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Global research trends and hotspots in CT-guided percutaneous transthoracic needle biopsy: a bibliometric analysis

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Abstract

Background: CT-guided percutaneous transthoracic needle biopsy (PTNB) is a critical diagnostic procedure for pulmonary lesions. This study aimed to map the global research landscape, collaborative patterns, and evolving hotspots in this field using bibliometric analysis.

Methods: Publications on CT-guided PTNB from 2010 to 2026 were retrieved from the Web of Science Core Collection. CiteSpace 6.4.R1 was used to perform co-authorship, co-institution, co-country, co-citation, keyword co-occurrence, clustering, and citation burst analyses.

Results: A total of 804 publications were included. Annual output showed a fluctuating upward trend with a peak in 2024. China produced the most publications, while Germany and the USA acted as key collaborative bridges. Seoul National University was the most productive institution. Four major research hotspots were identified: diagnostic accuracy and technical optimization, complication management (pneumothorax and pulmonary hemorrhage), advanced navigation and ablation techniques, and molecular profiling for precision oncology. Keyword bursts revealed an evolutionary shift from early hardware-focused studies toward safety-oriented and theranostic approaches.

Conclusion: This study provides a comprehensive visualization of the field, offering researchers and clinicians a clear roadmap of past achievements and future directions.

1. Introduction

Lung cancer remains the leading cause of cancer-related mortality worldwide, with an estimated 2.2 million new cases and 1.8 million deaths annually [1]. Early and accurate diagnosis of pulmonary lesions is essential for guiding appropriate management, particularly as screening programs increase the detection of small and ground-glass opacity nodules [2]. Among the available tissue acquisition techniques, computed tomography (CT)-guided percutaneous transthoracic needle biopsy (PTNB) has become a cornerstone procedure, offering high diagnostic yield with relatively low invasiveness for both peripheral and central lung lesions [3]. Over the past decade, technological refinements such as cone-beam CT, electromagnetic navigation, and robotic-assisted systems have further expanded the capabilities and safety profile of PTNB [4].

Despite its widespread clinical use, several challenges persist. The procedure carries a non-negligible risk of complications, most notably pneumothorax and pulmonary hemorrhage, which continue to drive research into risk prediction and mitigation strategies [5]. Moreover, the growing demand for molecular profiling—driven by targeted therapy and immunotherapy—has placed new emphasis on obtaining adequate tissue quantity and quality, influencing the choice between fine-needle aspiration and core needle biopsy [6]. Consequently, the scientific literature on CT-guided PTNB has expanded rapidly, creating a need for systematic synthesis of publication trends, collaboration patterns, and thematic evolution.

Bibliometric analysis offers a powerful approach to map the intellectual landscape of a research field objectively. By quantifying co-authorship, co-citation, keyword co-occurrence, and citation bursts, it can identify influential works, collaborative networks, and emerging hotspots [7]. CiteSpace, a widely used visualization tool, integrates these metrics into intuitive knowledge maps, facilitating the detection of paradigm shifts and research frontiers [8]. Several bibliometric studies have been conducted in lung cancer diagnostics, but a comprehensive bibliometric analysis specifically focusing on CT-guided PTNB is still lacking.

Therefore, this study aimed to: (1) analyze the global publication output and collaborative patterns among countries, institutions, and authors; (2) identify the intellectual foundation through co-cited reference analysis; (3) delineate research hotspots and evolutionary trends using keyword co-occurrence, clustering, and citation burst detection; and (4) provide a visualized overview of the development trajectory of CT-guided PTNB over the past 16 years. The findings are expected to assist researchers and clinicians in understanding the current state and future directions of this essential diagnostic procedure.

2. Data and methods

2.1Data sources

The Web of Science (WoS) is widely recognized as the most authoritative and comprehensive multidisciplinary bibliographic database, providing high-quality, curated records essential for rigorous bibliometric analysis. For this study, the Web of Science Core Collection (WoSCC) was selected as the primary data source. The search strategy employed the following topic-based query: TS=((CT OR “computed tomography” OR “computerized tomography”) AND (guid OR “guided” OR “guidance”) AND (“percutaneous” OR “transthoracic”) AND (puncture OR “needle puncture” OR aspiration OR “fine needle aspiration” OR FNA OR “core needle” OR “needle biopsy” OR “biopsy”) AND (lung OR pulmonary)). The search timeframe spanned from January 1, 2010 to May 13, 2026.

2.2Inclusion and exclusion criteria

Studies were considered eligible if they met the following criteria: original research articles or systematic reviews. The exclusion criteria were defined as follows: (1) meeting abstracts, editorials, letters, case reports, or conference proceedings; (2) studies not directly related to CT-guided percutaneous transthoracic needle biopsy (e.g., bronchoscopic biopsy, surgical biopsy without CT guidance, or biopsy of other organs); (3) duplicate publications.

To ensure the rigor and reproducibility of the literature selection process, two independent researchers conducted the initial screening by reviewing titles and abstracts. Any disagreements were resolved through discussion or by consulting a third arbitrator when consensus could not be reached. A total of 1273 records were initially retrieved from the Web of Science Core Collection. After applying the above

inclusion and exclusion criteria, 804 publications were finally included for subsequent bibliometric analysis(Fig. 1).

2.3Bibliometric and bibliometric analysis

The search results retrieved from the Web of Science Core Collection were exported in plain text format to facilitate subsequent computational analysis. All bibliometric analyses and knowledge mapping were performed using CiteSpace (version 6.4.R1), a widely adopted software tool for visualizing and analyzing scientific literature. The time slicing parameter was set to one year to capture temporal dynamics, and the threshold was configured as the Top 50 most cited or occurring items per slice to ensure the inclusion of the most influential nodes. The following analytical functions were conducted to comprehensively explore the research landscape: co-authorship analysis (including authors and institutions), co-country analysis, co-cited reference analysis, co-citation network of keywords, keyword network and clustering, and keyword citation burst detection. Based on these analyses, corresponding knowledge maps were generated to visualize the intellectual structure, collaborative patterns, disciplinary clusters, and evolving research hotspots within the domain of CT-guided percutaneous transthoracic needle biopsy.

3. Results

3.1Distribution of Articles by Publication Years

From 2010 to 2019, the annual publication output exhibited a generally fluctuating yet upward trend, indicating growing research interest in CT-guided percutaneous transthoracic needle biopsy(Fig. 2). A temporary decline occurred in 2020, followed by a swift rebound and a notable peak in 2021. After a moderate decrease over the next two years, output surged again in 2024, reaching a relatively high level. Although minor fluctuations have emerged recently, the overall trajectory reflects sustained research activity and evolving attention in this field.

3.2Co-Authorship, Co-Institution, and Co-Country

A co-occurrence network analysis of authors was generated (Fig. 3). The collaboration network comprises 1,657 nodes and 3,328 edges, with a network density of 0.0024, indicating a relatively sparse but structured collaboration pattern. Among the most productive authors, Park Chang Min (19 publications) and Goo Jin Mo (18 publications) serve as central figures, exhibiting high betweenness centrality and connecting multiple research groups. Other prolific contributors include Yoon Soon Ho (14 publications), Han Dae Hee, Hur Jin, Carrafiello Gianpaolo, and Lee Sang Min. Geographically, the network is predominantly led by Korean researchers, notably from Seoul National University. This pattern reflects a moderate level of global scientific cooperation, with Korean institutions acting as the primary hubs driving collaborative research in this field.

A co-occurrence network analysis of institutions was generated (Fig. 4). The collaboration network comprises 1,027 nodes and 2,521 connections, with a density of 0.0048, indicating a moderately connected inter-institutional landscape. Seoul National University emerges as the most prolific institution (25 publications), exhibiting high centrality (0.05) and serving as a key hub, closely followed by Seoul National University Hospital and Catholic University of Korea, collectively forming the dominant Korean cluster. Chinese institutions demonstrate substantial research activity and extensive collaboration: Fudan University, Shanghai Jiao Tong University, and Capital Medical University show high centrality (0.07, 0.05, and 0.06 respectively), indicating their pivotal bridging roles. Other active contributors include Zhejiang University, Huazhong University of Science and Technology, Sichuan University, and Fujian Medical University. Internationally, Massachusetts General Hospital (13 publications, centrality 0.05) and Mayo Clinic represent significant Western participation. Overall, the network reflects strong regional concentration in East Asia, particularly Korea and China, with moderate transcontinental cooperation.

Based on the co-country analysis, the international collaboration network comprises 48 nodes and 56 edges, with a density of 0.0496, indicating a moderately interconnected global research landscape (Fig. 5). China ranks first in publication volume (310), followed by the USA (136) and South Korea (81) (Table 1). In terms of centrality, Germany exhibits the highest value (0.44), serving as the most influential bridge connecting different regional clusters, followed by Canada (0.40) and the USA (0.29). In contrast, despite its large output, China has a relatively low centrality (0.06), suggesting its collaborations are more bilateral or clustered. Overall, European and North American countries demonstrate stronger bridging functions, while East Asian countries dominate in productivity, indicating a complementary pattern between research activity and collaborative connectivity.

Table 1
Top 10 countries by publication volume from 2010 to 2026

Rank	Publication Volume	Centrality	Country
1	310	0.06	PEOPLES R CHINA
2	136	0.29	USA
3	81	0.06	SOUTH KOREA
4	65	0.12	ITALY
5	42	0.15	JAPAN
6	41	0.44	GERMANY
7	31	0.06	TURKEY
8	25	0.06	FRANCE
9	19	0.4	CANADA
10	17	0	NETHERLANDS

3.3Co-cited references analysis

Co-cited reference analysis identifies references that are frequently cited together by subsequent publications, thereby revealing the intellectual structure and knowledge base of a research field. Highly co-cited works typically represent foundational studies, key methodologies, or landmark discoveries that collectively shape the evolution of a discipline.

A co-occurrence network analysis of references was generated (Fig. 6). A total of 692 nodes and 2,084 links were generated, with a network density of 0.0087. The largest connected component comprised 652 nodes (94%), indicating a highly integrated intellectual structure. .

Table 2 summarizes the top five co-cited references, which collectively constitute the core knowledge base of this field. The most frequently cited work is Heerink et al. (2017) (n = 99), a landmark meta-analysis on complication rates of CT-guided transthoracic lung biopsy, published in European Radiology. Lee et al. [9](n = 50) follows, reporting a large-scale clinical experience of 1,108 patients using C-arm cone-beam CT guidance for lung nodule biopsy, appearing in Radiology. Huo et al. [10] (n = 41) provides a systematic review and meta-analysis specifically focusing on pneumothorax risk factors, published in British Journal of Radiology. Tai et al. [11](n = 30) examines the frequency and severity of pulmonary hemorrhage based on 1,175 cases, also in Radiology, while Choo et al.[12] (2013) (n = 30) addresses technical success in small (< 1 cm) lung nodules under virtual navigation guidance, published in European Radiology. Notably, Radiology and European Radiology are the dominant journals among the top five, highlighting their leading role in disseminating high-impact evidence on procedural safety and technical innovation. Together, these highly cited references highlight the pivotal research themes of diagnostic accuracy, complication profiling (pneumothorax and hemorrhage), technical optimization, and evidence synthesis, thereby shaping the evolutionary trajectory of CT-guided percutaneous transthoracic needle biopsy research.

Table 2
co-cited references by publication volume from 2010 to 2026

Publication year	First author	Title	Journal	Co-Citations	Centrality
2017	Heerink WJ[5]	Complication rates of CT-guided transthoracic lung biopsy: meta-analysis	EUR RADIOL	99	0.01
2014	Lee SM[9]	C-arm cone-beam CT-guided percutaneous transthoracic needle biopsy of lung nodules: clinical experience in 1108 patients	RADIOLOGY	50	0.03
2020	Huo YR[10]	Pneumothorax rates in CT-Guided lung biopsies: a comprehensive systematic review and meta-analysis of risk factors	BRIT J RADIOL	41	0.01
2016	Tai R[11]	Frequency and Severity of Pulmonary Hemorrhage in Patients Undergoing Percutaneous CT-guided Transthoracic Lung Biopsy: Single-Institution Experience of 1175 Cases	RADIOLOGY	30	0.03
2013	Choo JY[12]	Percutaneous transthoracic needle biopsy of small (≤ 1 cm) lung nodules under C-arm cone-beam CT virtual navigation guidance	EUR RADIOL	30	0.02

3.4Co-citation network of keywords

Keyword co-occurrence analysis reveals the thematic structure and evolving research hotspots by examining the frequency and association patterns of terms within publications. This method assumes that keywords frequently appearing together reflect underlying conceptual relationships, thereby mapping the intellectual landscape of a research field. The analysis generated a network of 415 nodes and 597 links (Fig. 7)., with the largest connected component comprising 393 nodes (94%), indicating a highly integrated thematic landscape. Table 3 lists the top ten high-frequency and high-centrality keywords. Among high-frequency terms, percutaneous lung biopsy (349), lung cancer (306), and pulmonary lesions (296) dominated the literature. In terms of centrality, ground glass opacity exhibited the highest value (0.43), followed by biopsy (0.33) and guidance (0.28), indicating their bridging roles across different research subtopics. Notably, pneumothorax appeared in both frequency and centrality rankings (179, centrality 0.20), underscoring its dual importance as a common complication and a connecting node.

Table 3
Top 10 keywords in terms of frequency and centrality

Rank	Frequency	Keywords	Centrality	Keywords
1	349	percutaneous lung biopsy	0.43	ground glass opacity
2	306	lung cancer	0.33	biopsy
3	296	pulmonary lesions	0.28	guidance
4	277	pulmonary nodules	0.26	classification
5	275	diagnostic accuracy	0.24	fluoroscopy
6	230	computed tomography	0.21	ct-guided biopsy
7	220	fine needle aspiration	0.21	carcinoma
8	218	risk factors	0.21	transthoracic needle aspiration
9	179	pneumothorax	0.2	pneumothorax
10	162	needle biopsy	0.2	core needle biopsy

3.4.1Keyword network and clustering

Based on the keyword co-occurrence network, a clustering analysis was performed using the latent semantic indexing (LSI) algorithm (Fig. 8). The top ten clusters are presented in Table 4. All clusters exhibited silhouette values above 0.9 (ranging from 0.911 to 0.984), indicating highly reliable and internally consistent clustering. The major clusters included #0 lung cancer, #1 ct-guided percutaneous transthoracic needle biopsy, #2 pulmonary nodule, #3 computed tomography, #4 ct-guided biopsy, #5 accuracy, #6 microwave ablation, #7 lung nodules, #8 lung biopsy, and #9 non-small cell lung cancer.

Table 4
The largest 10 clusters of keywords

Cluster ID	Size	Silhouette	Mean (Year)	Label (LSI)
0	38	0.922	2016	ct-guided percutaneous transthoracic needle biopsy
1	33	0.939	2015	lung cancer
2	32	0.957	2016	pulmonary nodule
3	29	0.96	2015	computed tomography
4	28	0.97	2017	ct-guided biopsy
5	26	0.936	2019	accuracy
6	24	0.911	2016	microwave ablation
7	24	0.96	2017	lung nodules
8	23	0.928	2017	lung biopsy
9	23	0.984	2016	non-small cell lung cancer

3.4.2Keyword citation burst

Citation burst analysis detects keywords that have experienced a significant surge of citations within a specific period, thereby reflecting emerging or declining research interests. Figure 9 presents the top 25 keywords with the strongest citation bursts from 2010 to 2026. Early bursts (2010–2013) were dominated by technical terms such as coaxial technique (strength 6.41), automated biopsy (4.83), and cutting needle (4.05), indicating an initial focus on biopsy hardware and procedural optimization. From 2012 to 2017, bursts of guided biopsy (3.11) and variables (3.86) suggested a shift toward methodological refinement and risk factor identification. A transient burst of cone beam CT (2.94) occurred in 2018–2019, highlighting the brief but intense interest in advanced imaging guidance. Starting in 2021, a new wave of bursts emerged and continues to the end of the study period (2026), including radiofrequency ablation (5.22), interventional radiology (3.21), society (3.96), safety (3.94), time (3.87), pulmonary hemorrhage (6.40), localization (4.05), pulmonary nodule (3.33), and electromagnetic navigation bronchoscopy (3.33). The strongest ongoing burst is pulmonary hemorrhage (6.40, 2024–2026), reflecting a recent surge in research on this serious complication. Overall, the burst pattern reveals a historical evolution from early technique-centric investigations to contemporary concerns with ablation therapies, navigation systems, complication management, and clinical safety.

4. Discussion

4.1Current status of research on CT-guided percutaneous transthoracic needle biopsy

The annual publication output has demonstrated a sustained upward trajectory over the study period, with a marked resurgence following a temporary decline around 2020, reflecting continuous clinical and academic interest. Internationally, a complementary pattern of collaboration has emerged: East Asian countries, particularly China and South Korea, dominate in publication volume, while Germany and the United States serve as central bridging nodes that facilitate cross-regional cooperation. Korean institutions, especially Seoul National University, act as the primary collaborative hubs, highlighting their leading role in advancing the field. Thematic analysis of the literature reveals that research has concentrated on several core domains, including diagnostic accuracy, complication management (notably pneumothorax and pulmonary hemorrhage), procedural optimization, and technical innovations such as microwave ablation. Keyword burst detection shows an evolutionary shift from early emphasis on biopsy hardware and basic techniques toward contemporary hotspots that include navigation-assisted biopsy, ablation therapies, and safety outcomes. Collectively, these findings indicate that the field is transitioning from a purely diagnostic procedure toward a comprehensive, safety-oriented, and technology-driven practice that integrates advanced imaging guidance and minimally invasive therapeutic strategies.

4.2. Research hotspots for CT-guided percutaneous transthoracic needle biopsy

Based on the keyword co-occurrence, clustering, and citation burst analyses, four main research hotspots have been identified: diagnostic accuracy and technical optimization, complication prevention (especially pneumothorax and pulmonary hemorrhage), advanced navigation and ablation techniques, and molecular profiling for precision oncology.

Diagnostic accuracy and technical optimization remain fundamental. In our keyword co-occurrence analysis, high-frequency terms such as “percutaneous lung biopsy”, “diagnostic accuracy”, and “pulmonary nodules” dominated the literature, underscoring the continued pursuit of reliable tissue diagnosis, particularly for small or ground-glass lesions. Notably, “ground glass opacity” exhibited the highest centrality, indicating its bridging role in connecting nodule characterization, biopsy planning, and diagnostic yield. Consistent with this finding, recent studies have refined biopsy techniques to improve yield for challenging nodules. A randomized controlled trial by Liu et al. compared CT-guided percutaneous lung biopsy with electromagnetic navigation against conventional approaches, demonstrating that the navigation system significantly reduced the median number of needle repositioning attempts required to obtain a diagnostic sample [13]. A prospective multicenter observational study by Chao et al. further validated that CT-guided percutaneous biopsy achieves high diagnostic accuracy for pulmonary nodules, confirming the robustness of this technique across different clinical settings [14]. Additionally, a study by Huang et al. reported that combining an active breathing coordinator with a custom-designed puncture needle guide significantly improves diagnostic accuracy

for smaller pulmonary nodules, particularly for those located in the lower lung lobe or requiring a non-zero puncture angle, directly addressing the challenge of small-nodule biopsy [15].

Complication management, especially pneumothorax and pulmonary hemorrhage, represents a persistent hotspot. In our analysis, “pneumothorax” appeared as both a high-frequency keyword and a high-centrality node, reflecting its central role in clinical practice and its function as a conceptual hub linking pre-procedural assessment, procedural technique, and post-biopsy care. Additionally, “pulmonary hemorrhage” exhibited a strong ongoing citation burst, highlighting recent intensified research interest in this serious complication. In line with these bibliometric findings, recent research has focused on risk stratification and preventive strategies. A prospective randomized trial by Maybody et al. demonstrated that autologous blood patch injection is noninferior to a hydrogel plug regarding the rate of pneumothorax after CT-guided percutaneous lung biopsy [16]. Furthermore, recent risk prediction models have been developed to identify high-risk patients. Bondarenko et al. developed and externally validated a risk nomogram for pneumothorax requiring chest tube placement, identifying age over 60, non-prone patient position, and severe emphysema as the most predictive factors [17]. Wang et al. quantified the lesion depth-to-diameter ratio, multiple passes through the pleura, longer needle tract length, and smaller lesions as independent risk factors for pneumothorax, providing actionable intra-procedural guidance [18]. For pulmonary hemorrhage, Lin et al. integrated clinical parameters with quantitative pulmonary vascular analysis to establish a nomogram prediction model, identifying lesion depth, vessel density, and BV5 as independent risk factors for higher-grade hemorrhage [19]. An observational study by He et al. reported that a mean pulmonary artery diameter larger than a certain threshold and a smaller nodule size are independent risk factors for high-grade hemorrhage, further refining risk stratification [20].

Advanced navigation and image-guided ablation techniques are emerging as transformative hotspots. Our citation burst analysis revealed strong ongoing bursts for “electromagnetic navigation bronchoscopy”, “localization”, and “cone beam CT”, indicating a clear shift from purely diagnostic procedures toward integrated interventional platforms. Moreover, clusters related to “microwave ablation” and persistent bursts for “radiofrequency ablation” reflect growing research interest in percutaneous thermal ablation as a therapeutic alternative for early-stage lung cancer. Consistent with these bibliometric patterns, a meta-analysis by Liu et al. compared the effectiveness and safety of RFA and MWA for lung cancer and metastases, concluding that while RFA appears to be more effective in terms of survival, both modalities show comparable safety profiles [21]. A study by Cui et al. further demonstrated that ablation therapy is safe and effective for stage I non-small cell lung cancer patients, with MWA and RFA showing comparable efficacy, safety, and prognosis, which could be recommended for patients who cannot tolerate open surgery [22]. For navigation technologies, a prospective single-center study by Li et al. evaluated an electromagnetic navigation system for CT-guided synchronous percutaneous lung biopsy and microwave ablation of pulmonary nodules, achieving high technical success rates and confirming the feasibility of one-stop diagnostic-therapeutic procedures [23]. These findings support the expanding role of percutaneous ablation as a therapeutic option, often performed in

the same setting as diagnostic biopsy, and align with the temporal evolution from early technique-centric investigations toward ablation-focused research.

Finally, molecular profiling has reshaped biopsy practice, moving beyond pure diagnosis toward precision oncology. Although not among the highest-frequency keywords, terms such as “non-small cell lung cancer”, “biomarker testing”, and “EGFR” are prominent in relevant clusters, reflecting the strong integration of genomic medicine into the biopsy research landscape. Additionally, the high centrality of “classification” and “guidance” in our network underscores the importance of precise histological subtyping and biomarker-guided decision-making. The demand for adequate tissue for next-generation sequencing has elevated the role of core needle biopsy over fine-needle aspiration. Ding et al. analyzed root causes of inadequate NGS sampling in non-small cell lung cancer and proposed solutions to optimize tissue yield, recommending specific approaches for small biopsies and fine-needle aspirations to enable timely therapy initiation and reduce repeat biopsies [24]. A study by Sato et al. demonstrated that percutaneous needle biopsy is a useful and safe method for performing multiplex gene testing via NGS in patients with thoracic cancer, achieving reasonable adequacy for extended genomic profiling [6]. Given the global lung cancer burden, as highlighted by Sung et al., these hotspots illustrate that CT-guided percutaneous transthoracic needle biopsy has transitioned from a purely diagnostic tool into an integral component of precision thoracic oncology, fully consistent with the evolutionary shift captured by our citation burst analysis [1].

4.3. Strengths and limitations

This study provides a comprehensive bibliometric overview of CT-guided percutaneous transthoracic needle biopsy using CiteSpace, revealing global collaboration patterns, intellectual structure, and evolving research hotspots. However, several limitations exist. First, the analysis is limited to English-language publications in the Web of Science Core Collection (WoSCC), which may introduce language and database bias. Nevertheless, WoSCC offers extensive coverage and strong academic authority, making it the preferred source for bibliometric analysis. Second, citation-based metrics may not capture the very latest advances due to citation accumulation lags. Despite these limitations, the findings provide valuable insights for researchers and clinicians.

5. Conclusion

This bibliometric study provides a comprehensive visualization of the global research landscape on CT-guided percutaneous transthoracic needle biopsy from 2010 to 2026. The sustained growth in publications, especially the recent surge, reflects continued clinical interest. Internationally, East Asian countries dominate in output, while Germany and the United States act as key collaborative bridges. Korean institutions, particularly Seoul National University, serve as central research hubs. Four major hotspots were identified: diagnostic accuracy and technical optimization, complication management (pneumothorax and pulmonary hemorrhage), advanced navigation and ablation techniques, and molecular profiling for precision oncology. Keyword burst analysis reveals an evolutionary shift from

early hardware-focused studies toward safety-oriented, technology-driven, and theranostic approaches. This study offers researchers and clinicians a clear roadmap of past achievements and future directions in this essential diagnostic field.

Declarations

Conflict of interest

We declare that we have no financial and personal relationships with other people or organizations that can inappropriately influence our work, there is no professional or other personal interest of any nature or kind in any product, service and/or company.

Author Contribution

Ling Wang contributed to study design, data collection, data analysis, and manuscript writing. Liu Huang contributed to data collection and study supervision. Qiancong Wang, Caixia Liu contributed to manuscript revision. All authors read and approved the final version of the manuscript.

Data Availability

he datasets generated and/or analyzed during the current study are available from the corresponding author upon reasonable request.

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Figures

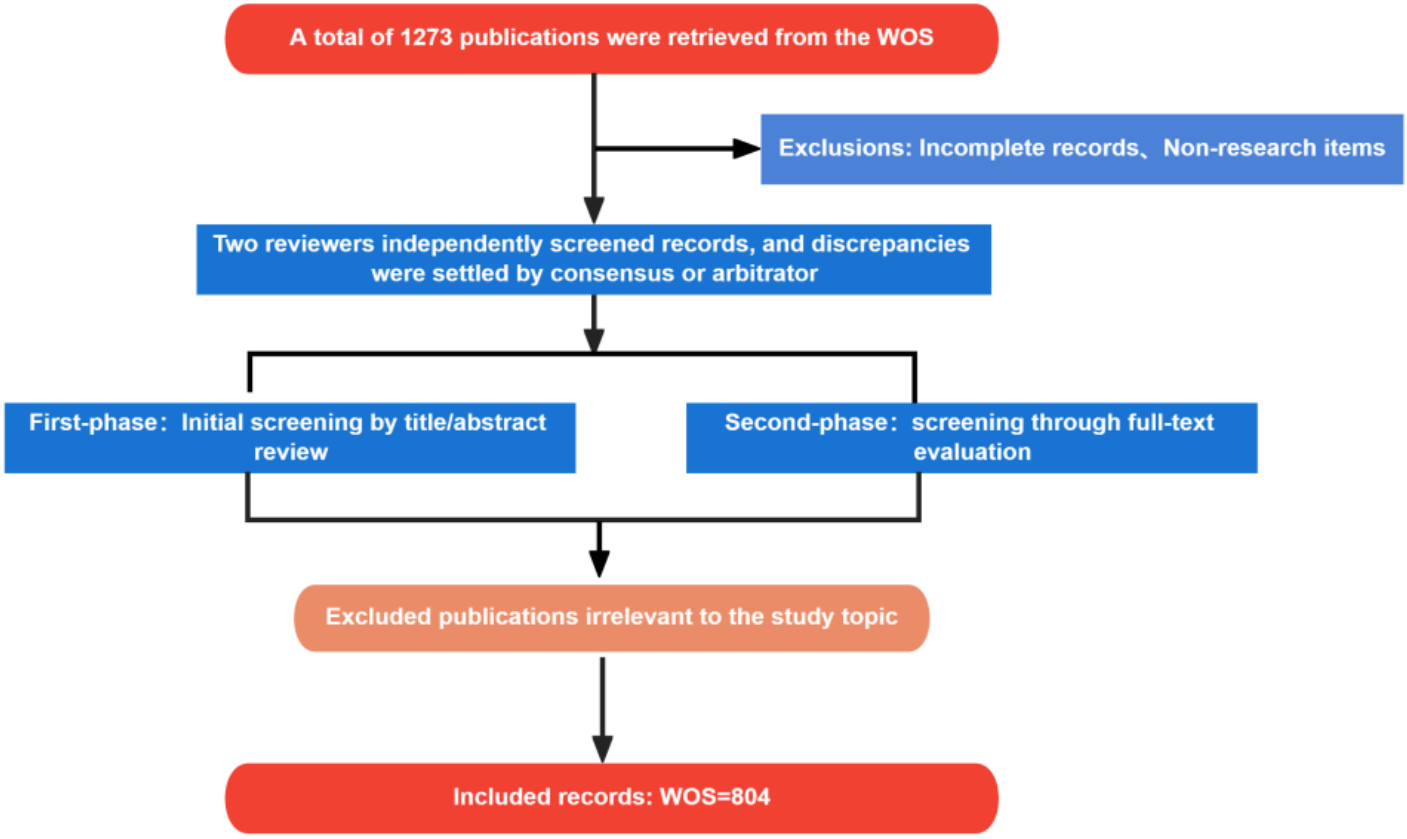


Figure 1

Literature screening and selection process flowchart

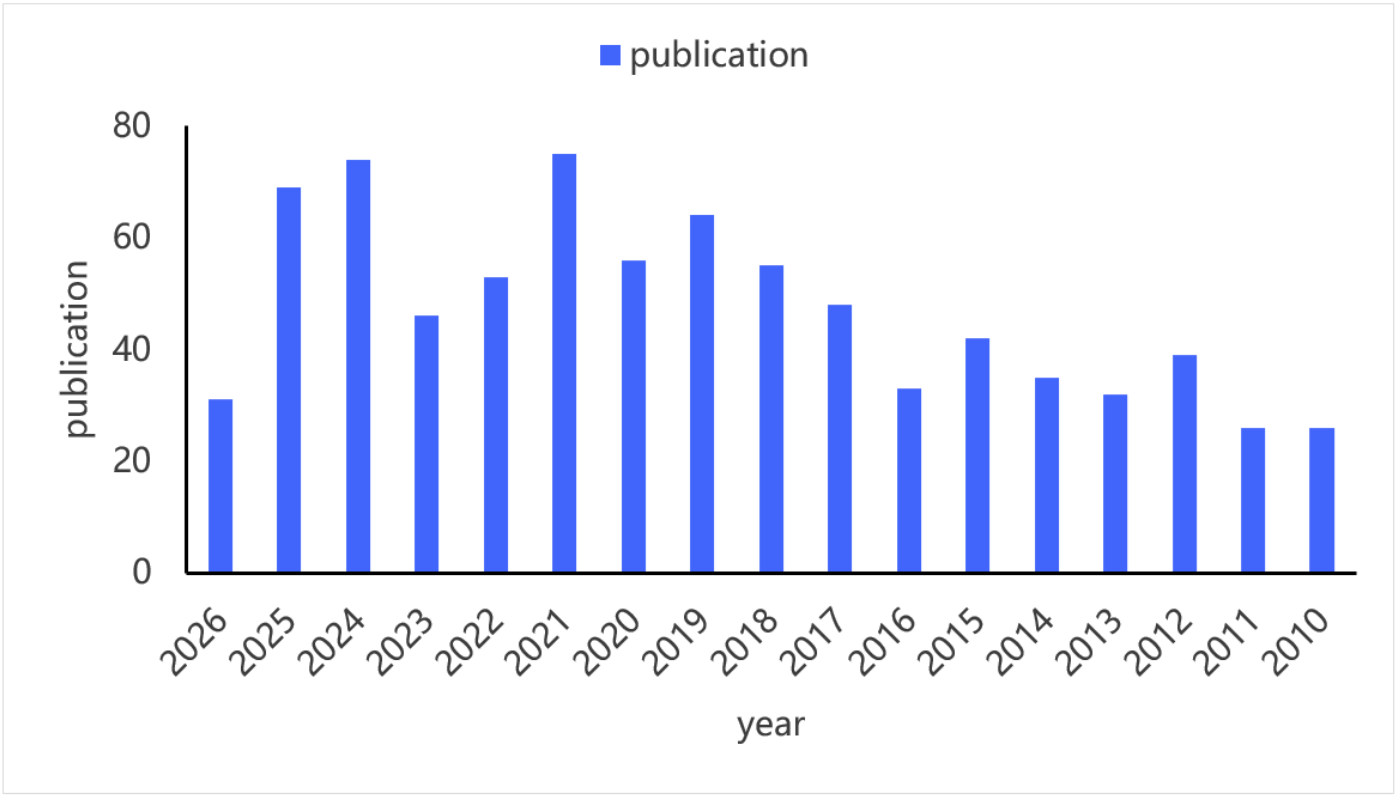


Figure 2

Annual trend chart of publications

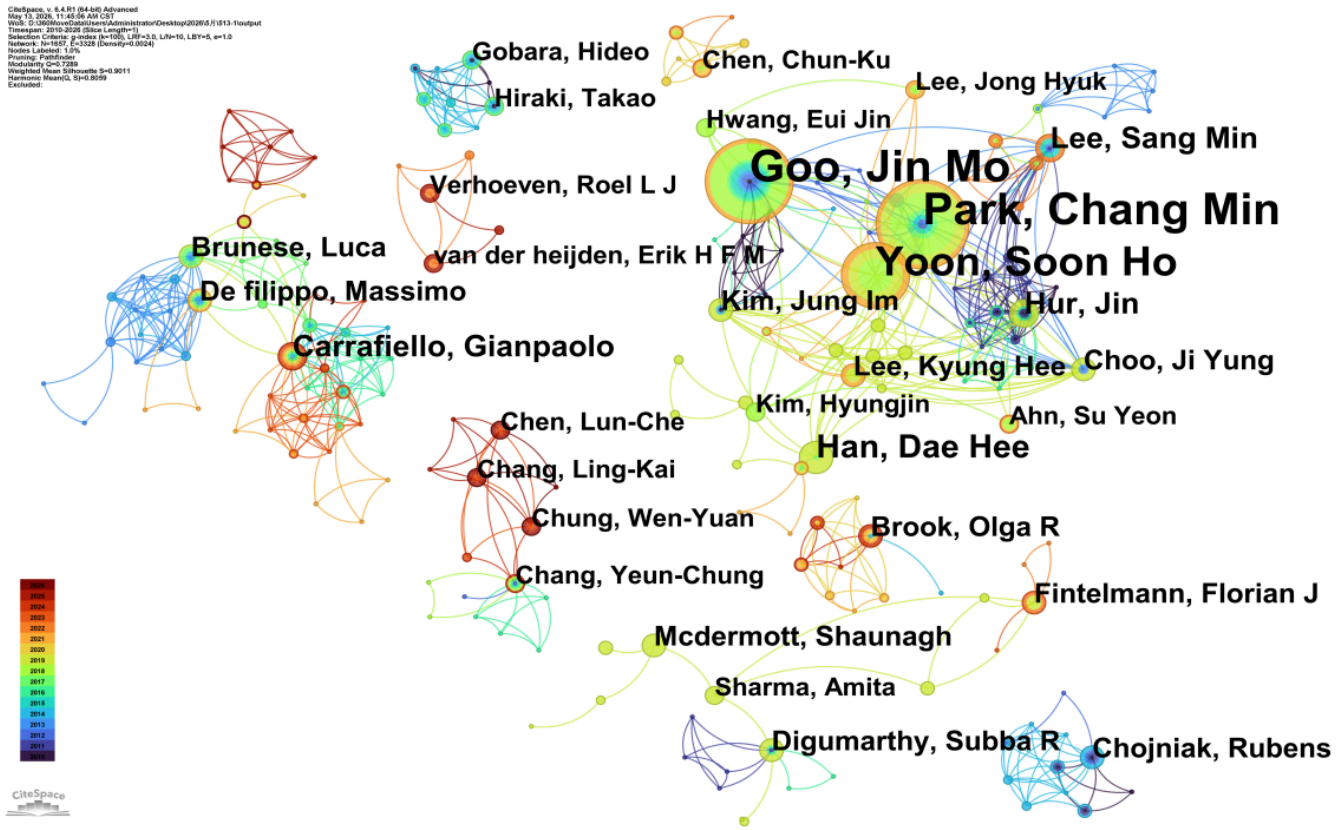


Figure 3

The network of co-authorship

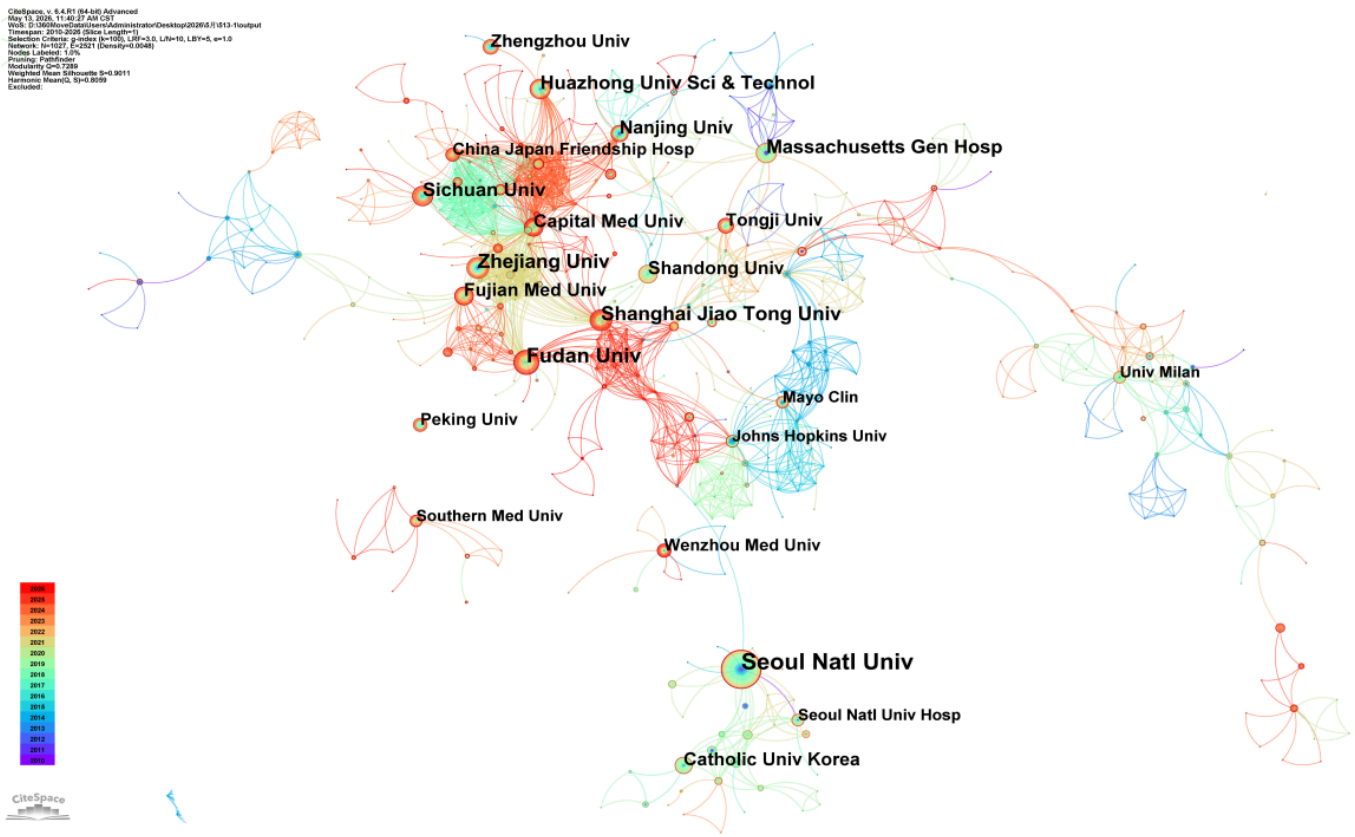


Figure 4

The network of co-institution.

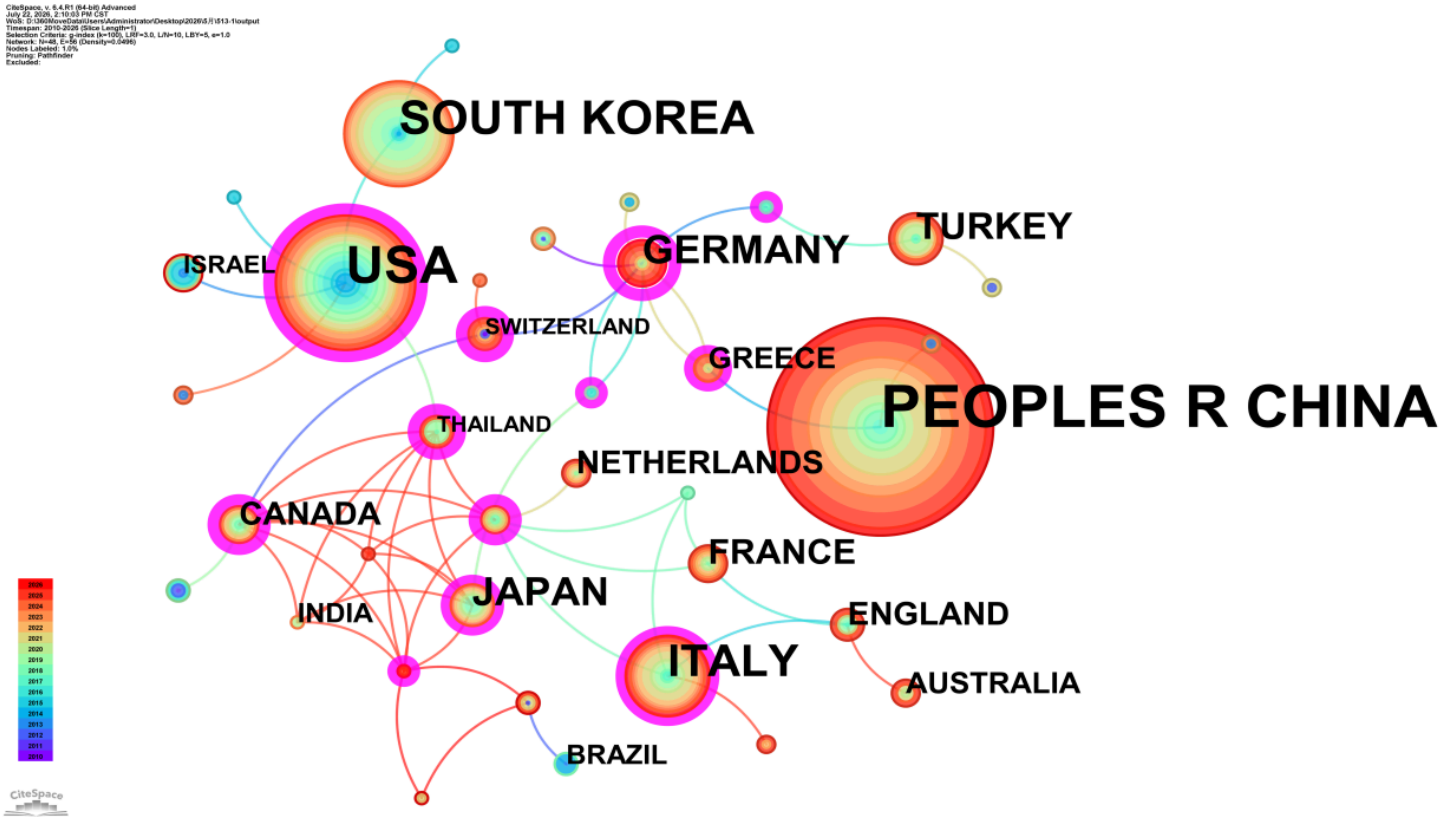


Figure 5

The network of co-country

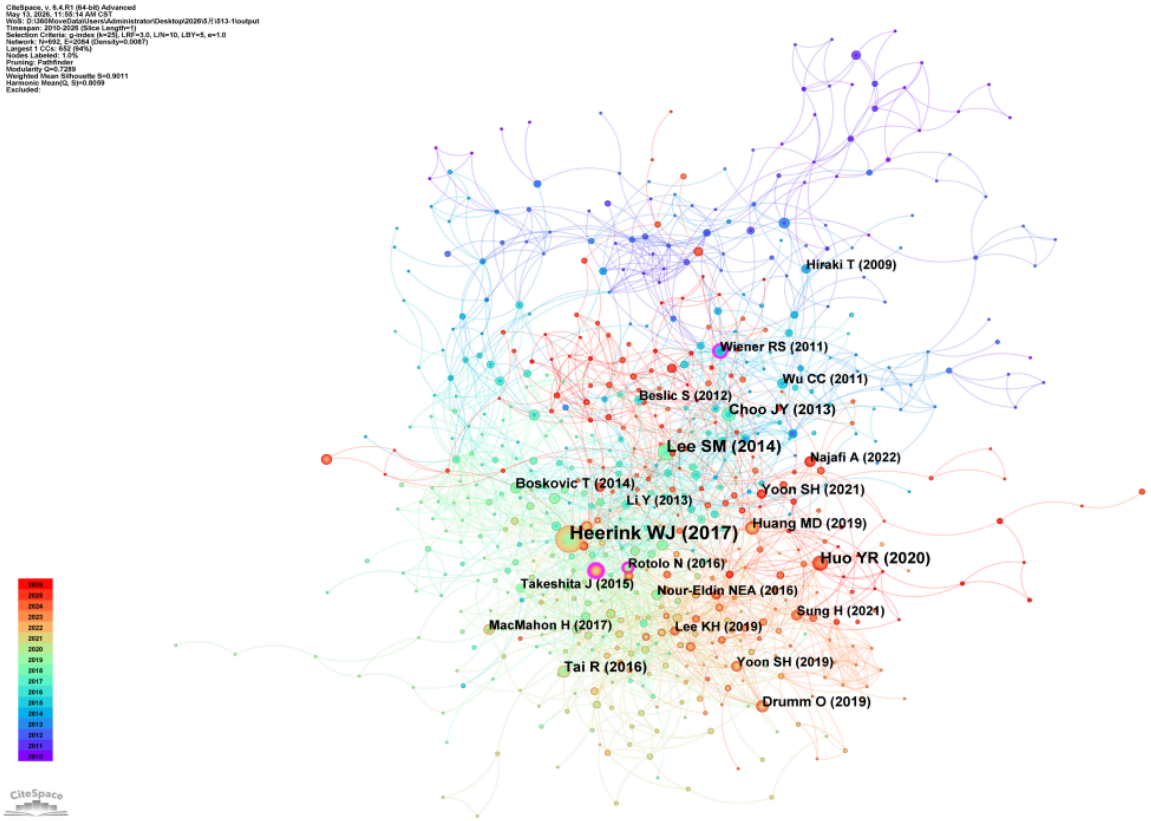


Figure 6

The network of co-cited references.

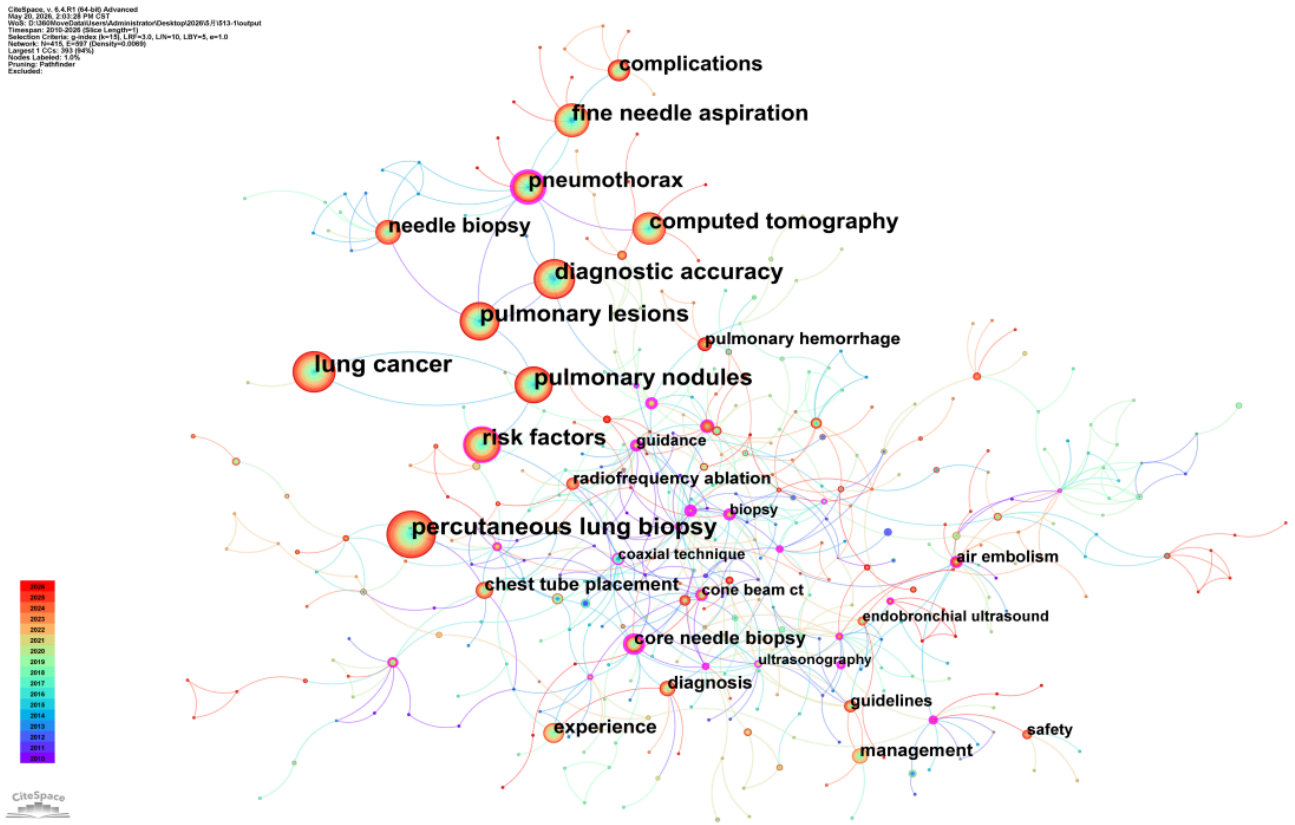


Figure 7

The network of co-occurring keywords

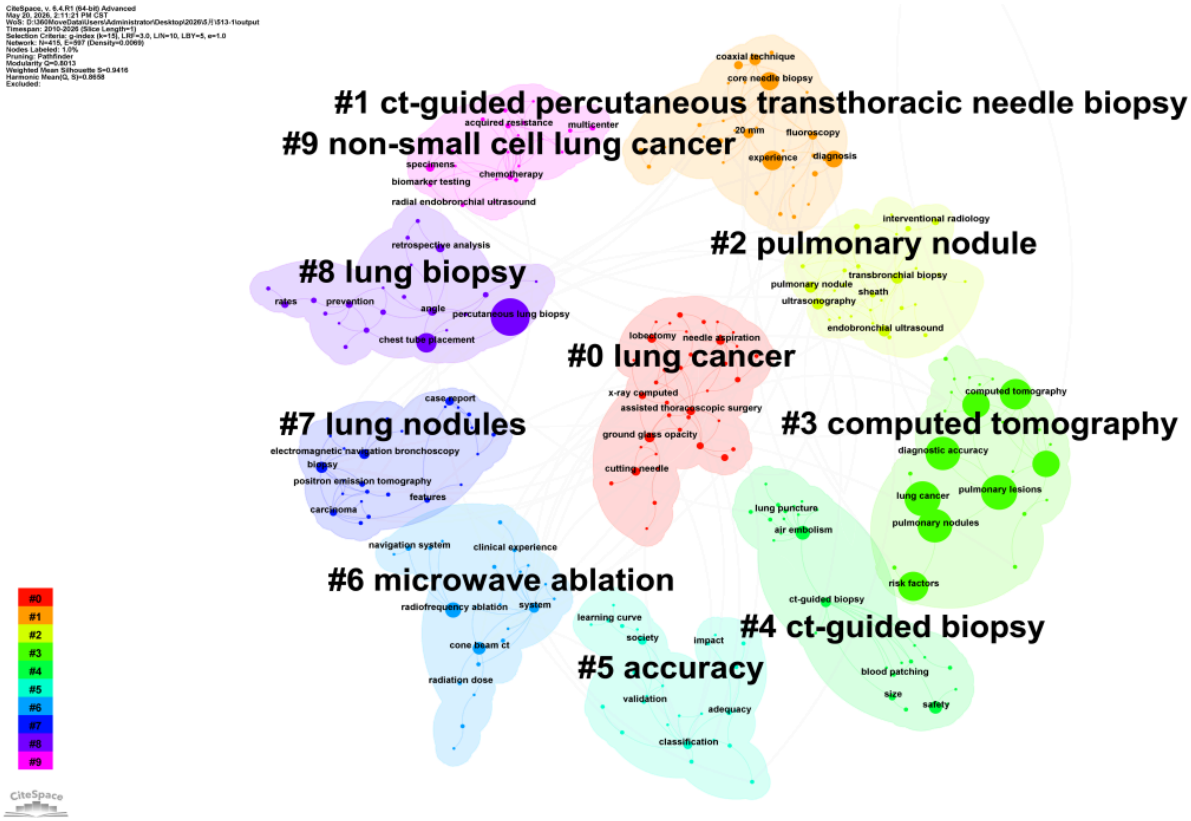


Figure 8

Keywords cluster analysis co-occurrence map

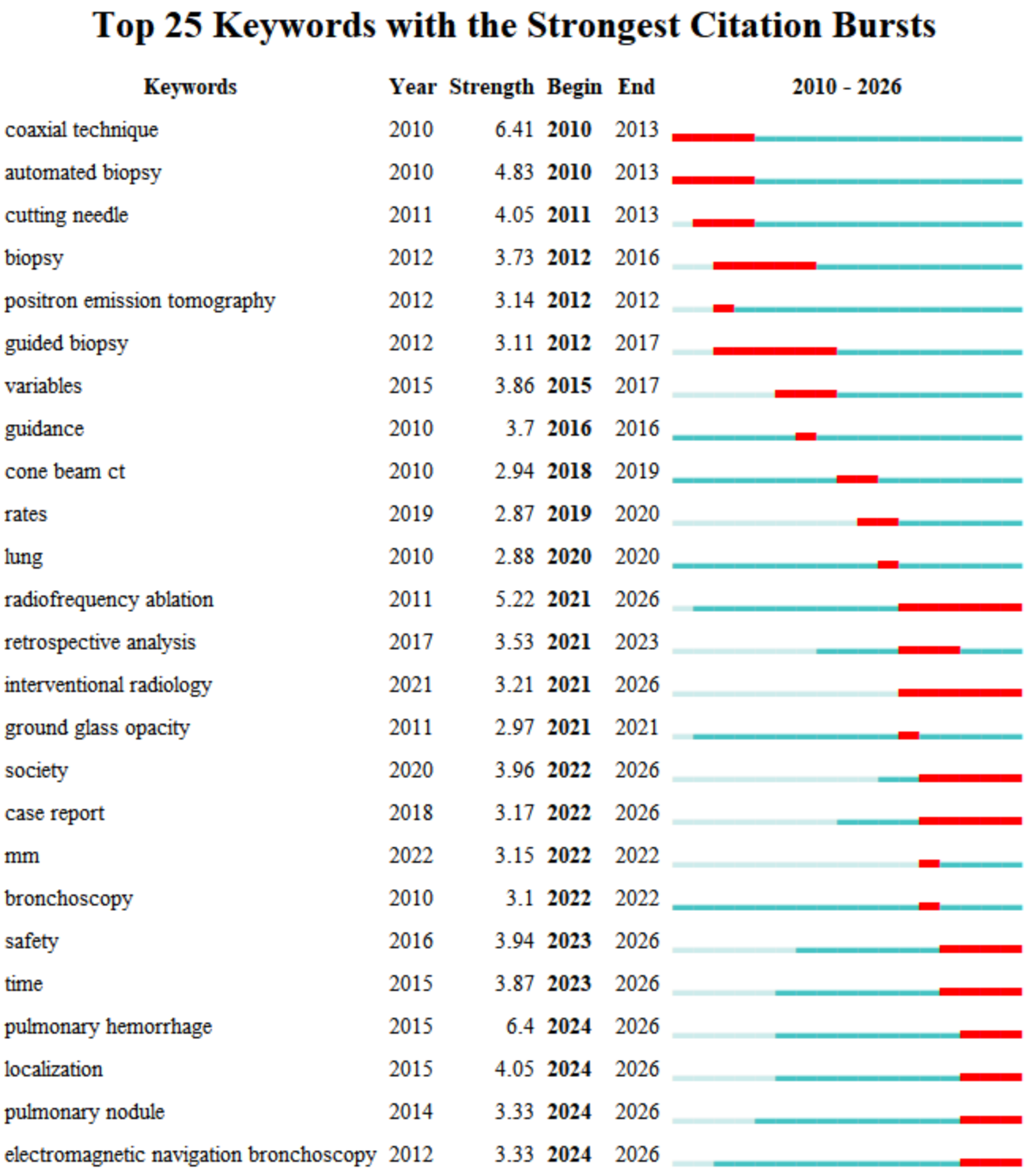


Figure 9

Top 25 keywords with strongest citation bursts.