



Review article

Mapping research on cognitive impairment in heart failure patients: A bibliometric analysis from 2013 to 2022

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ABSTRACT

Background: Cognitive impairment is a common concern among individuals with heart failure, and the intersection of these conditions poses significant challenges for scholarly investigation. This study aims to conduct a comprehensive bibliometric analysis to visually depict the current state and emerging trends regarding cognitive impairment among heart failure patients.

Methods: Articles focusing on cognitive impairment in heart failure patients published between 2013 and 2022 were retrieved from the Web of Science Core Collection on February 3, 2023. Analysis of publication trends was conducted using Microsoft Excel 2016. The bibliometric analysis, involving identification of the leading countries, institutions, and authors, as well as the analysis of keywords co-occurrence and burst-detection, was performed using CiteSpace and VOSviewer.

Results: A total of 260 original articles were included. The data showed a stable pattern of annual publications on cognitive impairment in heart failure patients over the last ten years. The United States stood out with 129 publications, Kent State University in the USA led in institutional output with 32 articles, and Gunstad John was identified as the most influential author with 32 articles and 572 citations. Analysis of keyword co-occurrence network revealed core research themes encompassing risk factors, interventions, assessment, and underlying mechanisms of cognitive impairment in heart failure patients.

Conclusions: This study presents the first bibliometric analysis of research on cognitive impairment in heart failure patients over the past decade, offering valuable insights for exploring future research frontiers in this domain. The findings provide researchers, clinicians, and policymakers with key information to advance understanding and interventions for cognitive impairment in heart failure patients.

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1. Introduction

Heart failure refers to a condition whereby the heart fails to pump adequately to maintain a blood flow for body's need, and is the common final pathway of various cardiac diseases [1]. About 1%–2% of adults worldwide are affected by heart failure [1], and the prevalence reaches up to 10 % in those aged 70 years and older [2]. The challenge of heart failure extends beyond health, exerting significant clinical, societal, and economic impacts [3]. Despite medical advancements, the condition continues to be associated with significant hospitalization rates and increased mortality [1]. Normal cognitive function is crucial for individuals with heart failure to maintain independency and improve health outcomes. Yet, individuals with heart failure tend to exhibit diminished cognitive functions compared to those of age-matched healthy ones [4]. Since “cardiogenic dementia” was first identified in 1977, there has been an increasing awareness of the possible connection between heart failure and cognitive decline [5].

Cognitive impairment is a kind of common age-related disease, which manifests as a decline in one or more key brain functions that range from mild to severe, significantly affecting daily life and independence [6]. Annually, 5–20 % of individuals with mild cognitive impairment progress to dementia [7], and about 80 % of them convert to dementia within 6 years [8]. In the context of heart failure, cognitive impairment is increasingly recognized, encompassing abnormalities in cognition, attention, memory, language, psychomotor function, and visual-spatial skills. This is often associated with declined cerebral function, potentially caused by reduced cardiac output, vascular dysfunction, and imbalances in the autonomic nervous system [9]. Studies have revealed that the incidence of cognitive impairment in heart failure ranges from 20 % to 80 % [10]. Furthermore, having concurrent cognitive issues is associated with poor self-care, worse prognosis, increased mortality rates, and higher readmission rates [11,12].

As the population ages, the incidence of cognitive impairment in heart failure also increased, sparking increased academic interest in the interplay between these conditions. This growing attention calls for a more in-depth examination of the cognitive issues associated with heart failure, urging for updated comprehensive reviews in this area. However, existing literature often narrows down on specific cognitive deficits within heart failure, overlooking broader research proceedings of this field. While traditional reviews offer valuable information, they often fail to reflect the dynamic trends and collaborations that mark this area of study. A bibliometric analysis can provide valuable insights into the current hotspots and frontier trends within this research domain.

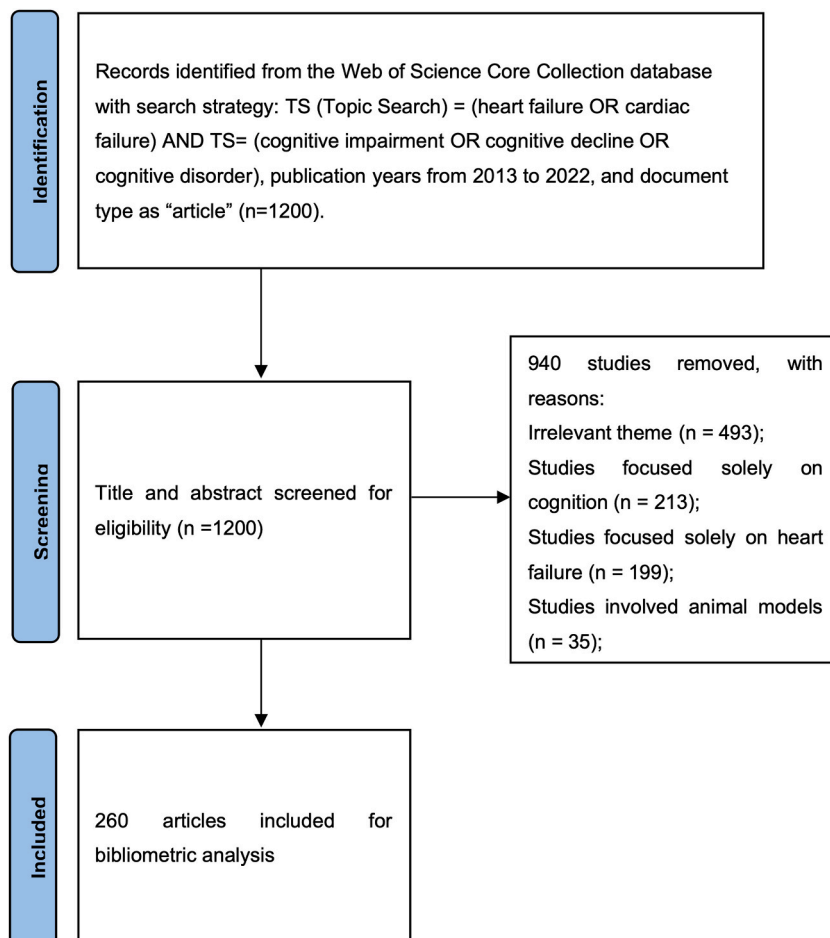


Fig. 1. PRISMA flowchart of included publications.

Bibliometric analysis is a valuable tool that uses statistical and mathematical methods to quantitatively analyze the developmental trends and hotspots in a given field, illuminating the current status of knowledge and guiding future research directions [13]. It reveals collaboration networks among countries, institutions, and authors, aiding in the discovery of potential research partnerships [14]. Tools like VOSviewer and CiteSpace are widely used software packages in creating these networks, allowing for the visualization of research dynamics and thematic developments. Despite previous bibliometric studies on related topics like heart failure and depression [15], empagliflozin for heart failure [16], and diabetic-associated cognitive decline [17], research specifically focusing on the intersection of heart failure and cognitive impairment is noticeably lacking.

The unique relationship between heart failure and cognitive impairment necessitates targeted scholarly exploration considering its clinical and prognostic implications. Although there is a growing body of literature on cognitive impairment and heart failure, a dedicated bibliometric analysis in this area has not been conducted. Therefore, in this study, we conducted a comprehensive bibliometric analysis utilizing CiteSpace and VOSviewer to spotlight the central themes and emerging trends in research concerning cognitive impairment in heart failure patients. We limited our review to papers published from 2013 to 2022 to focus on the most recent developments. This project is beneficial in mapping out the primary directions and future research imperatives, setting a foundation for subsequent inquiries and guiding scholars towards areas for further intervention and exploration.

2. Materials and methods

2.1. Data source and search strategies

This study utilized the Web of Science Core Collection (WoSCC) database as the data source, which is the most comprehensive and influential academic resource database covering various fields [18]. The data retrieval was carried out on February 3, 2023, using the following strategy: TS (Topic Search) = “heart failure” OR “cardiac failure” AND TS = “cognitive impairment” OR “cognitive decline” OR “cognitive disorder”. The search was specifically limited to papers published from 2013 to 2022 to concentrate on recent advancements. The type of document was limited as “Article” to maintain a focus on high-quality academic output. We did not restrict our search to English-language articles nor did we include ‘age’ as a specific search term, allowing for a comprehensive global scope and inclusive age range in our study.

From the initial pool of 1200 articles, we utilized Rayyan (<https://www.rayyan.ai/>) for the screening process. Our inclusion criteria were centered on the themes of heart failure and cognitive impairment across all age groups, excluding only animal studies. Two independent reviewers (Zhao Qing and Fang Yang), conducted the initial screening based on titles and abstracts. Discrepancies were resolved through consultation with a third reviewer (Cao Xiaodong). Ultimately, 940 articles not aligned with our research focus were removed, resulting in a refined dataset of 260 articles. The citations of these articles were downloaded and saved as “full records and citation references” in plain text files for subsequent visualization analysis. Fig. 1 presented the literature search and selection process.

2.2. Bibliometric analyzing

Data for this study was imported to Microsoft Excel 2016, CiteSpace (version 6.1 R6), and VOSviewer (version 1.6.18) to facilitate a comprehensive bibliometric analysis. We used Microsoft Excel 2016 to analyze the trend of annual publications over the past 10 years, providing a clear visual representation of temporal shifts within the research landscape.

CiteSpace is recognized for its effectiveness in knowledge mapping and is extensively utilized in academic research [19]. We



Fig. 2. Annual number of publications on cognitive impairment in heart failure from 2013 to 2022.

utilized Citespace for the co-occurrence analysis of countries and keywords, thereby revealing the collaborative and thematic frameworks shaping the field. Additionally, this software was instrumental in detecting research 'bursts', thus identifying emerging hotspots and evolving frontiers within the domain. In this study, we employed CiteSpace for burst detection to demonstrate the most active research hotspots and frontiers that are developing quickly.

Furthermore, VOSviewer was employed for its robust capabilities in constructing extensive bibliometric network maps, facilitating knowledge clustering and visual analysis of distinct parameters [20]. In this study, we used this software to visualize the collaborative network of institutions and authors.

3. Results

3.1. Trends in annual publications

In our study, 260 documents were included in the analysis. The trend in annual global publications exhibited fluctuations, reflecting a dynamic landscape in research interest and output over the examined period. Despite these fluctuations, there appears to be a general trend towards stability with minor variations in the number of publications year-to-year. As shown in Fig. 2, a slightly uptrend in publications is observed, with the highest number of articles (34 publications) was published in 2022 and the lowest (17 publications) in 2013. The inclusion of a trend line, representing the linear progression of annual publications, indicates a modest upward trajectory over the decade. This suggests a growing, albeit fluctuating, academic and clinical interest in the nexus between cognitive impairment and heart failure.

3.2. Analysis of countries or regions contribution

From 2013 to 2022, research on cognitive impairment in heart failure was conducted across 35 countries or regions, illustrating the global scope of investigation in this area. Dominating in publication volume and research intensity, the United States contributed to 49.62 % of the total research output, positioning it as a central figure in this academic field. The leading ten countries or regions, spanning North America, Europe, Asia, and Oceania, underscore the widespread geographic engagement with this topic (refer to Table 1).

The patterns of international collaborations were visualized using CiteSpace, revealing a comprehensive network of partnerships among the countries or regions. The network map (As shown in Fig. 3) indicated extensive collaborative links among countries, with the United States standing out for its pivotal role, as evidenced by the highest centrality measure of 0.63. This underscores the United States' leading role in fostering global cooperation in research on cognitive impairment with heart failure.

3.3. Analysis of institutions

In total, 530 institutions participated in the subject research. Leading the field in terms of scholarly publications, Kent State University stood out with 32 papers, closely followed by Case Western Reserve University with 31 publications, Akron City Hospital with 20, University of Georgia with 14, and Harrington Heart & Vascular Institute with 13. Notably, these top-contributing institutions, all from the United States, were predominantly higher education entities.

A network map illustrating institutional collaboration was generated using VOSviewer, as depicted in Fig. 4. Within this network, Kent State University, Case Western Reserve University, and Akron City Hospital emerged as pivotal nodes, indicating their significant roles in fostering academic connections within the field. These institutions formed the core of a complex, web-like structure, highlighting extensive collaborative ties. Nonetheless, the analysis revealed a distinct lack of cross-cluster interaction, suggesting potential avenues for enhanced interdisciplinary collaboration among diverse research groups.

3.4. Analysis of author cooperative network

A total of 1477 authors have engaged in research, yielding relevant scholarly contributions in this field. The top 5 most productive

Table 1
Top 10 countries/regions with the highest number of publications.

Rank	Country/Region	Number of publications	Percentage	Centrality
1	USA	129	49.62 %	0.63
2	Italy	20	7.69 %	0.10
3	Australia	20	7.69 %	0.02
4	Germany	18	6.92 %	0.17
5	China	18	6.92 %	0.09
6	Korea	15	5.77 %	0.00
7	Japan	13	5.00 %	0.00
8	Netherlands	12	4.62 %	0.12
9	England	10	3.85 %	0.06
10	Sweden	9	3.46 %	0.17

369 citations, respectively.

According to the Price Law [21], the minimum number of papers among core authors (m) can be calculated as $m \approx 0.749\sqrt{n_{\max}}$, where n_{\max} represents the publication count of the most productive author. In this context, individuals contributing more than 4 articles were considered as core authors. A total of 44 authors met this criterion, making up 2.98 % of the total number of authors. These core authors produced 354 papers, constituting 17.63 % of the total 2008 publications.

A network map of author collaboration was generated using VOSviewer software and illustrated in Fig. 5, which highlighted the central role of Gunstad John, around whom significant academic clusters had formed. However, the level of research collaborations among the core authors were limited, signaling opportunities for enhanced interconnectivity and collaborative depth.

3.5. Analysis of keywords co-occurrence

In this study, 316 keywords related to cognitive impairment with heart failure were extracted. To visualize the research hotspots in this field, we utilized Citespace to generate a keyword co-occurrence network map, which was presented in Fig. 6. This analysis identified the top 10 most prevalent keywords: “heart failure” ($n = 179$), “cognitive impairment” ($n = 98$), “impairment” ($n = 90$), “older adults” ($n = 59$), “risk” ($n = 57$), “dementia” ($n = 52$), “association” ($n = 50$), “disease” ($n = 48$), “self-care” ($n = 46$), and “cognitive function” ($n = 45$). Additionally, “prevalence”, “Alzheimer’s disease”, “mortality”, and “depression” were identified as noteworthy keywords, reflecting their increasing focus in global studies.

Based on the prominent keywords identified, four main research hotspots concerning cognitive impairment in heart failure patients were delineated in global investigations over the last decade.

- 1) Investigating risk factors associated with cognitive impairment in heart failure patients, highlighted by keywords such as “age”, “risk”, “prevalence”, and “depression”.
- 2) Developing interventions to address cognitive impairment among heart failure patients, indicated by “self-management”, “management”, “intervention”, “quality of life”, and “compliance”.
- 3) Evaluating cognitive impairment in heart failure patients using diverse approaches, marked by “diagnosis”, “MMSE scale”, “reliability”, “validity”, “MoCa scale”, and “mini-cog scale”.
- 4) Exploring the underlying mechanisms of cognitive impairment in heart failure patients, involving keywords such as “brain function”, “ejection fraction”, “brain natriuretic peptide”, “blood flow”, “white matter hyperintensities”, and “C-reactive protein”.

3.6. Analysis of top 10 keywords with the strongest citation bursts

Using CiteSpace, a burst detection analysis was conducted to track evolving trends within global research on cognitive impairment in heart failure patients over the period 2013 to 2022, as illustrated in Fig. 7. This analysis unveiled significant shifts in the thematic focus of global research. Keywords such as “reliability”, “physical activity”, “knowledge”, “stroke”, “preserved ejection fraction”, and “association” had experienced a waning of interest over recent years. Conversely, topics like “symptoms”, “blood pressure”, “white matter hyperintensities”, “elderly patients”, “anxiety”, “cognitive function assessment scales”, and “cardiac resynchronization therapy” had risen to prominence, attracting increased academic focus in the latter part of the decade.

4. Discussion

This study performed a bibliometric analysis to comprehensively explore the research landscape on cognitive impairment in heart failure patients. By conducting a quantitative examination, detailed information regarding countries, institutions, authors, and keywords over the past decade have been collected, shedding light on the current state and future trends in this field. The annual publication trends revealed a consistent level of research activity, highlighting the sustained interest and significance of cognitive impairment within the disciplines of neurology and cardiology.

The collaborative analysis of countries or regions demonstrated that United States ranked first in both publication output and centrality. Notably, the top five institutions with the highest publication numbers were all located in the United States, implying the dominant role of the US in the field of cognitive impairment in patients with heart failure. These significant contributions might be backed by significant prevalence and considerable investments in medical and research facilities targeting the intersection of heart failure and cognitive impairment. Epidemiological findings indicate a rise in the occurrences of both conditions within the US. Currently, over 6.7 million Americans over the age of 20 are living with heart failure, with projections suggesting an increase to 8.5

Table 2
Top 5 productive authors.

Rank	Name	Articles	Total Citations	Average Citations
1	Gunstad John	32	572	17.875
2	Josephson Richard	27	514	19.037
3	Spitznagel Mary Beth	19	369	19.421
4	Alosco Michael L	17	356	20.941
5	Hughes Joel	17	342	20.118

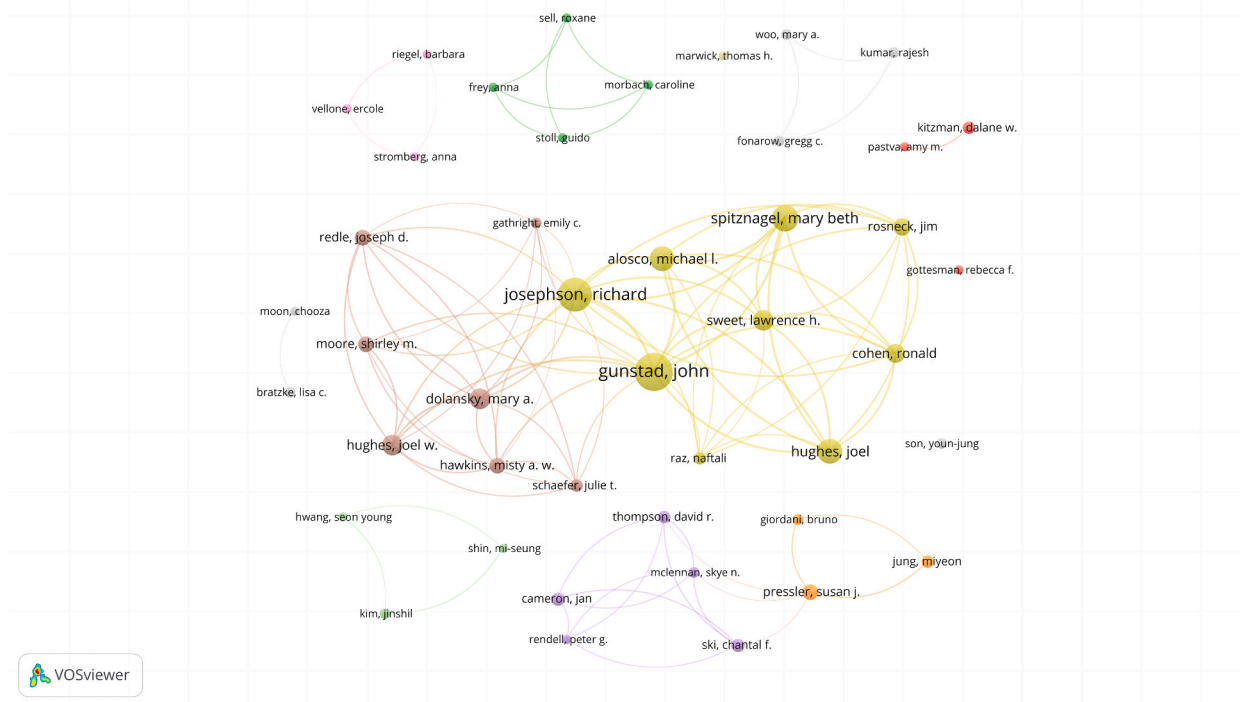


Fig. 5. The visualization network of author collaboration. Each node represents an author, with the node size reflecting the author's publication count. Links between nodes indicate co-authorship relations, with line thickness indicating collaboration strength. Different colors of nodes represent the collaboration among authors.

million by 2030 [22]. Additionally, the dementia prevalence rate stood at 11.3 % in 2020, equating to roughly 6.07 million dementia cases in the US [23]. In all countries involved, Italy ranked second in publication output yet showed a minimal level of international engagement, as seen in its low centrality score. Conversely, Germany and Sweden might have fewer publications, but exhibited greater international influence and research excellence, reflected in their high centrality rankings. Asian countries such as China, India, and Japan exhibited lower centralit, pointing towards a need for enhancing their efforts to foster innovative research and increase their impact. While these countries hvave made contributions to the field, there exists potential for deeper and more extensive global collaborations.

The analysis of author productivity identified prominent scholars contributing extensively to this domain, with Gunstad John from Kent State University standing out in both the number of publications and citations received. Collaborative efforts among scholars from Kent State University, Akron City Hospital, and Case Western Reserve University have exemplified a comprehensive approach to addressing cognitive impairment in heart failure. These collaborations have delved into a spectrum of subjects such as exploring risk factors of cognitive function [24–26], developing strategies to enhance cognitive abilities [27,28], and understanding how cognitive dysfunction influences heart failure outcomes [29,30]. Additionally, another distinguished team led by Kitzman, Dalane W, Pastva, Amy M, Nelson, M. Benjamin, Whellan, David J, Mentz, Robert J, and Reeves, Gordon R., has been pivotal in assessing the prevalence and determinants of cognitive impairment in older adults with heart failure [31,32], thereby providing vital insights into the field.

The keyword co-occurrence analysis identified the central themes within the field of cognitive impairment in heart failure patients. Three of the top five keywords were closely aligned with the subject of our study, indicating that existing literature predominantly revolves around “heart failure” and “cognitive impairment.” Through keyword co-occurrence and burst detection, we can detect the current research hotspots and frontiers of cognitive impairment in patients with heart failure. This highlights research directions focused on risk factors, interventions, assessment, and mechanisms underlying cognitive impairment in heart failure patients.

Previous studies have identified several risk factors associated with cognitive impairment in heart failure patients, which appear to be multifactorial. Older age, non-White race, being female, having a lower level of education, and a higher ranking in the New York Heart Association (NYHA) classification are reported to be associated with an increased risk of cognitive decline [33]. Additionally, patients displaying lower scores in the Six-Minute Walk Test(6MWT) are also observed to have more severe cognitive issues [34]. Furthermore, the presence of other health conditions like anemia [35], atrial fibrillation [36], and obesity [37], has been identified as additional contributors to cognitive impairment in heart failure patients. These insights underline the urgency for prompt and efficient intervention strategies within in this vulnerable population.

While clinical guidelines for heart failure have begun acknowledging the importance of cognitive impairment, there is a scarcity of clear directions for healthcare providers on how to approach this issue [38]. It is crucial to address modifiable risk factors like

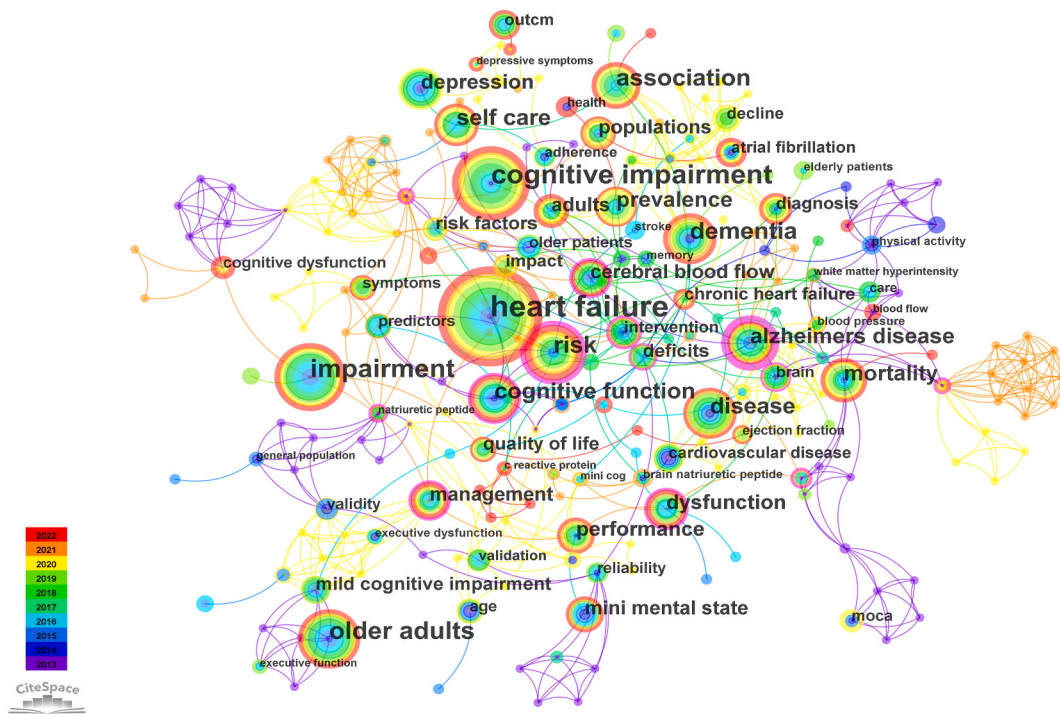


Fig. 6. Network visualization of keywords co-occurrence. Each node represents a keyword. The size of the nodes reflects the frequency of the keywords, with larger nodes indicating higher frequency. The thickness of the lines indicates the closeness of the interactions between nodes. The colors of the nodes indicate the cluster to which keywords belong.

education level and exercise capacity, through non-pharmacological interventions. Evidence from a large randomized controlled trial suggests that a multidomain intervention involving diet, exercise, cognitive training, and vascular risk monitoring, can either enhance or preserve cognitive function over a two-year period [39]. Previous systematic reviews have also confirmed the beneficial effects of non-pharmacological strategies like cognitive intervention, exercise training, and self-care management on cognitive function in heart failure patients [40]. Recent studies further underscore the necessity of incorporating self-management and appropriate physical activities, tailored to the capacities of individuals with heart failure, along with cognitive training [41]. Additionally, cardiac resynchronization therapy has been noted for its potential in enhancing cognitive functions by improving the heart's pumping efficiency in those with heart failure [42].

While there is no consensus on the specific formal tools for evaluating cognitive function in heart failure patients [43], various methods have been utilized and can be integrated into standard clinical practice. The Mini-Mental State Examination (MMSE) and the Montreal Cognitive Assessment (MoCA), are among the most frequently used tools, both proving to be effective in clinical practice [44]. In particular, the MoCA has shown higher sensitivity than the MMSE for detecting mild cognitive impairment in middle-aged and older heart failure patients [45]. Despite this, both instruments exhibit comparable specificity [46]. Consequently, greater prevalence of cognitive impairment may be identified using the MoCA compared to the MMSE [47]. This indicates a potential need for the reevaluation or replacement of the MMSE with the MoCA to more accurately detect cognitive issues among individuals with heart failure [45]. Additionally, the Mini-Cog takes only 3 min to administer, but this tool might lack the sensitivity required for detecting mild cognitive impairment. The selection of screening tools in routine clinical practice should be based on differences in diagnostic performance.

The concept of the “bidirectional heart-brain interconnection” between the heart and brain has recently emerged as a significant focus in understanding the progression and outcomes of chronic heart failure [48]. This interaction involves complex feedback interactions that are central to the pathophysiology of heart failure, impacting the symptomatic presentation and various comorbidities associated with the condition. Additionally, these neuro-cardiac feedback signals are implicated in exacerbating heart failure, thereby influencing its prognosis [49]. However, the exact pathogenesis of cognitive impairment in heart failure remains unclear [10]. A main factor identified is the reduction in cerebral blood flow, attributed to diminished systemic circulation resulting from lowered cardiac output and blood pressure [50]. This has been linked to brain atrophy and an increased prevalence of deep white matter lesions, adversely affecting cognitive abilities in heart failure patients. Moreover, this condition may be exacerbated by the brain's impaired autoregulation of its blood flow [51]. Furthermore, the worsening of cognitive issues may be related to brain congestion, which occurs when congestion in the body's circulation increases pressure in the central veins, leading to increased pressure in the brain's veins. This sequence of events can cause cognitive deterioration through various biological processes [52,53]. Beyond these hypotheses, factors such as reduced cerebral blood flow, systemic inflammation [54], metabolism disorders [55], sympathetic-parasympathetic imbalance

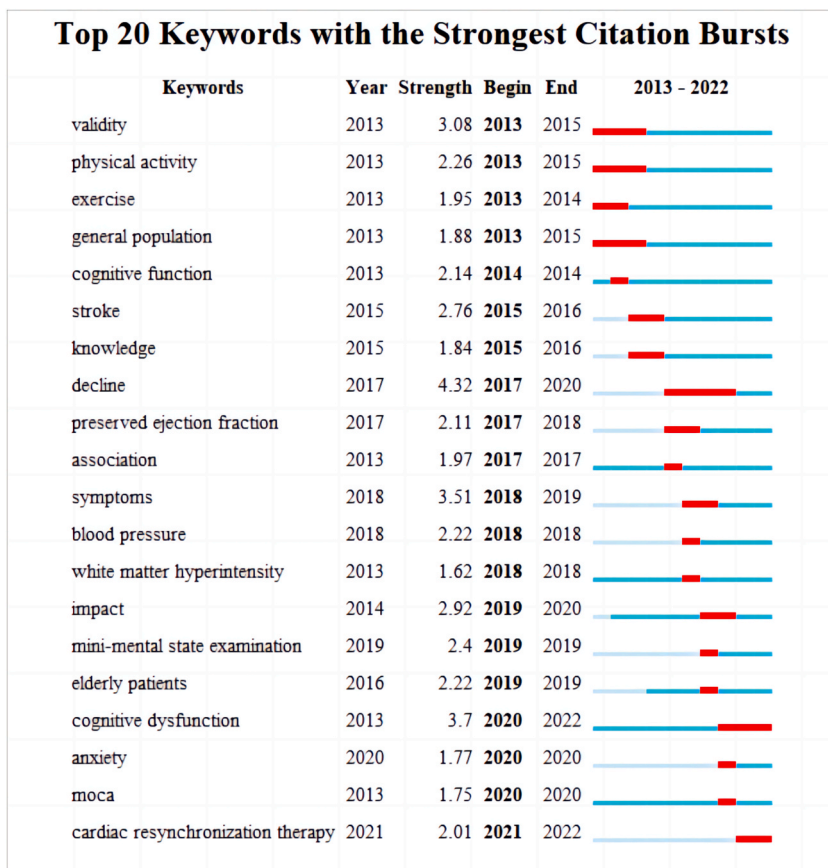


Fig. 7. Top 20 keywords with the strongest citation bursts. The blue line stands for the overall time span of publications, from 2013 to 2022. The red line represents the time interval of a specific burst word.

[41], impaired brain network properties and decreased connectivity [56] are also under investigation as contributing mechanisms. Further research is crucial to decipher the intricate biological causes of this condition, and a more comprehensive understanding of these mechanisms is anticipated to improve both the treatment and the outlook for patients suffering from heart failure.

This study has some limitations. First, our bibliometric analysis relies solely on articles from the WoSCC, which might exclude relevant studies from alternative databases or those published in non-SCI journals, potentially leading to a non-inclusive representation of existing literature. Additionally, our review was confined to articles published from 2013 to 2022, which may neglect prior research works. Furthermore, the quality of individual studies could not be evaluated in bibliometric analyze, as citation counts are influenced by time, often disadvantaging newer publications due to their more recent publication dates. These limitations might slightly affect our findings, but are unlikely to substantially modify the main trends depicted. Despite these limitations, this study stands as the first bibliometric analysis to delineate the current landscape and evolving directions in research on cognitive impairment in heart failure patients.

5. Conclusions

This study provides an in-depth bibliometric analysis of cognitive impairment in patients with heart failure, revealing the global research landscape, international collaboration, publication trends, research hotspots, and emerging frontiers. The global output of publications maintains a balanced growth, highlighting the active engagement in this field. The analysis recognizes leading researchers and institutions globally, with the United States standing out as a major contributor, Kent State University in the USA leading in publication numbers, and Gunstad John as the most notable author. The investigation has focused on risk factors, interventions, evaluations, and the underlying mechanisms of cognitive impairment in those with heart failure. Despite these insights, gaps remain, particularly in understanding the optimal interventions and exact mechanisms of cognitive impairment in heart failure, necessitating further investigations. Nevertheless, this research sheds light on the current landscape of research into heart failure-related cognitive impairment, providing a solid groundwork for further academic exploration.

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Ethics declarations

This study was reviewed and approved by the Institutional Ethics Committee of Wuxi People's Hospital, with the approval number: No. (2023)136. Informed consent was not required because the study purely analyzed publicly available data, without involving human subjects or accessing personally identifiable information.

Data availability statement

The data for this study comes from the publicly accessible Web of Science database and is not confidential. Researchers can replicate this study following the detailed methodology outlined in this article. Further inquiries can be directed to the corresponding author.

CRedit authorship contribution statement

Qing Zhao: Writing – review & editing, Writing – original draft, Software, Methodology, Funding acquisition, Conceptualization. **Xuefen Zhu:** Project administration, Methodology, Formal analysis, Conceptualization. **Xia Wan:** Software, Project administration, Formal analysis, Conceptualization. **Jun Wu:** Software, Methodology, Formal analysis. **Fei Shen:** Software, Methodology, Formal analysis. **Fengli Bian:** Software, Methodology, Formal analysis. **Fang Yang:** Writing – review & editing, Supervision. **Xiaodong Cao:** Writing – review & editing, Supervision.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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