Peer Review File

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Reviewer A

This manuscript provides a robust, methodologically rigorous bibliometric analysis of global research trends in pulmonary rehabilitation (PR) for chronic obstructive pulmonary disease (COPD) from 2011 to 2024. Leveraging a comprehensive dataset from the Web of Science Core Collection (WoSCC) and advanced analytical tools (VOSviewer, CiteSpace, Scimago Graphica, and Microsoft Excel), the authors deliver a visually compelling and interpretatively rich synthesis of publication trends, key contributors, journal impact, and emerging research themes. The inclusion of high-quality figures and tables enhances the manuscript's clarity and elevates it to a publishable standard.

Key Strengths

1. Comprehensive Data and Methodology: The study draws on a well-filtered dataset of 2,132 articles, with clear inclusion/exclusion criteria ensuring robust analysis.
2. Advanced Analytical Tools: The use of multiple bibliometric tools (VOSviewer for network visualization, CiteSpace for clustering, and Scimago Graphica for geographic mapping) provides a multidimensional perspective.
3. High-Quality Visualizations: Figures 3–7 and 8C are particularly effective in illustrating global collaborations, author networks, and citation bursts, adding significant value to the narrative.
4. Emerging Themes: The manuscript adeptly highlights trending topics, such as telerehabilitation, personalized rehabilitation protocols, and COPD comorbidities (e.g., anxiety, lung cancer), aligning with current clinical and research priorities.
5. Up-to-Date Referencing: The inclusion of 2025 publications demonstrates the study's relevance and timeliness.

6. Balanced and Clear Writing: The tone is scientifically precise yet accessible, effectively balancing dense technical content with interpretative insights.

Points Requiring Revision

1. Global Research Disparities

Issue: The manuscript notes limited contributions from developing countries but does not explore this observation in depth, missing an opportunity to address global research equity.

Recommendation: Add a dedicated paragraph in the Discussion to analyze disparities in research output, particularly between high-income and low- to middle-income countries. Highlight examples of innovative PR interventions from underrepresented regions to underscore their potential.

Suggested Addition: "Contributions from developing countries remain underrepresented, yet they offer critical insights for context-specific PR. For instance, Belloumi et al. (2024) demonstrated the feasibility of a home-based PR program in Tunisia, highlighting the need for scalable, resource-appropriate interventions to address global disparities (Belloumi et al., Prim Health Care Res Dev, 2024;25:e7, doi:10.1017/S1463423623000324)."

Reply: Thank you very much for this suggestion; I have added the relevant content to Discussion section 3.5.

Changes in the text: (see Page 26-27, line 387-390).

2. Discussion Structure and Concision

Issue: The Discussion is comprehensive but overly dense, with granular details that may overwhelm readers.

Recommendation: Organize the Discussion into thematic subheadings to improve readability and flow.

Suggested structure:

4.1 Global Research Output and Trends

4.2 Technological Advancements in Telerehabilitation

4.3 Personalized and Multidisciplinary PR Approaches

4.4 COPD Comorbidities and Psychological Factors

4.5 Addressing Global Research Inequities

Additionally, condense repetitive or overly detailed sections (e.g., keyword evolution) to maintain focus on key insights.

Reply: Thank you very much for the suggestion; I have restructured the Discussion with subheadings, making it more concise and clearer.

Changes in the text: (see Page 22-27, line 305-390):

3.1 Global Research Output and Trend

Over the past two decades, COPD PR has experienced substantial advancements. This study analyzed 2, 132 articles authored by 8,369 researchers affiliated with 3,040 institutions across 78 countries. England leads in publication volume, while Spain holds the highest number of citations per article among the top-ranking countries. Australia dominates institutional contributions, hosting six of the top 10 publishing institutions with strong collaborative networks. Notably, developing nations show limited output, with only China (5th in volume) and Brazil ranking in the top 15. In contrast, developing countries made limited contributions: only China and Brazil ranked among the top 15 in publication volume. Notably, China, despite being the fifth most prolific nation, recorded the lowest citation impact per article within this group, this may be due to limited international collaboration.

3.2 Technological Advancements in Telerehabilitatio

Burst detection analysis of keywords further highlighted the prominent rise of telemedicine-related research in recent years. Studies have demonstrated the feasibility and effectiveness of delivering PR education through YouTube video platforms(16) and interactive 3D visualization technologies(17). The rapid development of telerehabilitation platforms—including smartphone/video conferencing systems(18), mHealth applications(19, 20), myCOPD digital tools(21), and various mobile healthcare solutions(22, 23)—has significantly improved patient adherence and enabled the implementation of more personalized rehabilitation programs. Besides, Cox's research further highlighted comparable efficacy between home-based, primary care, and hospital-based PR for COPD patients (24), including during episodes of acute exacerbation(25). These findings suggest that telerehabilitation is both adaptable across various healthcare settings(26) and cost effective(27); however, further economic evaluations and implementation studies are needed to assess its effectiveness in COPD PR(28).

3.3 Personalized and Multidisciplinary PR Approache

Researchers Spruit and Cox have played pivotal roles in advancing pulmonary rehabilitation, their evolving work illustrates that the field is moving toward personalized, multidisciplinary approaches. Spruit—a pioneer in the field—has authored the highest number of publications, while Cox, a later entrant, holds the highest citation impact per article. A review of their academic work revealed that Spruit's early research focused on exercise training, a foundational theme in COPD PR. Recent studies by Spruit emphasize personalized rehabilitation programs(29), the development of core outcome sets(30), patient education tailored to individual needs(31, 32), and the implementation of multidisciplinary rehabilitation frameworks(26). Cox's research, initiated in the post–COVID-19 era(33), centers on telerehabilitation and referral pathways within PR programs. Concurrently ,timeline analysis of reference clusters revealed a strong association between Cluster #2 (elderly patients) and Cluster #3 (Medicare beneficiaries), likely attributable to the predominant representation of elderly populations in Medicare coverage systems(34, 35). This finding highlights the critical importance of considering Medicare policy frameworks and coverage dimensions when investigating healthcare interventions for elderly populations. Furthermore, a detailed examination of Cluster #13 (the Dutch model) elucidated its core principle as a patient-centered approach that achieves a seamless transition from acute care to long-term management through multidisciplinary collaboration and integration of community resources(36-38). The Dutch model provides valuable insights for future development trajectories in PR. Studies have shown that low physical activity levels in COPD patients represent an increasingly significant challenge(39). Exercise training has been demonstrated to enhance exercise capacity, muscle strength, and physical fitness in COPD patients by reducing Th17-mediated inflammatory responses and augmenting Treg cell–mediated immunosuppressive activity(40), whereas impaired ventilatory efficiency during exercise leads to exertional dyspnea(41). Comparative analysis suggests that high-intensity interval training (HIIT) may be more suitable for COPD patients than high-intensity continuous training (HICT) and moderate-intensity continuous training (MICT), as it induces less exertional dyspnea(42). Neuromuscular electrical stimulation (NMES) effectively addresses exercise reluctance caused by dyspnea in COPD patients(43), demonstrating significant improvements in maximal inspiratory pressure, maximal expiratory pressure, tidal volume, and decannulation success rate among mechanically ventilated patients(44). Furthermore, the combination of NMES with respiratory muscle training (RMT) significantly enhances pulmonary function, oxygenation capacity, and carbon dioxide elimination in COPD patients(45).

3.4 COPD Comorbidities and Psychological Factor

COPD comorbidities, characterized by diagnostic complexities due to overlapping clinical factors, constitute a critical determinant of risk in COPD patients(46, 47). Timeline analysis of keyword evolution indicated that research on COPD combined with musculoskeletal diseases, anxiety, and lung cancer is relatively mature. COPD patients can experience impaired body balance due to musculoskeletal problems(48, 49). Targeted PR interventions have demonstrated efficacy in improving balance capacity(50), with low-intensity core training enhancing central nervous system–mediated muscle coordination and high-intensity regimens strengthening core muscle groups(51). Anxiety is recognized as one of the most prevalent psychiatric comorbidities among COPD patients(52), presenting considerable challenges for intervention(53). Preliminary evidence suggests that adjunctive therapies such as music therapy may alleviate anxiety symptoms, though these findings require further validation(54). Notably, although timeline visualizations suggest a decline in anxiety-related research since 2020, detailed analyses indicate ongoing investigations, with current classification algorithms erroneously categorizing such studies under manual therapy domains. The COPD–lung cancer comorbidity increases the symptomatic burden(55). Preoperative PR has been shown to improve recovery outcomes and clinical efficacy(56), while postoperative rehabilitation programs similarly exhibit favorable prognostic benefits(57). Moreover, integrated cardiopulmonary rehabilitation programs have been increasingly proposed for COPD patients with cardiovascular comorbidities(58). The emergence of Baduanjin within rehabilitation medicine timelines (Cluster #6) signifies growing interest in the application of traditional Chinese Qigong practices(59). Contemporary research suggests that Qigong may facilitate PR in COPD patients by modulating pulmonary function, immune regulation, and neural adaptation mechanisms(60-62).

3.5 Addressing Global Research Inequities

Contributions from developing countries remain underrepresented, yet they offer critical insights for context-specific PR. For instance, Belloumi(63) demonstrated the feasibility of a home-based PR program in Tunisia, highlighting the need for scalable, resource-appropriate interventions to address global disparities Future efforts should prioritize adaptable models for underrepresented regions.

In conclusion, the future development of PR should prioritize telerehabilitation and the implementation of personalized rehabilitation protocols. Key research directions include advancing research on the efficacy of telerehabilitation modalities in COPD management by integrating economic evaluations and implementation science to assess their contextual adaptability and cost-effectiveness across diverse healthcare systems; tailoring PR programs to individual patients by accounting for characteristics such as age, gender, disease severity, and comorbidities, in order to improve rehabilitation outcomes; conducting mechanistic studies on the therapeutic effects of PR for COPD comorbidities (e.g., musculoskeletal disorders, anxiety, lung cancer, and cardiovascular diseases), with an emphasis on personalized intervention design, and substantiating the anxiolytic effects of music-assisted rehabilitation and novel psychotherapeutic interventions; standardizing outcome measures and PR assessment methods to improve the accuracy of rehabilitation effectiveness evaluations, monitor disease progression effectively, and provide a basis for adjusting rehabilitation programs; elucidating the mechanistic superiority of HIIT compared with MICT in terms of enhancing exercise capacity and applicability in clinical settings; combining NMES with RMT to better improve pulmonary function, oxygenation capacity, and other indicators in COPD patients and to determine the best application methods and treatment durations; deciphering the mechanisms and effects of Qigong (such as Baduanjin) in COPD PR and its integration with conventional methods to enrich rehabilitation approaches; and promoting the Dutch model, which emphasizes patient-centered care and facilitates seamless transitions from the acute phase to long-term management through multidisciplinary teamwork and community resource integration. In addition, multidisciplinary collaboration models and resource integration strategies tailored to the specific needs of different regions should be explored. Moreover, current research has yet to clarify how different COPD phenotypes (e.g., chronic bronchitis vs. emphysema), disease severity (GOLD stages), or comorbidities (e.g., heart failure, lung cancer) affect pulmonary rehabilitation outcomes; future studies should explore this area.

3. Methodological Clarity

Issue: The manuscript does not fully address the limitations of bibliometric methods, such as potential biases in WoSCC coverage or the impact of self-citation on author rankings.

Recommendation: Expand the Limitations section to include:

1) Potential underrepresentation of non-English or regional journals in WoSCC.

2) The influence of self-citation or citation cartels on author/institution rankings (e.g., Spruit's prolific output).

3) A brief note on the manual verification process to clarify the extent of human oversight in algorithm-driven results.

Reply: Thank you very much for your suggestion; I have added the relevant content to Section 4 of the manuscript.

Changes in the text: Fourth, the potential underrepresentation of non-English or regional journals in WoSCC. Fifth, the influence of self-citations or citation cartels on author and institutional rankings (for example, Spruit's prolific output) (see Page 28, line 423-425).

4. Language and Syntax

Issue: Minor grammatical and syntactic errors persist (e.g., "the co-exitance" → "co-existence"; "has remained central foci" → "has remained a central focus").

Recommendation: Conduct a final round of professional copyediting to polish complex sentences and transitions, ensuring clarity and consistency.

Reply: Thank you very much for your suggestion; I have run another round of spelling and grammar checks on the manuscript.

Changes in the text: have → has (see Page11, line 168).

Tables and Figures

Strengths: The visualizations (e.g., Figures 6A–6C, 8C) are excellent and provide clear insights into journal impact and citation trends.

Issues and Recommendations:

1) Table 1 and Table 2: Briefly discuss the discrepancy between China's high publication output and lower citation impact. Is this due to novelty, indexing biases, or limited international collaboration? A sentence in the Discussion could clarify this.

Reply: Thank you very much for your suggestion; I have now added this content to Discussion section 3.1.

Changes in the text: Notably, China, despite being the fifth most prolific nation, recorded the lowest citation impact per article within this group, this may be due to limited international collaboration (see Page 223, line 319).

2) Figure 8C (Citation Bursts): Highlight the significance of the GOLD 2023/2024 guidelines in the text to align with the figure's emphasis.

Reply: Thank you very much for your suggestion; I have incorporated this content into the detailed analysis of Figure 8C in the manuscript.

Changes in the text: It is readily apparent that this is fully consistent with GOLD 2023/2024 guidelines (see Page 20, line 301-302).

3) Figure Consistency: Ensure all figures use consistent terminology (e.g., "telerehabilitation" vs. "tele-rehabilitation").

Reply: Thank you very much for your suggestion; I have performed a thorough find-and-replace to ensure consistent terminology throughout the manuscript.

Changes in the text: tele-rehabilitation → telerehabilitation (see Page 24, line 324).

Reviewer B

1. Suggest to analyze the effect of different phenotypes of COPD (e.g., chronic bronchitis vs. emphysema), severity (GOLD grade), or comorbidities (e.g., heart failure, lung cancer) on PR outcomes.

Reply: After further literature review, I found no existing studies addressing this issue, so I have placed your suggestion as the final sentence of the Discussion to highlight it as a future research direction for readers.

Changes in the text: Moreover, current research has yet to clarify how different COPD phenotypes (e.g., chronic bronchitis vs. emphysema), disease severity (GOLD stages), or comorbidities (e.g., heart failure, lung cancer) affect pulmonary rehabilitation outcomes; future studies should explore this area (see Page 27, line 410-414).

2. It is reasonable that the future research should focus on remote rehabilitation and personalized programs. But it may be better if taking into account specific barriers (e.g., digital literacy in older patients, equipment costs) or cultural adaptation (e.g., the acceptance of Qigong in Western populations).

Reply: Thank you for raising this point; in the Discussion's summary, I now state that future research should emphasize a patient-centered approach, tailoring personalized rehabilitation programs and exploring multidisciplinary collaboration models suited to the specific needs of different regions.

Changes in the text: which emphasizes patient-centered care and facilitates seamless transitions from the acute phase to long-term management through multidisciplinary teamwork and community resource integration (see Page 27-28, line 408-411).

3. Conclusion in abstract in not consistent with results.

Reply: After carefully reviewing the abstract and conclusions of the paper, I did not find any inconsistencies in the findings; I therefore suspect a possible difference in interpretation. I have accordingly revised the wording.

Changes in the text: Combine the number of publications and the number of citations of the article, Australia holds the greatest influence in this domain, with leading institutions such as La Trobe University and Alfred Health producing numerous high-quality publications (see Page 3, line 50-53).

4. Page 3 Line 40 "Although effective, these treatments are associated with adverse effects; for example, beta-blockers significantly increase the risk of acute exacerbations in severe and very severe 42 COPD(3)". Bronchodilators in COPD only include antimuscarinic agents and Beta-Agonists, no beta-blockers.

Reply: Thank you very much, reviewer, for correcting my mistake in time. It has been corrected correctly in the original text.

Changes in the text: Beta-Agonists significantly increase the risk of acute exacerbations in severe and very severe COPD(3) (see Page 3 Line 40).

5. Page 3 Line 52 "Current clinical guidelines strongly recommend PR for patients with stable COPD and those recently hospitalized due to exacerbations while conditionally endorsing supervised maintenance PR or standard care following initial rehabilitation in adults". Please define PR indication for COPD in simple and clear sentences.

Reply: Thank you very much for your suggestions; I have revised the manuscript accordingly.

Changes in the text: Current clinical guidelines strongly recommend PR for all patients with stable COPD and those within four weeks of an exacerbation-related hospital discharge, and advise choosing either supervised maintenance programs or standard long-term exercise after initial rehab, according to individual needs (see Page 3 Line 52).

6. Page 7 Line 96 "The earliest identified literature in the field of COPD telerehabilitation was published in 2011". "COPD telerehabilitation" may be replaced by "COPD rehabilitation".

Reply: Thank you very much for your suggestions; I have revised the manuscript accordingly.

Changes in the text: The earliest identified literature in the field of COPD rehabilitation was published in 2011 (see Page 7 Line 96).

Reviewer C

1. Thank you for your revisions and the updates made to your paper. However, we note that certain critical points raised during the review process appear to remain unaddressed, specifically regarding the issues of specific barriers and cultural adaptation Reviewer 2 raised. Your response does not fully address the reviewer's specific concerns.

We kindly request that you revise your manuscript further to explicitly address the following comment:

Reviewer B Comment 2

It is reasonable that the future research should focus on remote rehabilitation and personalized programs. But it may be better if taking into account specific barriers (e.g., digital literacy in older patients, equipment costs) or cultural adaptation (e.g., the acceptance of Qigong in Western populations).

Reply: Thank you for your insightful and constructive feedback. We agree entirely that for future research on remote rehabilitation and personalized programs to be truly impactful, it must explicitly address practical implementation barriers—such as digital literacy among older patients and equipment costs—as well as cultural adaptations, including the acceptability of interventions like Qigong in Western populations.

Changes in the text: In response to your comment, we have revised the manuscript to include a new subsection (3.6 Implementation Barriers and Cultural Considerations) within the Discussion section. This addition explicitly discusses:

The technical, economic, and clinical barriers to implementing telerehabilitation, especially among elderly and resource-limited populations.

The importance of cultural adaptation when translating personalized.

interventions (e.g., Qigong/Baduanjin) across different socio-cultural contexts (see Page 28-29, line 415-442).

2. We noticed a minor grammatical issue in your revises manuscript. Please check your revised text carefully to ensure grammatical accuracy.

Abstract

Methods: Combine the number of publications and the number of citations of the article, Australia holds the greatest influence in this domain, with leading institutions such as La Trobe University and Alfred Health producing numerous high-quality publications.

Reply: Thank you very much for your thorough review and for pointing out this issue. We have revised the sentence in the Abstract section according to your suggestion to ensure grammatical accuracy and clarity.

Changes in the text: Based on a combination of publication volume and citation count, Australia holds the greatest influence in this domain, with leading institutions such as La Trobe University and Alfred Health producing numerous high-quality publications (see Page 1, line 21-24).