

# Research Trends in Health-Related Quality of Life Among Extracorporeal Membrane Oxygenation Survivors Between 2013 and 2024: A Bibliometric Analysis

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**Purpose:** To analyze and summarize research hotspots and development trends in the health-related quality of life (HRQoL) of patients undergoing extracorporeal membrane oxygenation (ECMO), providing a reference for future studies on survivor outcomes.

**Methods:** Articles published between 2013 and 2024 were retrieved from the Web of Science Core Collection. VOS viewer was used to assess contributions by countries, institutions, and authors in ECMO-related research. Collaboration networks, trending topics, and keyword patterns were analyzed using VOS viewer and Pajek.

**Results:** A total of 164 publications from 22 countries were included, accumulating 2870 citations overall. Research on ECMO patients' health-related quality of life demonstrated an annual growth rate of approximately 15% over the past decade. The United States, Germany, and Australia were the primary contributors. High-frequency keywords included outcomes, survivors, and ARDS, with COVID-19 emerging prominently from 2020 to 2024.

**Conclusion:** This bibliometric analysis, the first to focus specifically on ECMO survivors' HRQoL, demonstrates steady progress in the field. The analysis highlights three major research hotspots: survivor outcomes, rehabilitation strategies, and the impact of COVID-19, offering concrete insights into evolving directions and areas requiring future investigation.

**Keywords:** extracorporeal membrane oxygenation, health-related quality of life, visual analysis, research hotspots, bibliometrics, VOS viewer

## Introduction

Extracorporeal membrane oxygenation (ECMO) has gained significant attention as a critical care treatment following the COVID-19 pandemic. As an artificial heart-lung system, ECMO primarily provides support for severe respiratory and cardiac insufficiency, enabling the heart and lungs to rest while maintaining the body's blood and oxygen supply.<sup>1</sup> Currently, ECMO technology supports patients with acute respiratory distress syndrome (ARDS), severe pneumonia, cardiogenic shock, and heart failure. It also assists in treating various acute and critical conditions, and serves as intraoperative and perioperative circulatory support for heart and lung transplantation.<sup>2</sup> According to ELSO registry data, as of November 2024, a total of 221,723 ECMO procedures had been performed globally, with a discharge survival rate of 54%.<sup>3</sup> In China, 2020 data showed survival rates of 54.5% for adult respiratory support cases and 56.1% for cardiac support cases.<sup>4</sup>

While the development and application of ECMO technology have significantly improved survival rates among critically ill patients, this increased survival does not necessarily translate to a return to normal quality of life post-treatment. ECMO treatment exposes patients to various physical and psychological effects that often persist beyond the

treatment period, substantially impacting their quality of life. Previous studies have shown that ECMO survivors may face persistent cognitive impairments, psychological symptoms, and physical limitations, sometimes lasting for at least a year following discharge. Common complications include anxiety, depression, post-traumatic stress disorder (PTSD), chronic fatigue, and reduced physical endurance, and they all profoundly affect patients' quality of life.<sup>5</sup> Consequently, comprehensive long-term assessment of health-related quality of life (HRQoL) following ECMO therapy is crucial for evaluating both the clinical benefits and cost-effectiveness of this intensive intervention.<sup>6</sup> HRQoL is defined by the World Health Organization as an individual's perception of their position in life in relation to their goals, expectations, standards, and concerns within the context of physical, psychological, and social domains.<sup>7</sup> Recent years have seen growing research interest in the HRQoL of ECMO survivors. Studies reveal significant variations in post-treatment HRQoL among ECMO patients, with VV-ECMO patients often demonstrating better outcomes than those receiving conventional respiratory support - potentially attributable to the lung rest strategy employed during VV-ECMO.<sup>8</sup> Notably, ECMO survivors show lower return-to-work rates. Some studies suggest that ECMO survivors may have lower return-to-work rates compared with ARDS patients managed conventionally,<sup>9</sup> but the evidence remains limited and not based on RCTs.

These findings suggest that post-ECMO HRQoL is influenced by a complex interplay of physical, psychological, and social factors. Despite this growing body of research, comprehensive reviews remain scarce, and few studies have employed professional bibliometric analysis tools. ECMO is frequently offered to patients with higher acuity who are not candidates for conventional management alternatives, such as mechanical ventilation or mechanical circulatory support devices. Previous studies have reported that ECMO survivors may experience reduced return-to-work rates, long-term neurocognitive impairments, and persistent mental health symptoms such as anxiety and PTSD.<sup>10</sup> Systematic reviews have also noted heterogeneity in HRQoL outcomes across different ECMO populations.<sup>11</sup>

Bibliometric analysis serves as a powerful quantitative method for identifying research hotspots and mapping global trends within scientific fields.<sup>12</sup> While it does not establish causal correlations, this approach provides a macroscopic overview of thematic development, collaboration patterns, and emerging research directions. Specialized software facilitates comprehensive analysis of contributions by countries, authors, and journals, along with keyword co-occurrence patterns, to reveal academic frontiers and emerging research trends.<sup>13,14</sup> Owing to its rigorous, data-driven approach, bibliometric analysis has emerged as a widely adopted methodology across disciplines for investigating research trends. A systematic search of databases including PubMed and Web of Science confirms that no bibliometric analysis has yet systematically mapped the research field of HRQoL in ECMO patients. This study therefore employs VOSviewer to perform bibliometric and visual analyses of HRQoL in ECMO patients, utilizing data from Web of Science's core collection over the past decade. Bibliometric analysis does not generate new clinical outcomes but provides a complementary, macroscopic perspective on the research landscape, revealing collaboration networks, thematic trends, and gaps in knowledge. Our objectives are threefold: (1) to assess the field's current state of development, (2) to identify research hotspots and evolving trends, and (3) to provide actionable insights for future research and clinical practice enhancement. Although ECMO significantly improves survival in critically ill patients, survival alone is not sufficient to evaluate long-term recovery. Survivors often face lasting physical, cognitive, and psychological challenges, which underscores the need to assess HRQoL as a key outcome.

## Materials and Methods

### Search Strategy

The Web of Science Core Collection (WOSCC) has been widely accepted by researchers for bibliometric analysis as a high-quality database of digital publication resources. WOSCC has been widely accepted by researchers for bibliometric analysis.<sup>15,16</sup> To perform an English literature search in WOSCC, the search formula was as follows: TS=(“Quality of Life” OR “Health-Related Quality Of Life” OR HRQoL OR QOL) AND TS=(“Extracorporeal Membrane Oxygenation” OR ECMO OR “VV ECMO” OR “VA ECMO” OR “Veno-arterial ECMO” OR “Veno-venous ECMO”) AND PY=(2013–2024). Articles or reviews whose studies focused on HRQoL in ECMO patients were included, and exclusion criteria were followed as: (1) The publication types were conference papers, abstracts, editorials, books, letters and notes;

(2) Not written in English; (3) Not consistent with the topic. Only English-language articles and reviews were included in this study.

## Data Collection

During data collection, two authors independently retrieved and determined eligible publications. They downloaded all records from the WOSCC and extracted relevant data using Microsoft Excel. The following information was gathered from eligible articles: article title, authors' names and nationalities, affiliations, publication year, journal name, research fields, keywords, and abstracts. Data extraction and screening were performed independently by two evaluators. In cases of discrepancies, a third author was consulted to resolve disagreements through discussion. Duplicate records were identified and removed using EndNote's duplicate check function, followed by manual verification.

## Tools and Process

Bibliometrics provides a comprehensive and intuitive understanding of the research hotspots and trends in the field through visual analysis software that synthesizes all the literature for a specific time period. All searches were conducted in November 2024. VOS viewer version 1.6.19 (Leiden University) and Pajek version 5.18 (University of Ljubljana) were used for visualization. Compared with Citespace, VOS viewer 1.6.19 (developed by Leiden University, the Netherlands) produces results that correspond more closely to WoSCC data and has been widely applied in the medical field.<sup>17,18</sup>

It is able to cluster high-frequency keywords that represent research hotspots in the field based on a correlation strength algorithm.<sup>19</sup> In the visualizations, node size indicates keyword frequency, colors denote cluster groupings, and connecting lines show the strength of co-occurrence between keywords. These features enable interpretation of thematic patterns, though they do not imply statistical correlation. The most important advantage of WOSCC is that its data visualization effect is better than that of similar analysis software.<sup>20</sup> Therefore, this study uses VOS viewer 1.6.19 analyzing the co-occurrence of keywords with the assistance of Pajek presenting a clearer picture of the keywords and assisted to present a clearer and more explicit view of the co-occurrence network.<sup>21</sup>

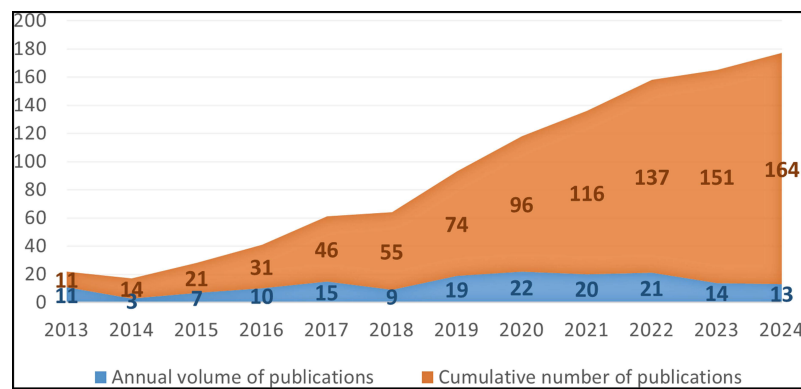
The included documents were imported into VOS viewer 1.6.19 and in plain text format with the content of "Full Record and Cited References", and the keywords were parameterized to generate the visual maps, and for the sake of clarity of the maps, clustering and node separation were carried out by using Pajek 5.18, and the maps were adjusted and outputted to VOS viewer. Keyword co-occurrence and clustering analysis, overlay analysis, and density analysis were performed on the imported English literature. The resulting maps represent co-occurrence relationships, where larger nodes indicate higher frequency of keywords, colors represent clusters of related terms, and links denote the strength of co-occurrence. These figures provide a descriptive visualization of research hotspots and trends rather than statistical correlation.

These visualizations are descriptive in nature and do not involve statistical hypothesis testing. Their role is to provide an overview of research trends rather than inferential analysis. The resulting maps are descriptive visualizations of keyword co-occurrence and do not provide statistical hypothesis testing or measures of significance. Their purpose is to highlight thematic groupings and research hotspots. Only keywords with a minimum occurrence of 10 were included in the co-occurrence analysis to ensure stability of the clustering results.

## Results

### Volume of Communications

In this study, 751 articles were initially retrieved, and a total of 164 English articles were included after de-duplication and nerfing. The included publications received a total of 2870 citations, with an average of 17.5 citations per article. Using a stacked area plot to show the magnitude of change over time, there was an increasing trend in the number of publications on HRQoL studies in ECMO patients from 2013 to 2024 (Figure 1). The top 10 countries with the highest number of publications from 2013 to 2024 are shown in Table 1, with the United States accounting for the largest number of publications, followed by Germany, Australia, China, and the United Kingdom in descending order.



**Figure 1** Stacked area map of the number of publications from 2013 to 2024.

## High Frequency Keywords

Keywords are a high degree of condensation of the core content of an article. It can reflect the hot research areas of a certain discipline through the statistical analysis of keywords, such as a keyword in a research area of high-frequency occurrences, it indicates that the keyword may be the hot research areas.<sup>22</sup> In the keyword screening, due to differences in the expression of authors, multiple words with one meaning were generated. Therefore, the VOS viewer data cleaning function was used to merge the synonyms, such as “adult”, “adult patients” can be unified as “adults”; “intensive care units”, “intensive-care-unit” can be unified as “intensive care unit”, etc. Meanwhile, keywords with high frequency and no analytical significance are excluded, such as “extracorporeal membrane oxygenation”, “quality of life”, “of-life” and so on. After integration, [Table 2](#) screened out keywords with more than 10 occurrences, of which the most frequent ones were outcomes, survivors, ARDS, and support, reflecting the fact that ECMO patient direction in which HRQoL studies are primarily concerned.

## Keyword Co-Occurrence Analysis

The clustering view of keyword co-occurrence consists of nodes and connecting lines, the nodes in the graph represent the selected keywords, different colors indicate different clusters. The larger the node, the higher the frequency of the keyword, and vice versa. The connecting lines represent the relationship between two keyword co-occurrences or clusters, the higher the frequency of two keywords co-occurrence, represents the closer the connection, the stronger the relevance, and these words with high relevance will be gathered together to form a class group.<sup>23</sup> Cluster analysis based on the co-occurrence of keywords can obtain the main research hotspots of HRQoL in ECMO patients.

As shown in [Figure 2](#) the co-occurrence network view can be divided into five clusters, five clusters were identified: (1) survivors and risk factors, (2) outcomes and measurement tools, (3) ICU-based studies and rehabilitation, (4) complications and qualitative research, and (5) pediatric follow-up and neurodevelopment, including cluster one: the red area is dominated by ECMO survivor-related studies, with diseases such as cardiogenic shock, congenital heart

**Table 1** Top 10 Countries by Number of Publications on HRQoL in ECMO Patients, 2013–2024

Nations	Volume of Publications	Percentage (%)	Nations	Volume of Publications	Percentage (%)
USA	50	30.5%	France	14	8.5%
Germany	18	11.0%	Italy	14	8.5%
Australia	17	10.4%	Netherlands	13	7.9%
China	15	9.1%	Korea	10	6.1%
England	14	8.5%	Canada	8	4.9%

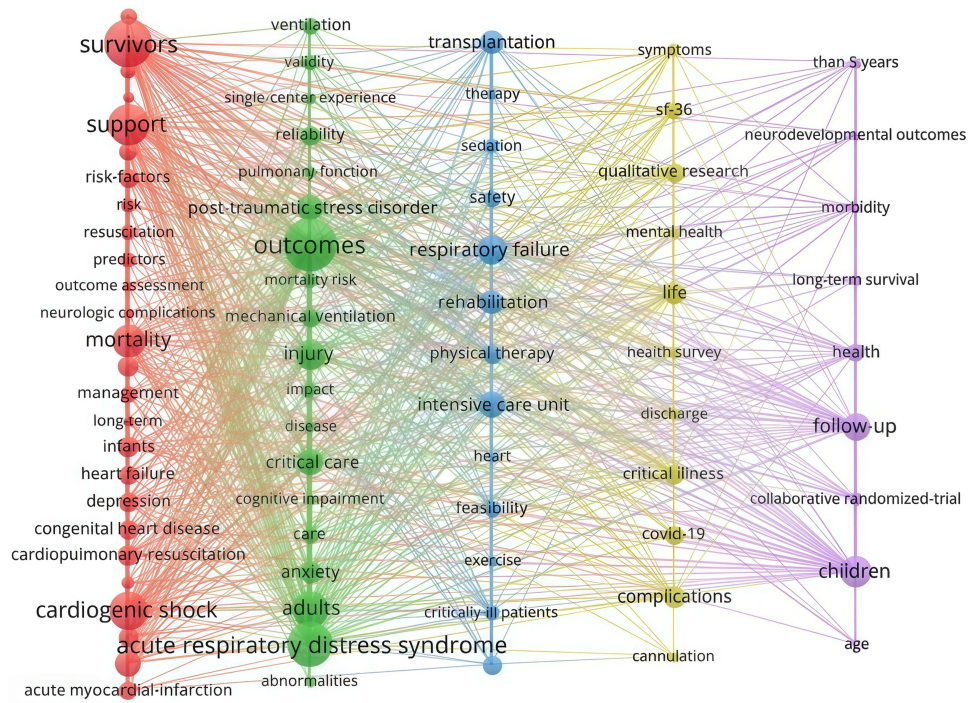
**Table 2** Keywords with a Frequency of HRQoL >10 Occurrences in ECMO Patients From 2013 to 2024

Byword	Frequency of Occurrence
Outcomes	64
Survivors	50
Acute respiratory distress syndrome	45
Support	38
Cardiogenic shock	32
Adults	29
Mortality	24
Children	23
Injury	20
Respiratory failure	18
Follow-up	17
Critical care	16
Post-traumatic stress disorder	15
Intensive care unite	15
Cardiac arrest	15
Rehabilitation	13
Transplantation	13
Anxiety	11
Life	11
Complication	11

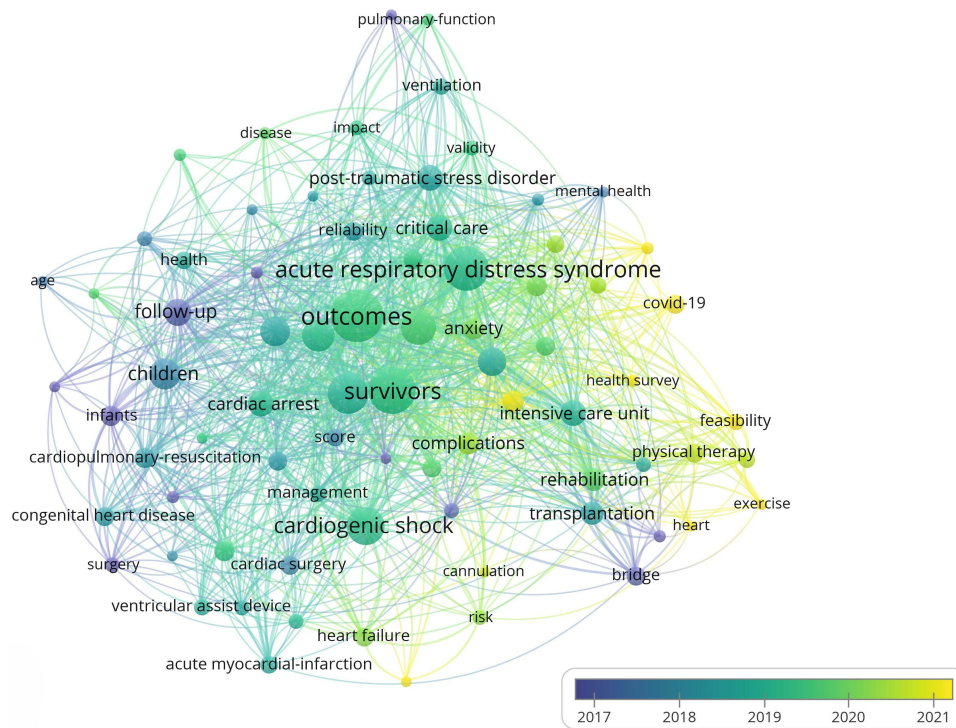
disease, heart failure, etc., including risk factors and predictors affecting HRQoL; cluster two: the green area is mainly centered on the outcomes of ECMO patients and their measurement tools, including the impact on life after discharge, the patient's health status, and the test of the reliability of the assessment tool, which is an important basis to explore the HRQoL of ECMO patients; Cluster three: the blue area takes the intensive care unit as the main location, and the respiratory failure, transplantation and other critical patients as the main research objects, involving patients' rehabilitation, safety and exercise; Cluster four: the yellow area mainly focuses on the complications of ECMO patients, and the qualitative interview is the main research method, focusing on symptoms, mental health, complications of tube placement, and post-discharge; Cluster five: the purple area focuses on follow-up, mainly in children, focusing on the health, long-term survival, and neurodevelopment of ECMO patients.

## Keyword Time Visualization Analysis

Figure 3 shows the temporal visualization mapping obtained along the time axis. The larger the node of the keyword, the higher the frequency of occurrence. The node color represents the research hotspot at a certain stage, which is determined by the average time of the year in which each key is located, and each line indicates knowledge flow direction, which transitions from purple to yellow based on the chronological order, and the more the keyword nodes are biased towards yellow, indicating that the research topic is more and more cutting-edge. Purple and yellow colors represent the keywords



**Figure 2** Keyword co-occurrence network view of HRQoL research hotspots in ECMO patients from 2013 to 2024.



**Figure 3** Time-visible view of HRQoL research hotspots in ECMO patients from 2013 to 2024.

superimposed on the amount of published literature around 2017 and 2021 respectively, which can reflect the development trend of research topics in recent years. Through the change of color, it can be seen that the research object changes from infants and children to adults, the follow-up time also tends to be five years or even longer, the type of disease ranges from congenital heart disease, respiratory failure to cardiogenic shock and then COVID-19, and the focus of the





are difficult to conduct. International consortia such as ELSO, ASAIO, and regional registries remain the primary means of collecting collaborative data.

Given the rapid advancements in ECMO-related knowledge and technology, it is crucial to foster stronger international and inter-institutional collaborations to facilitate data sharing and establish standardized datasets for HRQoL research in ECMO patients. Such efforts will help enrich clinical experience and ultimately improve the well-being of ECMO patients.

Advances in ECMO support technology have gradually expanded its application in selected high-risk populations.<sup>29</sup> In the overlay analysis, pediatric cases were more frequently represented before 2019, while adult ECMO cases became increasingly studied after 2019, particularly during the COVID-19 pandemic. The diversity of research subjects is conducive to proposing personalized protocols for different ECMO groups to adapt to different disease or population characteristics, and to effectively improve the HRQoL of ECMO patients in various subgroups.

As can be seen from the time visualization graph and the superimposed view, the research content of HRQoL in ECMO patients has been deepening, the topics have been gradually diversified, and the frequency of some keywords has been increased and repetitively reinforced, such as influencing factors. Clinical outcomes have been a hot research topic of HRQoL in ECMO patients, including risk factors and predictors. With the change of medical model, clinical treatment is no longer only focusing on the disease and mortality, but the psychological dimension of the patient has been emphasized, and intervention studies related to HRQoL in ECMO patients have gradually appeared and become a hotspot. Intervention is an effective means to influence the HRQoL of ECMO patients, such as physical therapy and rehabilitation exercises. Healthcare professionals can appropriately use psychological interventions to help ECMO patients recognize the disease process and reduce their negative emotions,<sup>30</sup> and provide with effective activity and rehabilitation exercise programs to prevent problems associated with limited physical activity,<sup>28,31</sup> promoting the recovery of physical function after ECMO patients post-discharged and improve HRQoL in ECMO patients. Genzor indicated that ECMO survivors require long-term follow-up and timely adjustment of rehabilitation exercise programs.<sup>32</sup> And guidelines issued by the Extracorporeal Life Support Organization (ELSO) require that ECMO centers should tailor their follow-up programs according to their specific populations and resources, including pre-discharge and post-discharge.<sup>33</sup> Regular follow-up is favorable to dynamically describe the HRQoL change trajectory of ECMO patients, to track the long-term health status and HRQoL change trend of ECMO survivors.

The bibliometric analysis shows increasing focus on post-discharge rehabilitation and psychological interventions, reflected in keyword clustering and temporal trends. These findings underscore the growing recognition of HRQoL as an essential outcome beyond survival statistics. The assessment of HRQoL in ECMO patients and the analysis of its influencing factors are also a key area of research, which are important basis for exploring HRQoL in ECMO patients. Currently, there is no specific assessment tool for HRQoL in ECMO patients, and the most widely used is the Short Form 36-item Health Survey (SF-36), which is internationally recognized as a measurement tool with high reliability and validity. According to the different subjects, the influencing factors of HRQoL in ECMO patients are also different, including: demographic factors, disease factors, psychological and mental states, cognitive function and social support.<sup>34</sup> Some studies noted that certain ECMO patients lacked sufficient social support.<sup>33</sup> Continuous support from family members and friends can help ECMO patients reduce their sense of isolation,<sup>35</sup> promoting their perception of life and enhances their sense of well-being. A full understanding of the influencing factors is conducive to proposing targeted intervention programs.

Compared to international research, Chinese studies on HRQoL in ECMO patients are lagging behind due to several factors. First, ECMO centers are not yet established worldwide, and the relatively small number of ECMO cases, coupled with high mortality rates, results in limited sample sizes and greater difficulty in conducting large-scale studies. Second, there is significant geographic disparity in the development of ECMO technology across China,<sup>4</sup> contributing to differences in patient outcomes and further widening the gap in research compared to other countries.<sup>36</sup> However, with the continuous advancement of ECMO technology and the accumulation of clinical experience, it is expected that future research on HRQoL in ECMO patients will expand. The dominance of the US and Europe may be explained by earlier adoption of ECMO technology, well-established national registries, and greater availability of research funding and infrastructure. This reflects structural limitations, as ECMO is concentrated in high-acuity, high-cost centers where

multicenter randomized trials are difficult. Collaborative efforts are primarily driven by national and international registries, including ELSO. These developments will contribute to improving the overall well-being of ECMO survivors.

## Limitations

This investigation has two principal methodological constraints. Primarily, the exclusive reliance on WOSCC data from the preceding decade introduces potential selection bias. While WOSCC maintains scholarly rigor, the exclusion of complementary databases (PubMed/Scopus/Google Scholar) may have compromised literature comprehensiveness. Temporal discrepancies in database synchronization likely resulted in underrepresentation of recent advancements in HRQoL research for ECMO recipients. Additionally, restricting the analysis to WOSCC and English-language journal articles may have excluded relevant studies, and the exclusion of conference proceedings or non-journal publications could limit comprehensiveness. Furthermore, language restriction to English publications might have excluded seminal works in other linguistic domains, potentially skewing geographical research trends. Additionally, the extended research lifecycle, from bibliometric analysis and critical synthesis to manuscript finalization, demands considerable time. This protracted workflow, compounded by peer-review latency, may result in temporal disjunction between data collection and contemporary research developments.

## Conclusion

Through bibliometric analysis of WOSCC data from 2013 to 2024, this study delineates the intellectual architecture of HRQoL research in ECMO survivors. These findings should be interpreted in light of study limitations, including reliance on a single database (WOSCC), restriction to English-language publications, and inclusion of journal articles only. The constructed knowledge maps reveal actionable insights regarding: (1) latent collaboration networks among research entities, (2) seminal references shaping the field, and (3) thematic evolution trajectories. These multidimensional outputs enable strategic benchmarking of current research paradigms and identification of underdeveloped investigation domains. These findings provide complementary insights to existing clinical guidelines by mapping research hotspots and highlighting areas where further evidence is needed. Our bibliometric analysis, the first focused specifically on HRQoL in ECMO survivors, identified five major research hotspots, particularly outcomes, rehabilitation and follow-up strategies, and the impact of COVID-19. The bibliometric analysis identified five major hotspots, with particular emphasis on three key areas: survivor outcomes, rehabilitation and follow-up strategies, and the impact of COVID-19. While these findings provide a unique macroscopic perspective, they are limited by regional differences in ECMO practice and the relatively modest volume of literature available to date. This underscores the need for multinational collaboration and more robust clinical research to validate and expand upon these trends. Future research should prioritize the development of ECMO-specific HRQoL instruments, strengthen multinational collaboration to improve sample diversity, and design prospective multicenter studies to evaluate long-term outcomes and targeted rehabilitation interventions. This study provides the first bibliometric overview of HRQoL in ECMO survivors, offering a comprehensive perspective on research trends and highlighting critical gaps to guide future investigations.

## Explanation for Exceeding Reference Limits

This paper cites 36 references, exceeding the journal's limit of 25. The excess is due to the complex, interdisciplinary study, which needs more references for comprehensiveness and accuracy. Non-essential references have been minimized, and all cited ones directly contribute to the research. We're willing to further refine the references per the reviewers' advice.

## Ethics Statement

This study did not involve animal or human experiments, so the ethical statement is not shown here.

## Patient Consent Statement

This study did not involve patient, so the patient consent statement is not shown here.

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## Author Contributions

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

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