmonary rehabilitation is of significance. An investigation found inadequate knowledge of pulmonary rehabilitation is evident among physicians who are involved in pulmonary disease management in China(41). The combined application of drug therapy and pulmonary rehabilitation exercise training contributed to promoting cardiopulmonary function and respiratory muscle recovery in lung cancer patients after thoracoscopic lobectomy(42). A meta-analysis revealed that exercise training in people with non-small cell lung cancer before lung resection leads to a worthwhile reduction in postoperative complications(43). Pre-operative pulmonary rehabilitation optimizes the condition of vulnerable, high-risk older lung cancer patients with frailty, allowing them to safely undergo surgery (44). Pulmonary rehabilitation exercise based on a wearable device pedometer can effectively improve the respiratory function and exercise endurance of lung cancer patients(45). A study showed significant benefit for the use of three-ball apparatus in patients after thoracoscopic lobectomy, whereas no significant benefit for those after wedge resection(46).

Not to be overshadowed by other aspects of treatment, airway clearance is fundamental to pulmonary rehabilitation. A meta-analysis showed the therapy of pulmonary expansion can enable patients to maintain an effective cough mechanism, promote the clearance of postoperative respiratory secretions(47). The utilization of incentive spirometry in pulmonary rehabilitation serves as a valuable instrument in respiratory exercise, with the aim of mitigating or reducing postoperative pulmonary complications and facilitating pulmonary rehabilitation(48). Kundra et al. (49) noted a noteworthy improvement in pulmonary function following preoperative incentive spirometry ($P< 0.05$), moreover, preoperative incentive spirometry was found to be more efficacious in preserving pulmonary functions compared to postoperative incentive spirometry. Dyspnea, anxiety, depression, and postoperative pulmonary complications were significantly improved at discharge for patients receiving ACBT(50). A three-arm, prospective, randomized, assessor-blinded, controlled trial in patients with lung cancer who underwent thoracoscopic lobectomy or segmentectomy was conducted. Patients were randomly assigned (1:1:1) to receive Acapella plus active cycle of breathing technique (ACBT), external diaphragm pacemaker (EDP) plus ACBT, or ACBT group (control group). EDP plus ACBT and Acapella plus ACBT significantly improved functional capacity and lung function in perioperative patients with lung cancer, compared with single-model ACBT, and the effects of EDP plus ACBT were clearly superior to those of other programs(51). The key intervention components of respiratory distress symptom intervention included controlled breathing techniques, cough suppression techniques, acupressure, and exercise(52), which is a clinically effective, low-risk intervention to help breathlessness and cough in lung cancer.

According to the Global Cancer Statistics 2022, lung cancer is the most common cancer and the leading cause of cancer-related deaths(53). Considering the distribution over time and its emergence, research on pulmonary rehabilitation of lung neoplasms patients primarily focuses on the different types of surgeries, as well as its interventions. This includes exploring the types of surgeries associated with postoperative pulmonary complications and how the treatment process for lung tumors affects lung function. The study of pulmonary rehabilitation in lung cancer has entered the clinical intervention stage, with interventions for lung diseases with heart failure being just the beginning.

Coexistence of chronic obstructive pulmonary disease and heart failure is associated with systemic inflammation, myocardial injury, and arterial stiffening, impacting cardiovascular risk and prognosis in patients(54). A study showed exercise training can better improve the average peak oxygen uptake of heart failure patients and chronic obstructive pulmonary disease patients(55).

5 Conclusion

Our study focuses on the research trends and status concerning pulmonary rehabilitation of respiratory tract neoplasms, providing valuable insights into the landscape of this important field. Through visual analysis, we found that research in this field is in a phase of rapid development, with a steady increase in the number of related publications. The United States leads in this field. Currently, key research areas include diseases needing pulmonary rehabilitation, interventions to better pulmonary rehabilitation, and studies focused on clinical trials. Recently, interventions related to pulmonary rehabilitation, particularly airway-clearance techniques, have emerged as a frontier area, representing future development trends.

Tables

Table 1 The top 10 countries/regions with the largest number of publications on pulmonary rehabilitation of respiratory tract neoplasms.

Country	Documents	Citations
USA	355	16,748
China	222	4,161
UK	171	10,896
Italy	100	3,507
Australia	90	3,339
Japan	90	1,837
Germany	85	4,017
Netherlands	78	4,142
Spain	75	7,833
Canada	67	3,044

Table 2 The top 10 institutions with the largest number of publications on pulmonary rehabilitation of respiratory tract neoplasms.

Organization	Documents	Citations
University of California System	50	1,907
University of London	45	3,304
Havard University	34	1,411
King's College London	29	1,920
University of Texas System	28	1,611
Duke University	27	1,146
University of Amsterdam	21	847
Univeristy of Melbourne	21	420
Ciber Centro de Investigacion Biomedica en Red	20	1,124
University of Cambridge	20	1,905

Table 3 The top 10 journals with the largest number of publications on the pulmonary rehabilitation of respiratory tract neoplasms.

Journal	Documents	Citations
Medical Physics	48	990
Physics in Medicine And Biology	30	566
Journal of Pain And Sympton Management	24	1,055
European Journal of Cardio Thoracic Surgery	23	821
Journal of Thoracic Disease	21	425
Supportive Care in Cncer	21	686
Journal of Breath Research	19	489
Chest	18	1,450
PLOS One	18	678
BMJ Open	16	118

Table 4 The top 10 studies with the most citations on pulmonary rehabilitation of respiratory tract neoplasms.

Document	Citations
The body-mass index, airflow obstruction, dyspnea, and exercise capacity index in chronic obstructive pulmonary disease	2,714
Diagnosing lung cancer in exhaled breath using gold nanoparticles	981
Mortality in COPD: role of comorbidities	739
Impact of air pollution on the burden of chronic respiratory diseases in China: time for urgent action	631
ERS/ESTS clinical guidelines on fitness for radical therapy in lung cancer patients (surgery and chemo-radiotherapy)	603
Interactive telemedicine: effects on professional practice and health care outcomes	514
An Official American Thoracic Society/European Respiratory Society Statement: Update on Limb Muscle Dysfunction in Chronic Obstructive Pulmonary Disease Executive Summary	499
An Official American Thoracic Society/European Respiratory Society Policy Statement: Enhancing Implementation, Use, and Delivery of Pulmonary Rehabilitation	492
Detection of lung cancer by sensor array analyses of exhaled breath	478
An integrated palliative and respiratory care service for patients with advanced disease and refractory breathlessness: a randomised controlled trial	423

Table 5 Summary of 17 keyword clusters on pulmonary rehabilitation of respiratory tract neoplasms.

Classification	Keyword clusters
Relevant Influencing Factors	#0 volatile organic compounds, #3 thoracic surgery, #4 radiotherapy, #5 lung resection, #6 postoperative pulmonary complications, #7 quality of life, #9 organic compounds, #14 double blind
Interventions	#1 palliative care, #2 mechanical efficiency, #8 deep learning, #10 insurance status, #12 exercise tolerance
Types of Diseases	#11 chronic obstructive pulmonary disease, #13 herat failure, #15 respiratory tract tumors, #16 childhood cancer, #17 systemic inflammation

Figures

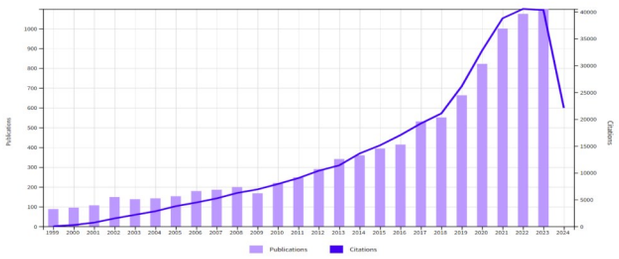

Figure 1. The publication and citation number

Figure 2 Map of collaboration relationships between countries/regions.

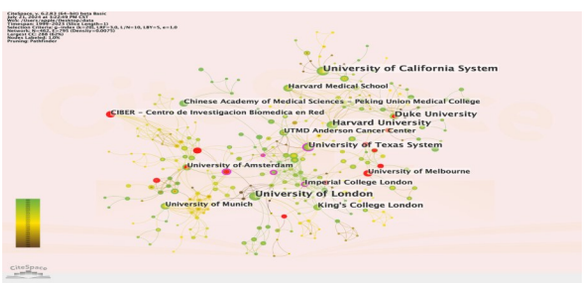

Figure 3 Map of collaborative relationships between institutions.

Figure 4 Map of cited relationships between journals.

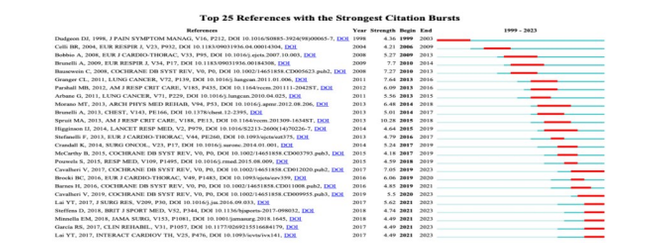

Figure 5 Map of top 25 references with the strongest citation bursts.

Figure 6 (A) The keywords with the most occurrences on pulmonary rehabilitation of respiratory tract neoplasms

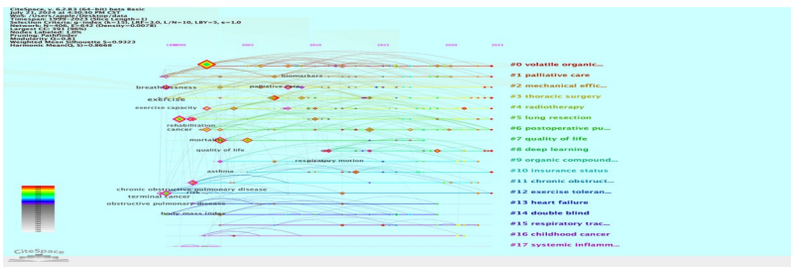

Figure 7 The map of 17 clusters of keywords.

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