

ORIGINAL ARTICLE

Unfolding the clinical research landscape on bacterial infections in cirrhosis: Trends, hotspots, and analytical insights

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ABSTRACT

Background: Bacterial infection is the most common complication among patients with cirrhosis. This study evaluated the research hotspots and trends of bacterial infections in cirrhosis through bibliometric analysis and provided guidance for future research on this topic. **Methods:** We extracted publications on bacterial infections associated with cirrhosis from the Web of Science Core Collection, covering the period from January 2000 to May 2025. CiteSpace and VOSviewer were used for bibliometric analysis. **Results:** Publications on bacterial infections in cirrhosis reflected an upward trend, with 69 countries or territories contributing to research, of which the United States ranked first, with 324 publications. The *Journal of Hepatology* was the prime publication on liver cirrhosis associated with bacterial infection, with Fernandez Javier being the most cited author. Cirrhosis with bacterial infection was the most popular research topic regarding mortality, infection, ascites, and sepsis. The research hotspots of the future are systemic inflammation, acute-on-chronic liver failure, and chronic liver failure. **Conclusion:** The hotspots and trends of related research were discussed, and the research results were presented objectively through knowledge maps. The research directions in this field were analyzed to provide a reference for subsequent clinical research.

Key words: cirrhosis, bacterial infections, bibliometric, data visualization

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INTRODUCTION

Cirrhosis of the liver is a major cause of death worldwide, and in many countries, it is one of the 10 most common causes of death.^[1-3] Bacterial infection is a common complication in patients with cirrhosis,^[4] whose susceptibility to infection may be related to humoral and cellular immune dysfunction due to liver dysfunction.^[5] In addition, portal hypertension aggravates intestinal ecological disturbances and bacterial translocation, and genetic factors are also determinants of the pathophysiology of infection in this population. For decades, epidemiological studies have observed these associations and confirmed that bacterial infection can lead to liver decompensation. Bacterial infection sets off a vicious cycle of repeated infection and progressive liver decompensation, with a mortality rate of more than 60% within 1 year without liver transplantation.^[6,7]

Thanks to researchers' efforts, substantial progress has been made in understanding the pathophysiological processes caused by infection in patients with cirrhosis. However, advances in research have not translated into significant survival benefits for the sickest patients requiring intensive care unit admission. Moreover, infections caused by multidrug-resistant pathogens are becoming more common, complicating the antibacterial management of inpatients with cirrhosis.^[8]

Bibliometrics analysis is used to obtain information and development trends in specific research fields and can help researchers identify the hotspots, trends, and frontiers in a particular field of study.^[9,10] This statistical technique is valued for its unique advantages and wide applications in various research fields. However, to the best of the authors' knowledge, no bibliometric study on bacterial infection in cirrhosis has yet been performed. This study utilizes a public database to collect and screen pertinent publications, and conducts a visual analysis of its global trends, research hotspots, and frontiers. We believe this study will provide a reference for future research.

MATERIALS AND METHODS

Study design and data sources

This study used a statistical bibliometric analysis method to analyze global research output on bacterial infections in cirrhosis. This method has been progressively used to monitor the research performance of various scientific disciplines and is an academic link closely related to scientific communication and basic theory. Commonly used medical databases are MEDLINE, Scopus, and Web of Science. The data in this study were retrieved on June 15, 2025, from the WoSCC database. To ensure that the data would not be updated, two researchers completed the data retrieval on the same day and

screened the results within a limited timeframe. Figure 1 shows the research strategy and detailed selection process. The search strategy was to set the topic to ("bacterial infection" or "bacteremia" or "hemorrhagic septicemia" or "bacterial meningitis" or "bacterial endocarditis" or "gram-negative" or "Bacteroidaceae" or "brucellosis" or "Burkholderia" or "Campylobacter" or "Enterobacteriaceae" or "Helicobacter" or "Pasteurellaceae" or "Vibrio" or "gram-positive" or "Clostridium" or "listeriosis" or "staphylococcal" or "streptococcal" or "Chlamydia"). There were no restrictions on the type and language of the research. The retrieval time span was from January 1, 2000, to May 31, 2025. The results were reviewed by title, abstract, and keyword information, and full papers were read when necessary.

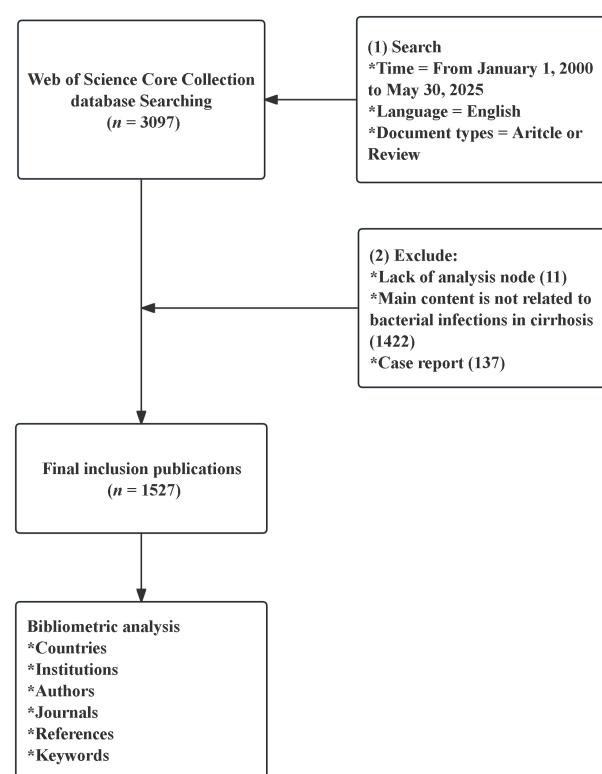


Figure 1. Flowchart of literature inclusion and exclusion.

The search results were saved as "Full Records and Cited References" in the "Plain Text Files" document format. Since the data used in this study were from a public database, approval from an ethics committee was not required.

Data analysis and visualization

The most commonly employed metrics in bibliometric analysis are co-authorship, co-citation, and co-occurrence analyses. The purpose of a co-authorship analysis is to examine the link between countries or institutions according to the number of articles jointly

produced. A co-citation analysis demonstrates the degree of association between cited authors or journals according to the number of cited items. Co-occurrence analysis is a quantitative tool used to analyze the connection between several objects according to whether they appear together. Keyword co-occurrence cluster analysis reflects the development and evolution of the theme structure in the research field.

CiteSpace (v.6.4.R2) and VOSviewer (v.1.6.20) were used for data processing and result visualization. CiteSpace, a web-based Java application, is document visualization analysis software developed for bibliometric analysis and data visualization. In this study, CiteSpace was used to analyze and visualize nodes such as countries/regions, institutions, journals, authors, keywords and keyword bursts, and references and reference bursts. We set "Years Per Slice" to 1 year, and the "Top N" to 50, while other parameters were left at their default values. In CiteSpace, the node size represents the number of publications or the frequency of citations. The timeline is displayed at the bottom left of the network visualization map, with different colors within the nodes representing different time periods and the color of the lines reflecting the years when cooperation or co-citation first appeared.

VOSviewer describes the structure, progression, coordination, and other aspects of knowledge fields by constructing linkages and visually analyzing literary knowledge items. In this study, it was used to visualize collaborations between countries/regions, institutions, and authors and the co-occurrence of keywords. The node size represents the number of publications, whereas different colors represent different clusters.

RESULTS

Annual publications and trends

A total of 1527 publications satisfied the inclusion criteria. The number of publications in a given period reflects the research development trends and speed of this discipline. Figure 2 depicts the annual global distribution of publications on bacterial infections in cirrhosis from 2000 to 2025. The largest number of publications appeared in 2021. The overall global trend in publications was upward before 2021, with a slight decline after 2022. It should be noted that the low number of publications in 2025 is due to the search deadline of June 15, 2025, in this study rather than the completion of the whole year. The steady upward trend in publication numbers reflects, to some extent, growing scientific attention in this research field.

Distribution of countries and research institutions

In total, researchers from 69 countries contributed to the research on cirrhosis with bacterial infections, and

the distribution of countries with more than five publications is shown in Figure 3A. Table 1 shows the 10 countries with the most publications, with the United States producing the most ($n = 324$, 21.22%), followed by the China ($n = 293$, 19.19%), and Spain ($n = 210$, 13.75%). The United States also conducted research on bacterial infections in cirrhosis in close collaboration with Spain and Canada. The number of citations is a crucial indicator of quantitative academic evaluation. Research from Spain was cited the most, indicating that the research results on bacterial infections in cirrhosis were relatively mature.

Among the top 10 countries, the United Kingdom produced publications of high academic quality, with higher average citations (108.76) than the other countries on the list. Spain had the most highly cited publications, with a total of 32. The betweenness centrality (BC) of nodes indicates node centrality, which reflects the importance of nodes in the network. The highest BC was recorded for both the United States (0.19) and the United Kingdom (0.19), indicating that they were at the heart of the network and played a critical intermediary role in collaboration between countries (Figure 3B).

According to the institutional node analysis, 2100 institutions participated in research on bacterial infections in cirrhosis, and we examined the major institutions with more than five articles in the institutional cooperation network (Figure 3C). The top 10 institutions by number of publications are listed in Table 2, with the University of Barcelona (75 papers) ranking first, followed by Virginia Commonwealth University (53 papers) and University College London (49 papers). As illustrated in Figure 3C, the institutional collaboration cluster network exhibits distinct regional characteristics. The left-side clusters are predominantly composed of institutions located in Europe, with the University of Barcelona, University College London, and the Institute of Health Carlos III emerging as key drivers of these research clusters. The green cluster positioned above primarily comprises North American institutions, with Virginia Commonwealth University, Yale University, and the Mayo Clinic standing out as leading contributors. The three clusters on the right correspond to Asian regions, with the pink cluster denoting South Korea and the yellow and orange clusters representing China. Notably, institutions within the European clusters demonstrated robust interinstitutional collaboration, whereas cross-border cooperative interactions appeared comparatively limited among clusters in Asia.

Analysis of authors and co-cited authors

Jasmohan S. Bajaj (41 papers), Pere Gines (30 papers), and Javier Fernandez (30 papers) were the most prolific authors in research on bacterial infections in cirrhosis. Of the 10 most co-cited authors, Javier Fernandez ranked first, with 1397 citations, followed by Jasmohan

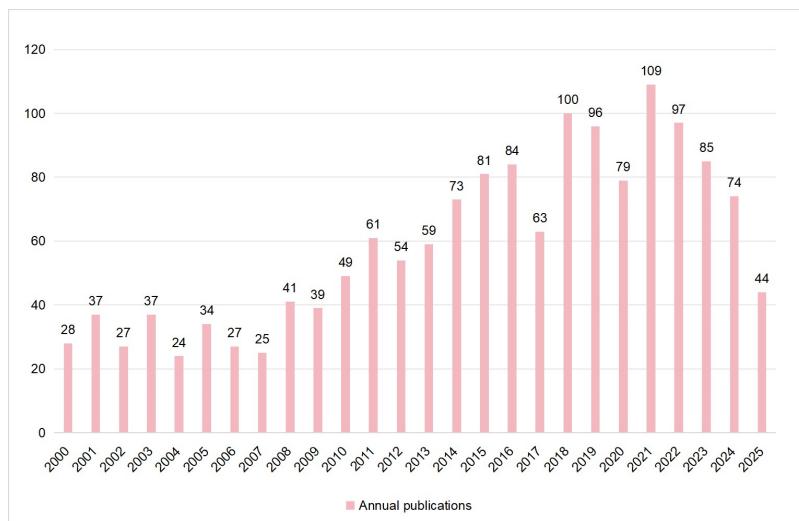
Table 1: Top 10 countries in terms of the number of publications related to bacterial infections in cirrhosis

Rank	Country	Total publications	Total citations	Average citations	Betweenness centrality	Highly cited publications ^a
1st	United States	324	19,413	59.9	0.19	27
2nd	China	293	6572	22.4	0.01	5
3rd	Spain	210	19,471	92.7	0.06	32
4th	Italy	176	12,778	72.6	0.08	17
5th	Germany	132	9326	70.7	0.03	13
6th	United Kingdom	119	12,943	108.8	0.19	21
7th	France	102	10,895	106.8	0.08	20
8th	South Korea	69	1966	28.5	0.02	1
9th	Canada	55	4193	76.2	0.04	9
10th	Japan	55	2168	39.4	0.06	1

^aWith citation counts of 187 or more, ranking in the top 5%.

Table 2: Top 10 institutions in terms of the number of publications related to bacterial infections in cirrhosis

Rank	Institution	Total publications	Country	Citations
1st	University of Barcelona	75	Spain	7798
2nd	Virginia Commonwealth University	53	United States	10,785
3rd	University College London	49	United Kingdom	3820
4th	Zhejiang University	46	China	4910
5th	Mayo Clinic	44	United States	5720
6th	Yale University	38	United States	4685
7th	Beaujon Hospital	37	France	5560
8th	Institute of Health Carlos III	37	Spain	2385
9th	Autonomous University of Barcelona	31	Spain	2091
10th	University of Padua	31	Italy	3971

**Figure 2.** Chronological trends in publications related to cirrhosis with bacterial infections.

S. Bajaj (1209 citations) and Bruce A. Runyon (758 citations). Javier Fernandez, Jasmohan S. Bajaj, Pere Gines, Rajiv Jalan, and Richard Moreau ranked among the top 10 in terms of the number of publications and co-citations (Table 3).

Analysis of citing and co-cited journals

Research articles on bacterial infections in cirrhosis were published in 356 journals. Table 4 lists the top 10 cited and co-cited journals. The *Journal of Hepatology* ($n = 94$, 6.2%) featured the highest number of articles, followed

Table 3: Top 10 authors and co-cited authors in the number of publications related to bacterial infections in cirrhosis

Rank	Author	Country	Documents	Citations	Rank	Co-cited author	Country	Citations
1st	Jasmohan S. Bajaj	United States	41	6170	1st	Javier Fernandez	Spain	1397
2nd	Pere Gines	Spain	30	6772	2nd	Jasmohan S. Bajaj	United States	1209
3rd	Javier Fernandez	Spain	30	4393	3rd	Bruce A. Runyon	United States	758
4th	Paolo Angeli	Italy	25	4799	4th	Rajiv Jalan	United Kingdom	509
5th	Patrick S. Kamath	United States	25	3017	5th	Richard Moreau	Spain	445
6th	Guadalupe Garcia-tsao	United States	23	4083	6th	Reiner Wiest	Switzerland	428
7th	Ruben Frances	Spain	23	1304	7th	A. Rimola	Spain	407
8th	Richard Moreau	Spain	22	5571	8th	Salvatore Piano	Italy	394
9th	Rajiv Jalan	United Kingdom	21	5894	9th	Agustin Albillos	Spain	385
10th	Vicente Arroyo	Spain	20	6724	10th	Pere Gines	Spain	355

Table 4: Top 10 citing and co-cited journals in terms of the number of publications related to bacterial infections in cirrhosis

Rank	Citing journal	Documents	IF*	Co-cited journal	Co-citations	IF*
1st	<i>Journal of Hepatology</i>	94	33.0	<i>Hepatology</i>	8425	15.8
2nd	<i>European Journal of Gastroenterology & Hepatology</i>	71	1.8	<i>Journal of Hepatology</i>	6949	33.0
3rd	<i>Liver International</i>	70	5.2	<i>Gastroenterology</i>	3911	25.1
4th	<i>Hepatology</i>	61	15.8	<i>Gut</i>	1965	25.8
5th	<i>World Journal of Gastroenterology</i>	42	5.4	<i>American Journal of Gastroenterology</i>	1931	7.6
6th	<i>Digestive Diseases and Sciences</i>	40	2.5	<i>Liver International</i>	1478	5.2
7th	<i>Alimentary Pharmacology & Therapeutics</i>	37	6.7	<i>New England Journal of Medicine</i>	1346	78.5
8th	<i>Journal of Gastroenterology and Hepatology</i>	28	3.4	<i>Clinical Infectious Diseases</i>	1062	7.3
9th	<i>PloS One</i>	28	2.6	<i>Alimentary Pharmacology & Therapeutics</i>	1034	6.7
10th	<i>Clinical Gastroenterology and Hepatology</i>	27	12.0	<i>Digestive Diseases and Sciences</i>	904	2.5

*Impact factor based on Clarivate Analytics's Journal Citation Reports 2024.

by the *European Journal of Gastroenterology & Hepatology* ($n = 71$, 4.6%), and *Liver International* ($n = 70$, 4.6%). It transpired that 32.6% of all articles were published in the top 10 journals, and the *Journal of Hepatology* had the highest impact factor (33.0). The citation density map of major journals is shown in Figure 4A, with a deeper shade of red showing a higher density.

The highest co-cited journal was *Hepatology*, with 8425 citations, followed by the *Journal of Hepatology* (6949 citations) and *Gastroenterology* (3911 citations). The top 100 co-cited journals with the highest total link strength were selected to create a density map to illustrate the distribution density of co-cited journals (Figure 4B). According to the cited journal density and co-cited journal density, *Hepatology* and the *Journal of Hepatology* were the most important journals in terms of research on bacterial infections in cirrhosis, and it was noted that co-cited journals tended to be influential journals.

As shown in Table 4, the average impact factor (IF) of the top 10 co-cited journals (20.75) was much higher than that of the top 10 journals (8.5). The topic distribution of academic journals is illustrated in the dual-map

overlay of journals (Figure 4C), with the citing journals on the left and the cited journals on the right. Two paths for citing and cited journals can be observed: (1) Medicine, Medical, Clinical—Molecular, Biology, Genetics; and (2) Medicine, Medical, Clinical—Health, Nursing, Medicine.

Co-cited references and reference bursts

The citation frequency of publications is the gold standard indicator for evaluating quality and academic influence. The most frequently cited documents, also referred to as highly cited publications, are the focus of researchers. Details of the top 10 cited references are shown in Table 5. The article "Bacterial Infections in Cirrhosis: Epidemiological Changes with Invasive Procedures and Norfloxacin Prophylaxis" was the most cited by relevant studies, with 329 co-citations, followed by "Infections in Patients with Cirrhosis Increase Mortality Four-fold and Should be Used in Determining Prognosis", with 317 co-citations, and "Acute-on-Chronic Liver Failure is a Distinct Syndrome that Develops in Patients with Acute Decompensation of Cirrhosis", with 257 co-citations. Articles with the top 25 co-citations related to bacterial infections in cirrhosis

Table 5: Details of the top 10 cited articles on bacterial infections in cirrhosis

Rank	Title	Journal	Year	First author	Co-citations	DOI
1st	Bacterial Infections in Cirrhosis: Epidemiological Changes with Invasive Procedures and Norfloxacin Prophylaxis	<i>Journal of Hepatology</i>	2002	Javier Fernandez	329	10.1053/jhep.2002.30082
2nd	Infections in Patients with Cirrhosis Increase Mortality Four-Fold and Should Be Used in Determining Prognosis	<i>Gastroenterology</i>	2010	Vasiliki Arvaniti	317	10.1053/j.gastro.2010.06.019
3rd	Acute-on-Chronic Liver Failure Is a Distinct Syndrome that Develops in Patients with Acute Decompensation of Cirrhosis	<i>Gastroenterology</i>	2013	Richard Moreau	257	10.1053/j.gastro.2013.02.042
4th	Bacterial Infections in Cirrhosis: A Position Statement Based on the EASL Special Conference 2013	<i>Journal of Hepatology</i>	2014	Rajiv Jalan	251	10.1016/j.jhep.2014.01.024
5th	Prevalence and Risk Factors of Infections by Multiresistant Bacteria in Cirrhosis: A Prospective Study	<i>Hepatology</i>	2012	Javier Fernandez	239	10.1002/hep.25532
6th	Diagnosis, Treatment and Prophylaxis of Spontaneous Bacterial Peritonitis: A Consensus Document. International Ascites Club	<i>Journal of Hepatology</i>	2000	A. Rimola	218	10.1016/s0168-8278 (00) 80201-9
7th	EASL Clinical Practice Guidelines on the Management of Ascites, Spontaneous Bacterial Peritonitis, and Hepatorenal Syndrome in Cirrhosis	<i>Journal of Hepatology</i>	2010	Pere Gines	215	10.1016/j.jhep.2010.05.004
8th	Effect of Intravenous Albumin on Renal Impairment and Mortality in Patients with Cirrhosis and Spontaneous Bacterial Peritonitis	<i>New England Journal of Medicine</i>	1999	P. Sort	192	10.1056/nejm199908053410603
9th	Cirrhosis-Associated Immune Dysfunction: Distinctive Features and Clinical Relevance	<i>Journal of Hepatology</i>	2014	Agustin Albillor	153	10.1016/j.jhep.2014.08.010
10th	Bacterial Infection in Patients with Advanced Cirrhosis: A Multicentre Prospective Study	<i>Digestive and Liver Disease</i>	2001	M. Borzio	153	10.1016/s1590-8658 (01) 80134-1

are listed in Figure 5. The strongest citation burst for research on bacterial infections in cirrhosis up to the end of 2025 was observed for Salvatore Piano's "Epidemiology and Effects of Bacterial Infections in Patients with Cirrhosis Worldwide" (strength = 46), which garnered the most significant attention in recent years.

Keyword co-occurrence and bursts

Keywords are the core and essence of an article. Analysis of high-frequency keywords determines the hotspots in a particular research field. VOSviewer was used to conduct a keyword co-occurrence cluster analysis to visually display the main directions and hotspot evolution of bacterial infection in cirrhosis. We set the occurrence frequency of keywords to 20 times or greater and formed four clusters after comprehensive analysis (Figure 6A).

The keyword co-occurrence cluster map overlay time trend is shown in Figure 6B, with the evolution of keyword hotspots ranging from purple to red. Different color clusters of keywords represent distinct research directions. After 2018, the keywords of research on bacterial infections in cirrhosis focused on liver (organ) failure in decompensated cirrhosis. The largest cluster, shown in red and containing 137 items, illustrates the expression and detection of biomarkers in bacterial infections associated with liver disease, featuring keywords such as "(liver) disease", "hepatic enceph-

alopathy", "bacterial translocation", "gut microbiota", and "tumor necrosis factor". The keywords of the green cluster pertain to the survival and diagnostic aspects of patients with end-stage cirrhosis, with the keywords "sepsis", "survival", "prognosis", "acute-on-chronic liver failure (ACLF)", and "hepatorenal syndrome". Yellow clustering reflects the focus on infection prevention during the compensatory phase of cirrhosis, encompassing keywords such as "infection", "spontaneous bacterial peritonitis (SBP)", "ascitic fluid", "antibiotic prevention", and "norfloxacin". Blue clustering centers on antibiotic treatment and the prediction of mortality risk in cirrhotic patients following infection, with prominent keywords including "mortality", "management", "risk factors", "diagnosis", and "prevalence". According to Figure 6B, the keywords "acute-on-chronic liver failure", "immune dysfunction", "systemic inflammation", and "gut microbiota" have been the hotspots of research in recent years.

The top 25 keywords with the strongest citation bursts are shown in Figure 6C, reflecting that *Helicobacter pylori* had the strongest citation bursts (24.2). The citation bursts of the keywords "chronic liver failure", "immune dysfunction", "acute-on-chronic liver failure", and "rifaximin" were identified in 2025, implying that these keywords—especially "acute-on-chronic liver failure"—may represent the main research focus of bacterial infections in cirrhosis at present and in the coming years.

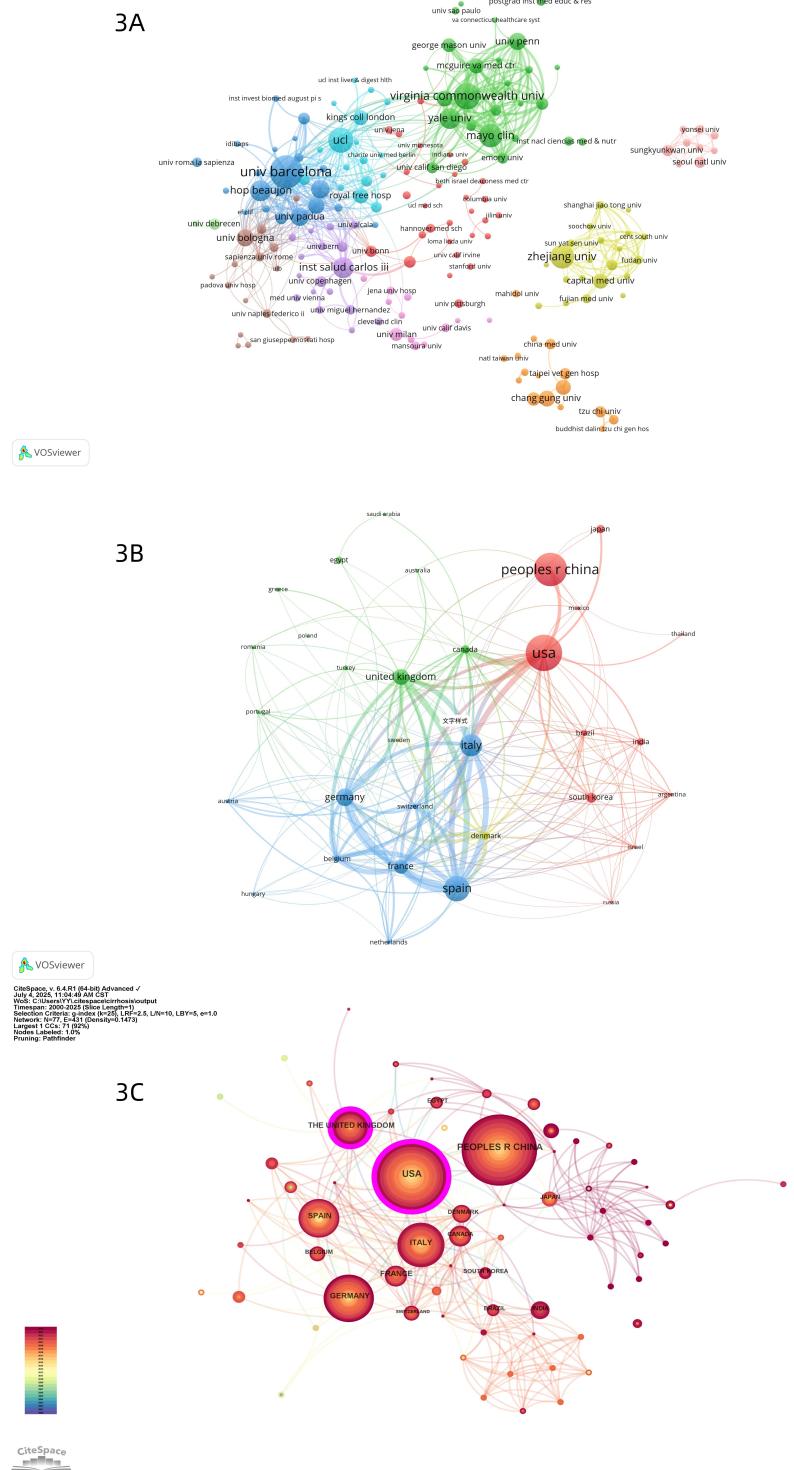


Figure 3. Visualization of cirrhosis-bacterial infection research collaboration networks. (A) Distribution of countries with five or more publications. (B) Betweenness centrality of country cooperation networks. (C) Institutional collaboration cluster networks.

DISCUSSION

Cirrhosis is a chronic disease with high mortality and represents a serious public health problem. Approximately 1 million deaths per year worldwide are attrib-

utable to cirrhosis.^[11] Although scientific discoveries have transformed the understanding of the pathogenesis of cirrhosis in the last decade, its progression is still considered an irreversible phenomenon in clinical practice.^[12,13] The worldwide incidence of cirrhosis is

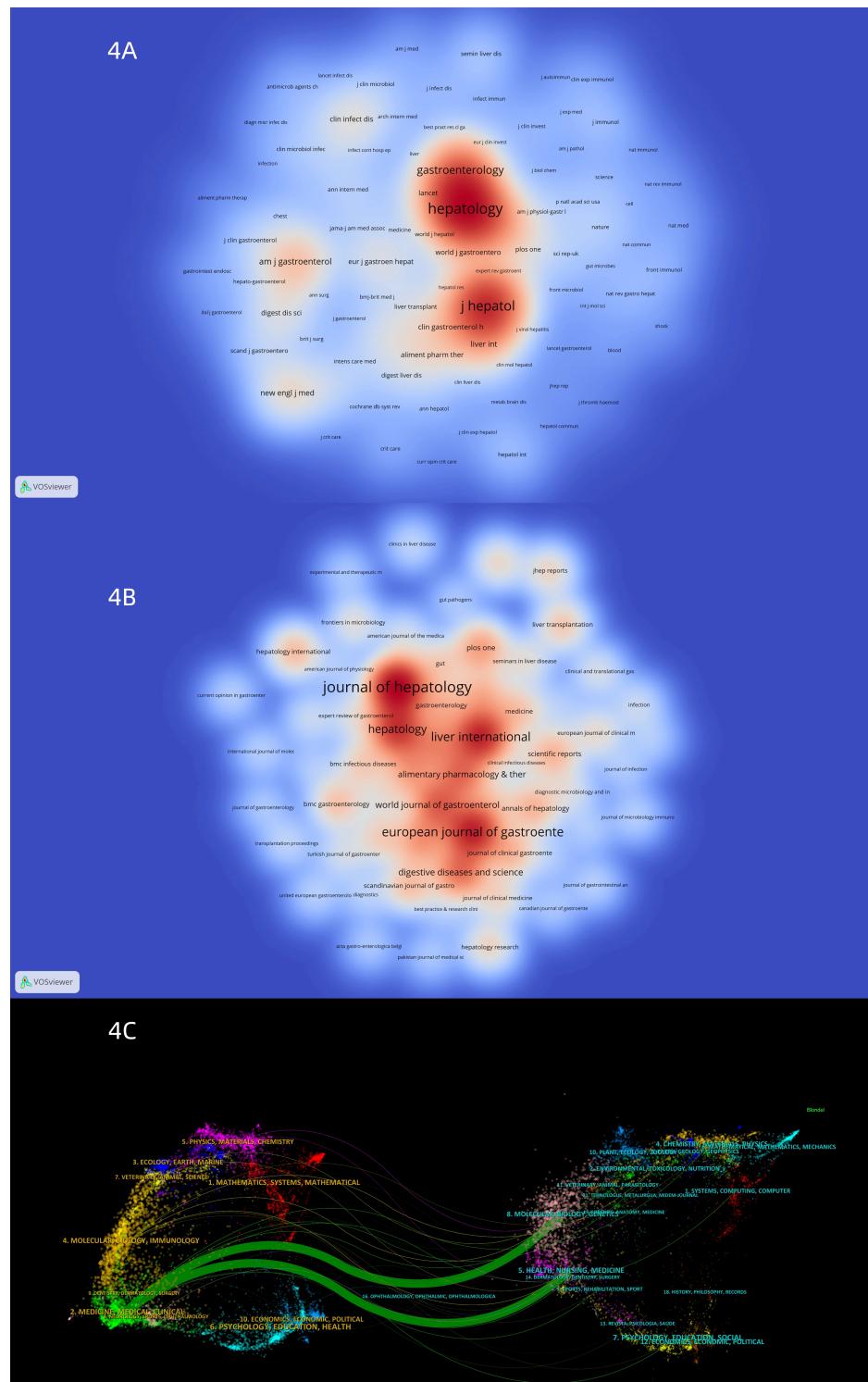


Figure 4. Contributions of top journals for research on bacterial infections in cirrhosis. (A) Density maps of citing journals. (B) Density maps of the cited journals. (C) Dual-map overlap of journals.

increasing continuously, and it ranks eighth in terms of economic cost among significant diseases, despite various public health measures.^[14,15] For cirrhotic patients, bacterial infections pose a serious health risk and herald the beginning of the terminal phase of this disease.^[16] The development of bacterial infections is usually associated with complications related to cirrhosis.

The prevalence of bacterial infections in patients admitted to the hospital due to cirrhosis ranges from 25% to 46%, and bacterial infections are a frequent cause of hospital readmission and increase the probability of mortality fourfold.^[17-19] The development of bacterial infections frequently leads to dysfunction and failure of the liver and other organs, and cirrhosis

Top 25 References with the Strongest Citation Bursts

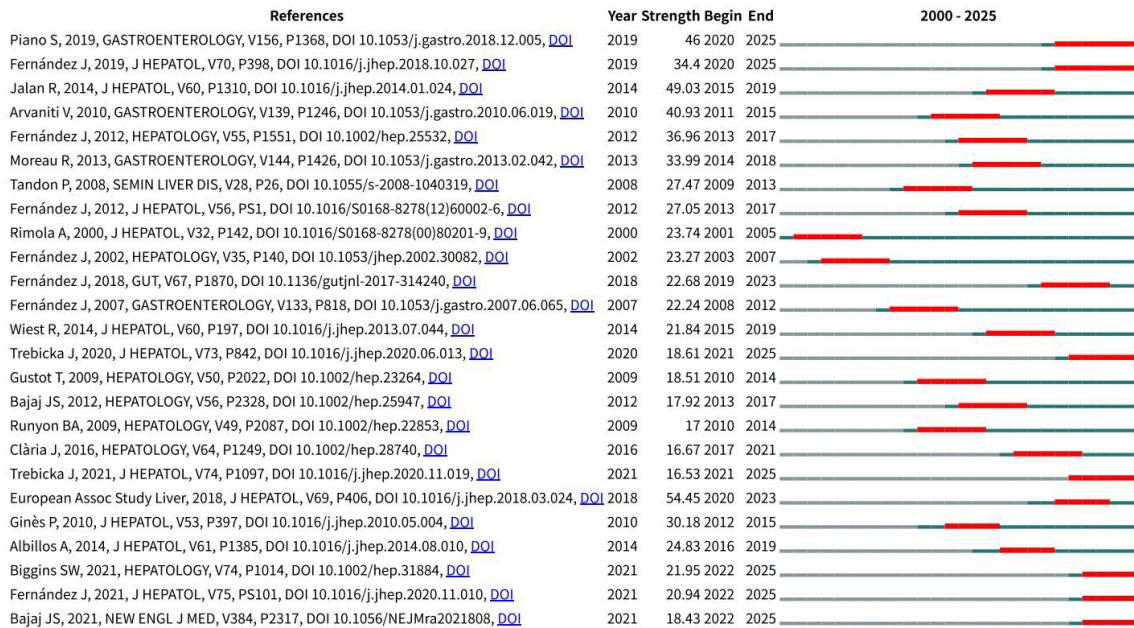


Figure 5. Top 25 references with the strongest citation bursts.

patients with bacterial infections show a worse clinical course and higher mortality rates.^[20,21]

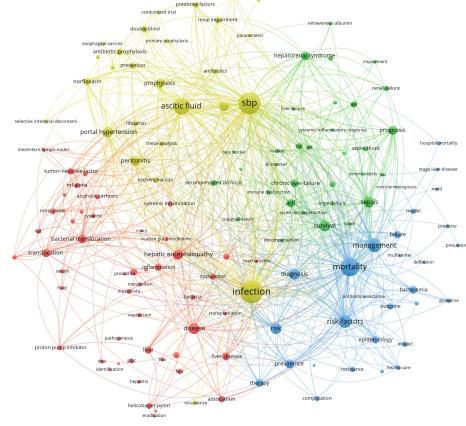
The search results indicated that research on bacterial infections in patients with liver cirrhosis has exhibited a consistent upward trajectory in recent decades. This growth is primarily attributable to two interrelated factors: the escalating global burden of liver cirrhosis and the increasing recognition of bacterial infections as a critical determinant of disease progression and prognosis in affected individuals.^[17,22] However, the global coronavirus disease 2019 (COVID-19) pandemic in 2020 exerted a notable influence on cirrhosis research, temporarily redirecting the investigative focus toward the urgent challenge of "concurrent liver disease and COVID-19"—a shift that diverted resources originally allocated to bacterial infection studies.^[23] Given the inherent lag between research completion and publication dissemination, the number of related articles began to decline after 2022. Furthermore, following years of cumulative progress, foundational understandings of bacterial infection mechanisms and antibiotic prophylaxis/treatment strategies have matured into a well-established theoretical framework.^[16] Current research has accordingly shifted toward more specialized frontiers, such as the precision management of multidrug-resistant bacterial infections and the development of novel biomarkers.^[17] Yet, these emerging areas demand extended periods of methodological refinement and data accumulation, precluding substantial short-term outputs and contributing to a

gradual deceleration in the overall research volume.

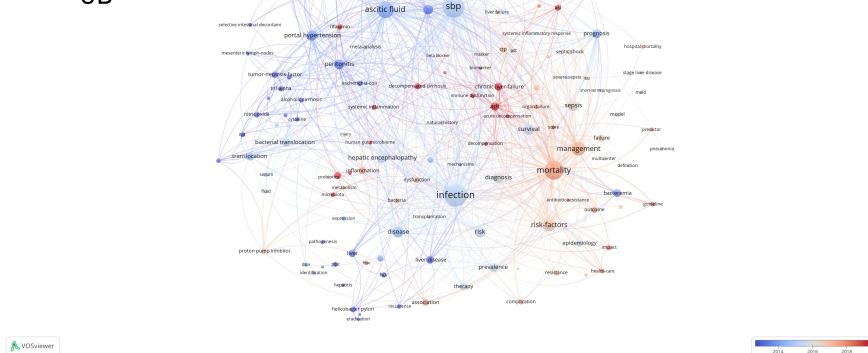
The United States (324 papers), China (293 papers), and Spain (210 papers) published the highest number of articles on bacterial infections in cirrhosis. In terms of the number of citations, although China ranked third in terms of the number of publications, its average citation number was lower than that of other countries. This disparity may stem from multiple factors, such as limited international dissemination of Chinese-language studies due to language barriers;^[24] a delayed start in this research field in China, where the influence of academic achievements requires time to accumulate; and the epidemiology of cirrhosis etiologies in China differing from that in Europe and the United States,^[17] which may have affected international collaboration networks. In contrast, the United States and the United Kingdom were not only relatively mature in this field of research but also served as bridges for international collaborations. It is worth noting that institutional cooperation primarily took place within the European Union member states and within the United States, and there is still potential for more extensive global cooperation to be explored.

Among the 10 institutions with the most published articles, six were in Europe, indicating the strongest influence and greatest achievements in this research field. In addition, bacterial infections were the most frequent precipitating factor of (acute-on-chronic liver

6A



6B



6C

Top 25 Keywords with the Strongest Citation Bursts

Keywords	Year	Strength	Begin	End
helicobacter pylori	2000	24.2	2000	2005
peptic ulcer	2000	16.07	2000	2008
tumor necrosis factor	2000	14.81	2000	2012
factor alpha	2000	13.51	2000	2007
selective intestinal decontamination	2000	12.3	2000	2005
renal impairment	2000	10.65	2000	2010
bile	2000	9.44	2000	2005
congestive gastropathy	2000	8.91	2000	2004
hyperdynamic circulation	2000	8.39	2000	2005
mesenteric lymph nodes	2000	7.03	2000	2011
nitric oxide	2001	21.07	2001	2009
pbc	2001	14.11	2001	2010
antibody	2001	10.19	2001	2006
rat	2001	7.64	2001	2011
norfloxacin prophylaxis	2003	9.9	2003	2010
molecular mimicry	2004	8.7	2004	2010
prophylaxis	2002	8.12	2004	2012
predictive factors	2000	18.36	2005	2010
lipopolysaccharide-binding protein	2005	7.07	2005	2014
renal-failure	2004	7.88	2010	2014
human gut microbiome	2016	7.93	2016	2022
chronic liver-failure	2014	11.05	2018	2025
acif	2011	11.38	2020	2025
systemic inflammation	2014	8.88	2020	2025
rifaximin	2020	8.6	2020	2025

Figure 6. Visualization map of keywords on bacterial infections in cirrhosis. (A) Keyword co-occurrence cluster map. (B) Keyword co-occurrence cluster map overlay time trend. (C) Top 25 keywords with the strongest citation bursts.

failure) ACLF—a serious complication of decompensated cirrhosis—in Europe and the United States.^[25] The University of Barcelona had the largest number of research achievements, while Virginia Commonwealth University had the most citations for its

research. Therefore, these two institutions have become the preferred institutions for research cooperation on bacterial infection in cirrhosis.

According to our study, the *Journal of Hepatology* is the

most authoritative journal in the research field. Research results in related fields may be published in this journal according to priority. However, based on the analysis of the dual-map overlap of journals, interdisciplinary cooperation in studying bacterial infections in cirrhosis may be lacking.

Jasmohan S. Bajaj is the most authoritative expert in the field of bacterial infections in liver cirrhosis. He has also published the largest number of papers. The article that received the most co-citations was published by Javier Fernandez in 2002, titled "Bacterial Infections in Cirrhosis: Epidemiological Changes with Invasive Procedures and Norfloxacin Prophylaxis", on the epidemiology and empirical antibiotic treatment strategies for bacterial infections in cirrhosis.^[25]

Keyword co-occurrence clustering showed that "mortality", "infection", "ascitic fluid", "spontaneous bacterial peritonitis", and "management" were the keywords with the highest research hotspots. Vasiliki's study showed that the mortality of patients with cirrhosis occurred in more than 60% of instances within 12 months after infection.^[18] SBP, defined as bacterial infection of the ascitic fluid without any identifiable, intra-abdominal, surgically treatable source of infection, is the most common type of infection in patients with cirrhosis. The pathogenesis of SBP has not been fully clarified, but it is generally believed to be closely related to alterations of intestinal microbiomes and translocation of bacteria and bacterial products.^[26] Although early diagnosis and prophylactic antibiotic treatment have improved the prognosis of SBP, in-hospital mortality remains at approximately 20%.^[27] Liver failure (34.2%) and sepsis (33.4%) are the major causes of death.^[18] In the keyword co-occurrence cluster map (Figure 6B), failure and sepsis showed higher co-occurrence intensities. According to the classification of D'Amico,^[28] sepsis can be considered stage 5 of the development of cirrhosis. In the decompensated stage of cirrhosis, due to the patient's low defense ability, 50-70% of patients with decompensated liver function and an infection developed sepsis or systemic inflammation response syndrome, resulting in multiple organ function injury accompanied by circulatory, cellular, and metabolic disorders, leading to organ failure.^[29]

The evolution trend of keywords showed that "chronic liver failure", "immune dysfunction", "acute-on-chronic liver failure", and "rifaximin" represented the leading research hotspots and keywords bursts by the end of 2025. Albillios defined cirrhosis-associated immune dysfunction as the main syndrome abnormalities of immune function, immune deficiency, and systemic inflammation existing in cirrhosis.^[5] Furthermore, a review by Arvaniti *et al.* proposed that systemic inflammation is the critical pathological mechanism driving the

transition of cirrhosis from the compensated to decompensated stages and triggering single- or multi-organ failure.^[30] ACLF, the most severe form of acute decompensation in cirrhosis, is characterized by high-grade systemic inflammation, characterized by decompensation, organ failure, and high short-term mortality, thus serving as a critical turning point in the course of cirrhosis. It is closely associated with trigger events, such as acute alcoholic, drug-induced, or viral hepatitis or bacterial infections, and is probably associated with intestinal translocation of bacterial products without trigger events.^[31] Whether ACLF is a distinct syndrome or a terminal stage in patients with cirrhosis varies across continents.^[32,33] Bacterial infections and alcohol consumption are the most frequent precipitating factors in Europe and the United States; the exacerbation or superposition of viral hepatitis is an independent risk factor in Asia.^[17] Since ACLF is a progressive disease associated with rapid clinical deterioration and high short-term mortality, the definition of ACLF worldwide must be harmonized urgently to facilitate studies on effective management,^[15] which may also be the main content of research on bacterial infections in cirrhosis in the upcoming years. Rifaximin, as a gut-selective antibiotic, has been widely used globally for the preventive treatment of high-risk patients with decompensated cirrhosis.^[34] Existing experimental and clinical evidence indicates that its core mechanism of action lies in regulating the gut microbiota and influencing the gut-liver axis, thereby controlling the disease progression of cirrhosis. Specifically, it can block the key pathological and physiological cascade reactions during the progression of decompensated cirrhosis, including inhibiting the amplification of systemic inflammatory syndrome, alleviating portal hypertension-driven pathological damage, and reducing infection risks caused by bacterial translocation, thereby providing multidimensional protective effects for patients.^[35] Moreover, the combination therapy of rifaximin has been demonstrated in clinical trials to enhance anti-infection effects and delay the development of drug resistance, which may be an important direction of exploration for future precision treatment strategies.^[36]

CONCLUSION

This study used CiteSpace and VOSviewer to visually analyze articles on bacterial infections in cirrhosis research from a public database. The hotspots and trends of relevant research were discussed, and the research results were presented truthfully and objectively *via* a clear knowledge map. Existing studies have focused on various aspects of bacterial infections in cirrhosis, including biomarker detection, antibiotic prophylaxis, survival management, and mortality prediction. Future research directions may revolve around the standardized

diagnostic and therapeutic protocols of ACLF, the regulatory mechanism of systemic inflammation, and the combination therapy of rifaximin. These directions aim to address critical gaps in clinical management and advance precision treatment paradigms for this high-mortality patient population.

LIMITATIONS

Our study has some limitations. First, it relied on a specific database (WoSCC) and may have missed some publications. Second, the included studies were limited to those in the English language, and important studies in other languages may have been ignored. Moreover, bibliometric analysis usually focuses only on metadata rather than on full content, which may miss key insights. We included relevant records from January 1, 2000, to May 31, 2025. Due to the time gap between research implementation and publication, the results presented in this article may differ from the latest research. These factors collectively affected the comprehensiveness and accuracy of this study.

DECLARATION

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Author contributions

Zhang ZY, Tan JT, Li Y, Zheng JY, Ni J, Yuan Y, Wu XX: Conceptualization, Methodology, Software, Validation, Visualization, Investigation, Data Curation, Writing- Original Draft Preparation and Writing—Review & Editing. All authors have read and approve the final manuscript.

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Ethical approval

Not applicable.

Informed consent

Not applicable.

Conflict of interest

Xiaoxin Wu is an associate editor of the journal. The article was subject to the journal's standard procedures, with peer review handled independently of the editor

and the affiliated research groups.

Use of large language models, AI and machine learning tools

None declared.

Data availability statement

The authors confirm that the data supporting the findings of this study are available within the article and its supplementary materials.

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