Acta Biomed 2025; Vol. 96, N. 4: 17288 DOI: 10.23750/abm.v96i4.17288 © Mattioli 1885

Review

Evolution of oxidative stress research in liver cirrhosis: A 30-Year bibliometric review (1992–2025)

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Abstract. *Background:* Oxidative stress plays a pivotal role in the pathogenesis of liver cirrhosis, yet scientific research on this topic remains fragmented. The main objective of this study was to provide a systematic overview of global research activity on oxidative stress in liver cirrhosis through bibliometric analysis. *Methods:* We conducted a bibliometric analysis of publications on oxidative stress in liver cirrhosis from 1992 to 2025, using data from the Scopus and Web of Science databases. Analytical tools included R (Biblioshiny) and VOSviewer for data processing and visualization. We evaluated publication trends, leading countries, institutions, authors, journals, collaboration networks, and research themes. *Results:* A total of 318 scientific articles from 196 journals were analyzed, involving more than 2,000 authors. The United States, China, and Italy were the top contributors. The University of Barcelona emerged as the most prolific institution. Keyword co-occurrence analysis identified major research clusters focused on mitochondrial dysfunction, antioxidant therapies, inflammatory processes, and biomarker development. Key research terms, such as "lipid peroxidation," "insulin resistance," and "gene regulation," reflect a growing interest in both molecular mechanisms and clinical applications. *Conclusion:* The study highlights a steady rise in research activity and underscores the need for interdisciplinary collaboration. These findings offer valuable insights to guide future scientific and clinical investigations. (www.actabiomedica.it)

Key words: liver cirrhosis, oxidative stress, mitochondrial dysfunction

Introduction

Cirrhosis represents a progressive, chronic liver disorder in which normal hepatic tissue is permanently substituted by fibrotic connective structures, resulting in significant impairment of liver functionality. This condition poses a considerable public health issue, especially in high-income countries, where it ranks among the most common causes of mortality among individuals aged 35–60 (1). In 2019, cirrhosis accounted for 2.4% of all deaths worldwide, reflecting a shifting epidemiological profile influenced by increasing rates of obesity and alcohol misuse, alongside improved treatment outcomes for hepatitis B and C infections (2). Early stages of cirrhosis are typically asymptomatic, but the disease often progresses toward severe complications, including hepatic failure and hepatocellular carcinoma (3). The principal etiological agents—chronic alcohol use, viral hepatitis (B and C), and exposure to hepatotoxic substances—induce oxidative damage within the liver. This occurs through the overproduction of reactive oxygen and nitrogen species (RONS), which overwhelm antioxidant defense mechanisms, initiating molecular injury and

inflammatory cascades (4). A redox imbalance caused by excess oxidants is recognized as a pivotal contributor not only to hepatic pathologies but also to broader aging processes, resulting in cumulative tissue damage and functional decline (4). In hepatic cells, such an imbalance marks the beginning of a pathogenic sequence driven by coexisting metabolic, viral, or environmental stressors (5). One of the critical molecular events in this cascade is mitochondrial dysfunction, which leads to the release of danger-associated molecular patterns (DAMPs). These DAMPs activate hepatic stellate cells, promoting fibrotic remodeling and advancing the disease toward cirrhosis (5). In parallel, portal hypertension—a common feature in advanced cirrhosis—aggravates liver injury by inducing mesenteric congestion, promoting intestinal ROS generation, and increasing gut permeability to endotoxins and microbial products (6,7). As liver function becomes compromised, its detoxifying ability declines, allowing harmful substances to bypass hepatic clearance via collateral circulation. This state fosters systemic endotoxemia, intensifying hepatic inflammation and oxidative stress (8). Liver cirrhosis, a late-stage consequence of chronic liver disease, is marked by fibrosis, nodular regeneration, and progressive loss of liver function (9,10). Among the multifaceted mechanisms implicated in its pathogenesis, oxidative stress has emerged as a central driver of hepatic injury. Oxidative stress results from an imbalance between the generation of reactive oxygen species (ROS) and the liver's antioxidant defense systems. This imbalance leads to lipid peroxidation, DNA damage, and mitochondrial dysfunction, which collectively exacerbate hepatocyte apoptosis and tissue remodeling(11,12). The interplay between ROS-mediated injury and hepatic deterioration perpetuates a cycle of inflammation and fibrosis progression (8). Scientific interest in the oxidative mechanisms underlying liver damage has surged in recent years. Alcohol-induced liver injury, for instance, has revealed significant involvement of ROS and inflammatory mediators in hepatocyte damage (5). During metabolism, the liver is exposed to ROS, which impair liver function and contribute to diverse hepatic pathologies (13–15). Similarly, Non-Alcoholic Fatty Liver Disease (NAFLD)—a prevalent metabolic liver condition—features hepatocellular lipid overload that often culminates in fibrosis or cirrhosis, mediated by redox imbalance (16). The liver's pronounced vulnerability to oxidative injury, combined with the regulatory role of antioxidant gene networks, further highlights the relevance of oxidative stress in systemic complications of cirrhosis, such as cardiovascular dysfunction and portal hypertension (6,17). Biomarker studies in cirrhotic patients reveal a consistent pattern of antioxidant depletion, characterized by reduced levels of superoxide dismutase (SOD) and catalase, accompanied by upregulated stress-response enzymes, such as glutathione reductase, underscoring the oxidative burden in these individuals (18). Given its pivotal role in liver injury and systemic complications, oxidative stress is not only a marker of disease severity but also a promising therapeutic target. Scientists are now targeting oxidative stress as a groundbreaking strategy to halt cirrhosis. Experimental therapies—from sirtuin activators to polyphenol-rich diets—aim to restore redox balance (11). However, despite progress, no study has systematically mapped the global research landscape. This article presents a pioneering bibliometric analysis, revealing key trends, collaborations, and future directions in the fight against oxidative liver injury (19).

Materials and Methods

Search strategy

We performed a thorough bibliometric review of research on "eryptosis" related to "liver cirrhosis" by gathering data from the Web of Science Core Collection (WOS-CC) and Scopus databases. Our research approach aimed to encompass a range of facets of this subject. Prior bibliometric studies, including those that outlined trends in alcoholic liver disease (14), highlight the importance of bibliometric techniques in uncovering thematic developments and guiding subsequent liver disease research. The data collection was completed in March 2025. Our search protocol was designed to identify relevant studies on oxidative stress in patients with liver cirrhosis. Specifically, the term "oxidative stress" was queried in the title field, and the combination of "oxidative stress" and "liver cirrhosis" was queried in the abstract field. To improve

our search's accuracy, we utilized Boolean operators (AND, OR) alongside Medical Subject Headings (MeSH) from the controlled vocabulary thesaurus of the U.S. National Library of Medicine (available at: https://www.nlm.nih.gov/mesh/).

This approach allowed us to formulate a precise search query, which facilitated the identification of highly pertinent publications (Table 1). Our search, based on the indexing features of the Web of Science and Scopus databases, focused on publications from 1992 to 2025 without enforcing additional temporal limits. Inclusion Criteria: We included only original research articles published in English that specifically discussed oxidative stress in patients with liver cirrhosis. Exclusion Criteria: We excluded duplicate entries, meta-analyses, review papers, and studies conducted in vitro or on animals (as illustrated in Figure 1).

Study selection and data extraction

The selection of articles was conducted in two stages based on the inclusion criteria. Initially, two authors (S.K. and M.M.) independently reviewed the titles and abstracts of the articles retrieved through the search strategy. Articles that received approval from both authors proceeded to full-text analysis. If there was any disagreement, the final decision was made after consultation with a third author (K.K.). This bibliometric review has been registered in the PROSPERO International Prospective Register of Systematic Reviews (registration number: CRD4202 51085842).

Table 1. Search strategy and key queries

Code	Queries
#1	"Oxidative Stresses" OR "Stress, Oxidative" OR "Oxidative Damage" OR "Damage, Oxidative" OR "Oxidative Damages" OR "Oxidative Injury" OR "Injury Oxidative" OR "Oxidative Injuries" OR "Oxidative Stress Injury" OR "Injury Oxidative Stress" OR "Oxidative Stress Injuries" OR "Stress Injury Oxidative" OR "Oxidative Cleavage" OR "Cleavage Oxidative" OR "Oxidative Cleavages" OR "Antioxidative Stress" OR "Antioxidative Stresses" OR "Stress Antioxidative" OR "Antioxidative Stress" OR "Antioxidative Stress" OR "Antioxidative Stresses" OR "Stress Antioxidative"
#2	"Liver Cirrhosis" OR "Cirrhosis Liver" OR "Hepatic Cirrhosis" OR "Cirrhosis Hepatic"
#3	#1 AND #2

Performance analysis

To conduct a comprehensive bibliometric analysis of research on oxidative stress in liver cirrhosis from 1992 to 2025, publication data were collected from the WOS-CC and Scopus databases. The extracted records, in txt and BibTeX formats, were imported into VOSviewer (version 1.6.18) and R software (version 4.0.2) for analysis and visualization. The dataset included detailed information on authors, institutional affiliations, publication titles, keywords, and other bibliometric indicators. By integrating data from both WOS-CC and Scopus, this approach ensured inclusive coverage of relevant scientific literature. The applied data extraction and processing methodology provided a solid foundation for identifying research trends, collaboration patterns, and thematic clusters, allowing for a thorough and representative assessment of global scientific activity in the field of oxidative stress related to liver cirrhosis.

Results

Summary of published scientific articles

A total of 318 scientific documents, sourced from 196 journals and other scholarly outlets, were analyzed, covering the period from 1992 to 2025. The dataset reflects a consistent upward trend in publication volume, marked by an Annual Growth Rate of 7.54%. The average age of the documents was 10.4 years, indicating sustained academic interest in the topic. Contributions were made by 2,098 authors, with only seven publications written by a single author, highlighting the field's strong emphasis on collaboration. On average, each document received 41.41 citations. Notably, 1.572% of the publications involved international co-authorship, suggesting limited but present global collaboration within this area of research.

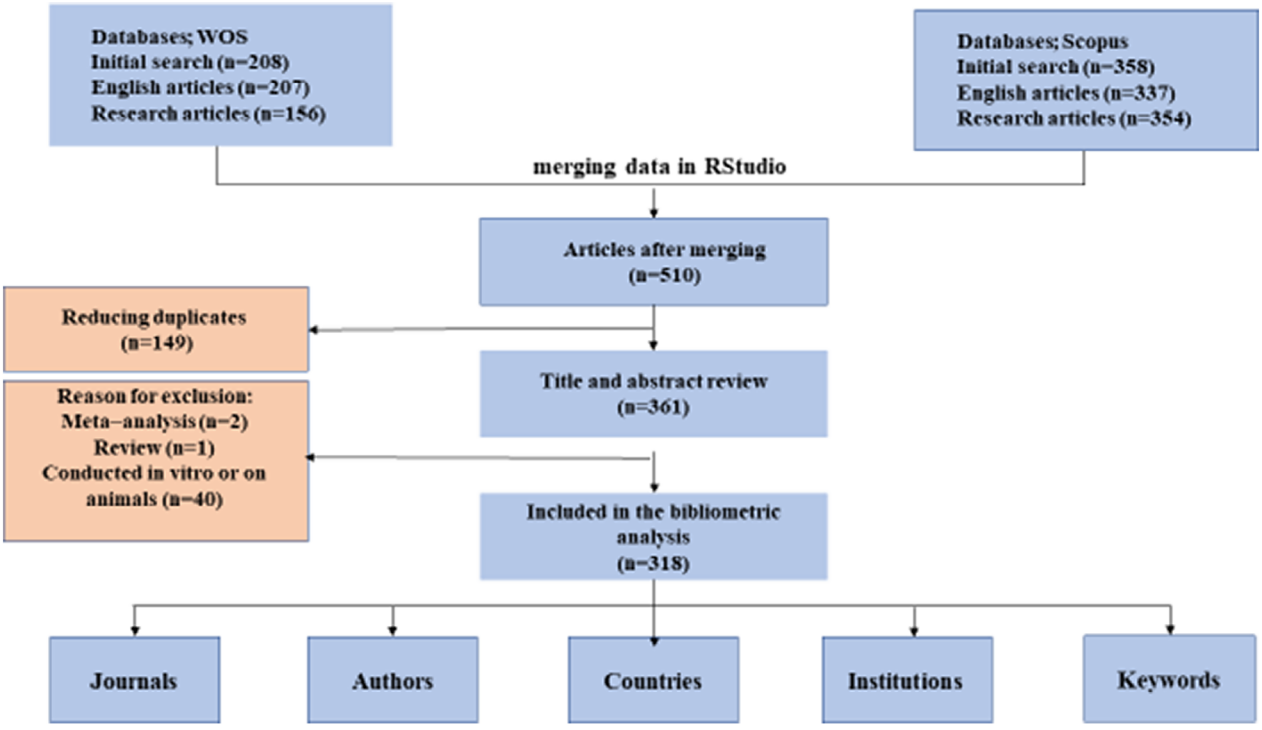

Figure 1. Search strategy for a bibliometric analysis of oxidative stress research in liver cirrhosis.

Annual analysis of publications and citations

Between 1992 and 2025, a total of 318 articles addressing oxidative stress in liver cirrhosis were identified. Research output remained limited until the mid-1990s, followed by a gradual upward trend. The highest average number of citations per article was observed in 1996 (167.67 citations), despite a relatively low publication count that year. In the subsequent decades, publication activity increased steadily, reaching a peak in 2022 with 24 articles. By 2025, however, the number of publications had declined to 11, and the average citation count per article dropped to 1.00. During the past five years (2021–2025), citation activity remained relatively stable, though lower than in previous periods, ranging from 3.91 citations per article in 2024 to 1.00 in 2025 (Figure 2).

Countries and affiliations

The United States led in the number of publications, with corresponding authors affiliated with American institutions contributing over 50 articles on oxidative stress in liver cirrhosis. China, Italy, and Japan also demonstrated strong research activity, each producing more than 25 publications. Noteworthy contributions were observed from countries such as Australia, India, and the United Kingdom. Although the majority of documents were authored within a single country (SCP), international collaboration Multiple Country Publications (MCP) was evident in several cases. The United Kingdom and Turkey showed a relatively higher share of internationally co-authored publications, reflecting their engagement in cross-border scientific cooperation. Germany, France, and Spain also participated in international collaborations despite having a more modest number of total publications. These results highlight the broad international distribution of research efforts in the field (Figure 3). It is important to emphasize that the countries previously mentioned also rank among the most cited in oxidative stress diagnostics. The United States leads in terms of total citations, accumulating 3,175, which reflects the considerable scientific influence of its research output.

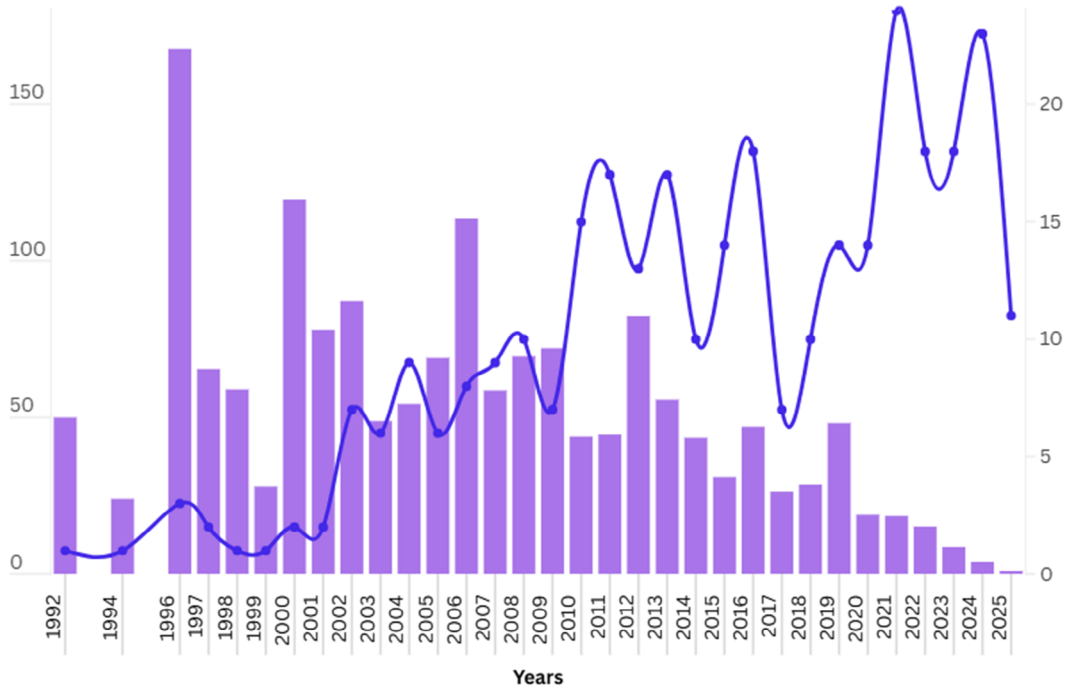

Figure 2. Annual publication and citation trends over time (1992–2025).

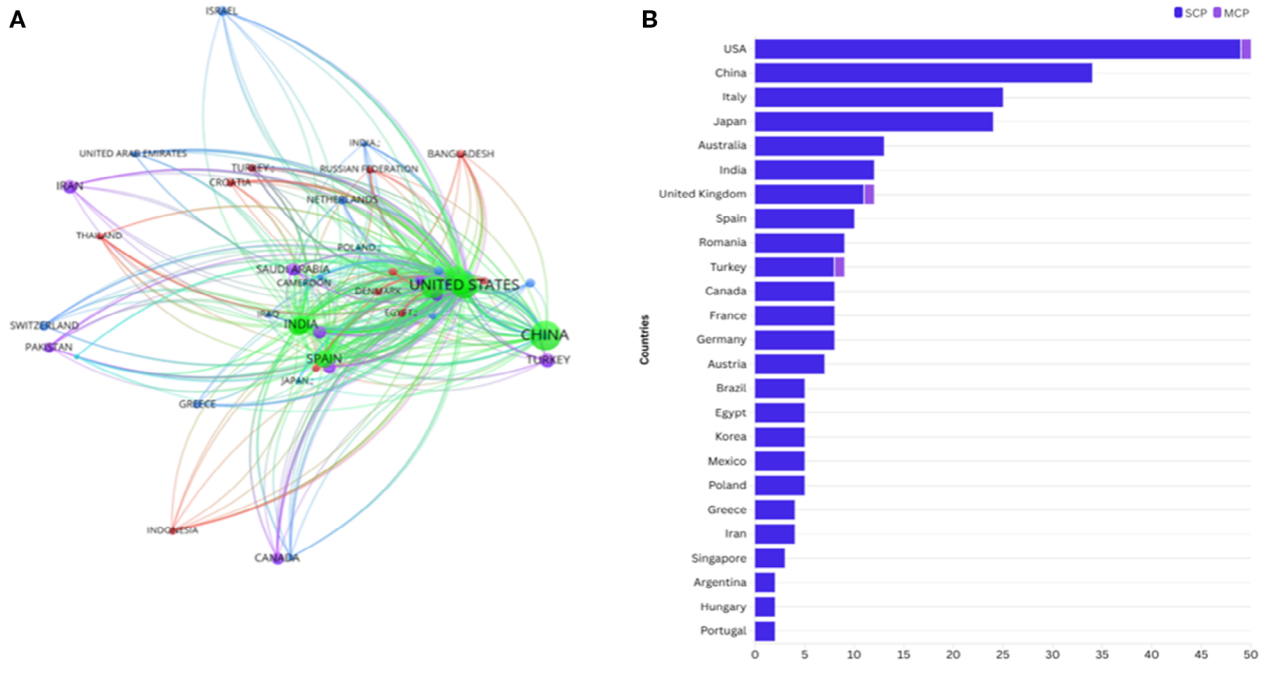

Figure 3. International collaboration and country-wise publication distribution on oxidative stress in liver cirrhosis. (a) International collaboration network on oxidative stress in liver cirrhosis research. (b) Top 25 countries by number of publications (SCP and MCP).

Table 2. Citation Metrics of the Top 10 Countries in Oxidative Stress Research

Rank	Country	Total Citations	Average Article Citations
1	USA	3175	63,50
2	Italy	967	38,70
3	Germany	917	114,60
4	Japan	838	34,90
5	Spain	706	70,60
6	United Kingdom	664	55,30
7	Mexico	658	131,60
8	Australia	544	41,80
9	China	420	12,40
10	France	346	43,20

Table 3. Most Relevant Affiliations in the Field of Oxidative Stress Research

Rank	Affiliation	Articles
1	University Of Barcelona	11
2	University Of Washington	10
3	Shiraz University Of Medical Sciences	9
4	Tottori University	9
5	Egyptian Knowledge Bank (Ekb)	8
6	Medical University Of Graz	8
7	Ovidius University Constanţa	8
8	Shahid Beheshti University Of Medical Sciences	8
9	University College London	8
10	Capital Medical University	7

Italy occupies the second position with 967 citations, followed by Germany, which received 917 citations. A noteworthy observation is that Mexico demonstrates the highest average number of citations per publication, reaching 131.6, indicating its individual studies' exceptional impact. These data reflect the key roles of these countries in shaping and advancing the global scientific discourse on oxidative stress (Table 2). The analysis of institutional productivity in oxidative stress research highlights several prominent academic and medical centers (Table 3).

The University of Barcelona emerges as the most prolific institution, contributing 11 scientific articles, thereby affirming its central role in advancing this field. The University of Washington follows closely with 10 publications, indicating sustained involvement in the topic. Shiraz University of Medical Sciences and Tottori University both contributed 9 articles, reflecting strong regional engagement. Several other institutions—including the Egyptian Knowledge Bank (EKB), Medical University of Graz, Ovidius University of Constanţa, and Shahid Beheshti University of Medical Sciences—each produced 8 publications, demonstrating a diverse international presence. Additionally, University College London is also among the key contributors with 8 papers, and Capital Medical University rounds out the top ten with 7 articles. This data indicates a wide geographical distribution of research activity, reflecting the global importance of studies on oxidative stress.

Table 4. Most Productive Authors Based on Total and Fractionalized Article Counts

Rank	Authors	Articles	Articles Fractionalized
1	Başa M	5	1,42
2	Häussinger D	5	0,77
3	Li J	5	0,65
4	Liu X	5	0,76
5	Roşoiu N	5	1,42
6	Wang J	5	0,56
7	Yang Y	5	0,54
8	Zhang Y	5	0,73
9	Bosch J	4	0,61
10	George J	4	0,72

The number off publications and citations by different authors

An evaluation of the most productive individual authors in the field of oxidative stress research reveals notable contributors based on both total and fractionalized publication counts (Table 4). Başa M and Roşoiu N lead the list, each having authored 5 articles

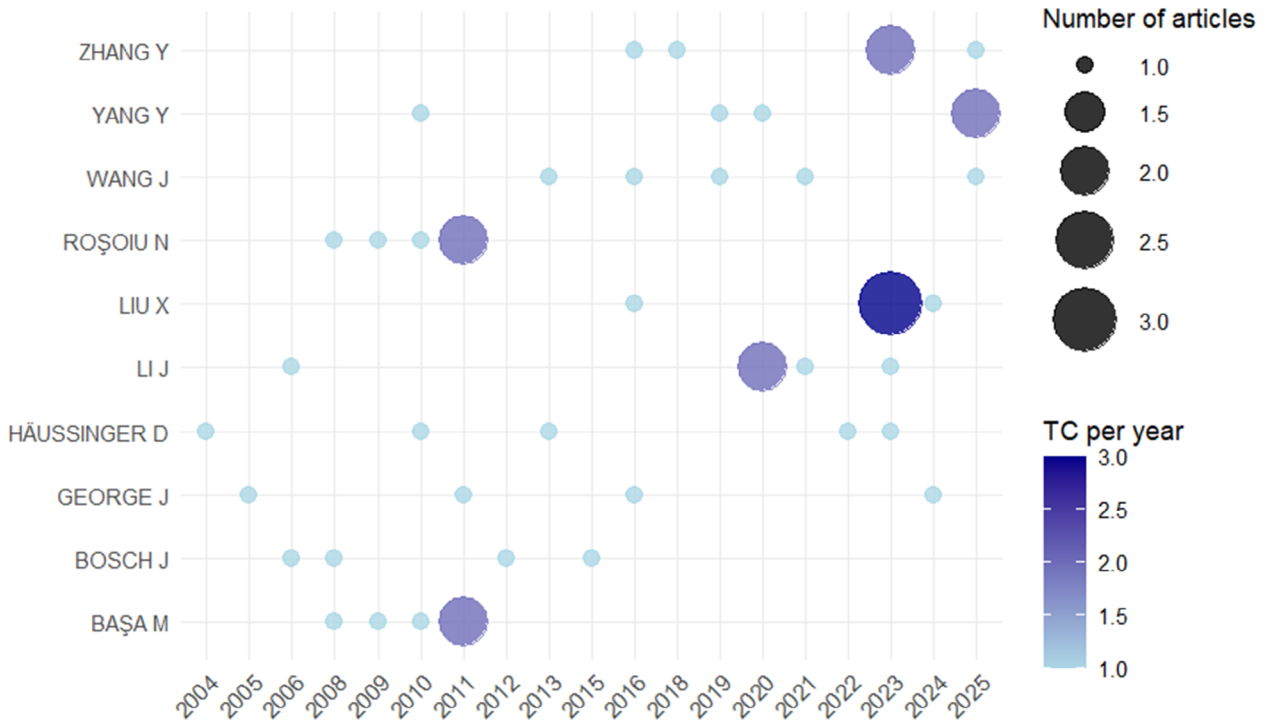

Figure 4. Authors' production over time.

with a fractionalized contribution of 1.42, indicating substantial authorship roles in multi-authored works. Häussinger D (19), Liu X (20), and Zhang Y(21) follow closely, each with 5 articles and fractionalized values ranging from 0.73 to 0.77, suggesting moderate levels of contribution across collaborative studies. Other frequently publishing authors include Li J(22), Wang J(23), and Yang Y(24), all with 5 publications, but with comparatively lower fractionalized scores (0.54–0.65), possibly reflecting smaller individual contributions within co-authored works. Notably, Bosch J and George J each contributed to 4 articles, maintaining moderate fractionalized scores (0.61 and 0.72, respectively), underscoring their consistent engagement in the research area despite a slightly lower output.

Journal publications

The analysis of author productivity, as shown in Table 4 and Figure 4, revealed the most prolific contributors to research on oxidative stress in liver cirrhosis. The highest number of publications (five articles) was recorded for authors such as Başa M, Roşoiu N, Häussinger D, Li J, Liu X, Wang J, Yang Y, And Zhang Y. Additionally, Bosch J and George J each published four articles. When adjusted for fractional authorship, which accounts for each author's contribution to multi-authored publications, Başa M and Roşoiu N had the highest values of 1.42, suggesting significant involvement in the published research. The fractionalized article values for other authors ranged from 0.54 to 0.77, indicating moderate levels of individual contribution within collaborative efforts. Figure 4 demonstrates the distribution of authors' scientific output over time. For example, häussinger d showed continuous publishing activity from 2005 to 2023. Authors like Liu X, Li J, and Yang Y became more active after 2016, reflecting an increasing interest in the topic in recent years. The size of each circle represents the number of articles per year, while the color intensity indicates the average number of citations per year, thus reflecting both research productivity and impact. Overall, a noticeable increase in publication

activity was observed from 2020 to 2024, indicating a growing scientific focus on oxidative stress mechanisms in liver cirrhosis during this period.

Journal publications

Bradford's law holds that a small group of "core" journals produces the bulk of publications in any field (25). In our analysis, 10 journals fall into Zone 1, underscoring their central importance in oxidative stress and liver disease research (Figure 5). Hepatology leads with 13 articles, followed by Journal of Hepatology (11 articles) and Hepatology Communications (10 articles) (Table 5); together, these three outlets account for over one-third of the total output. Next are World Journal of Gastroenterology (9 articles) and Liver International (8 articles), with Free Radical Biology and Medicine (7 articles) highlighting the field's interdisciplinary reach. Although Archives of the Balkan Medical Union, Gastroenterology, Hepatology Research, and Alcoholism: Clinical and Experimental Research each contribute five or fewer articles, their high impact factors also secure them in Zone 1. Notably, 70 % of these journals rank in the first quartile (Q1) of the 2023 JCR, emphasizing their selectivity and leading role as primary sources in the discipline.

An analysis of author keywords, Figure 6 shows that "liver cirrhosis" dominates with 342 mentions, closely followed by general descriptors "human" 331 and "oxidative stress" 313. The frequent occurrence of "article" 291 reflects its routine inclusion in abstracts, while "male" 253 and "female" 245 signal the common practice of reporting sex-based analyses. Demographic labels— "adult" 211, "humans" 206, "middle aged" 141, "aged" 122 —indicate that research predominantly involves adult and elderly populations. The term "controlled study" 155 points to a strong emphasis on interventional designs. Clinical themes "fatty liver" and "nonalcoholic fatty liver" (110 each), together with "liver fibrosis" (106), underscore the ongoing interest in steatohepatitis and fibrotic pathways. Key laboratory markers— "alanine aminotransferase" 68,

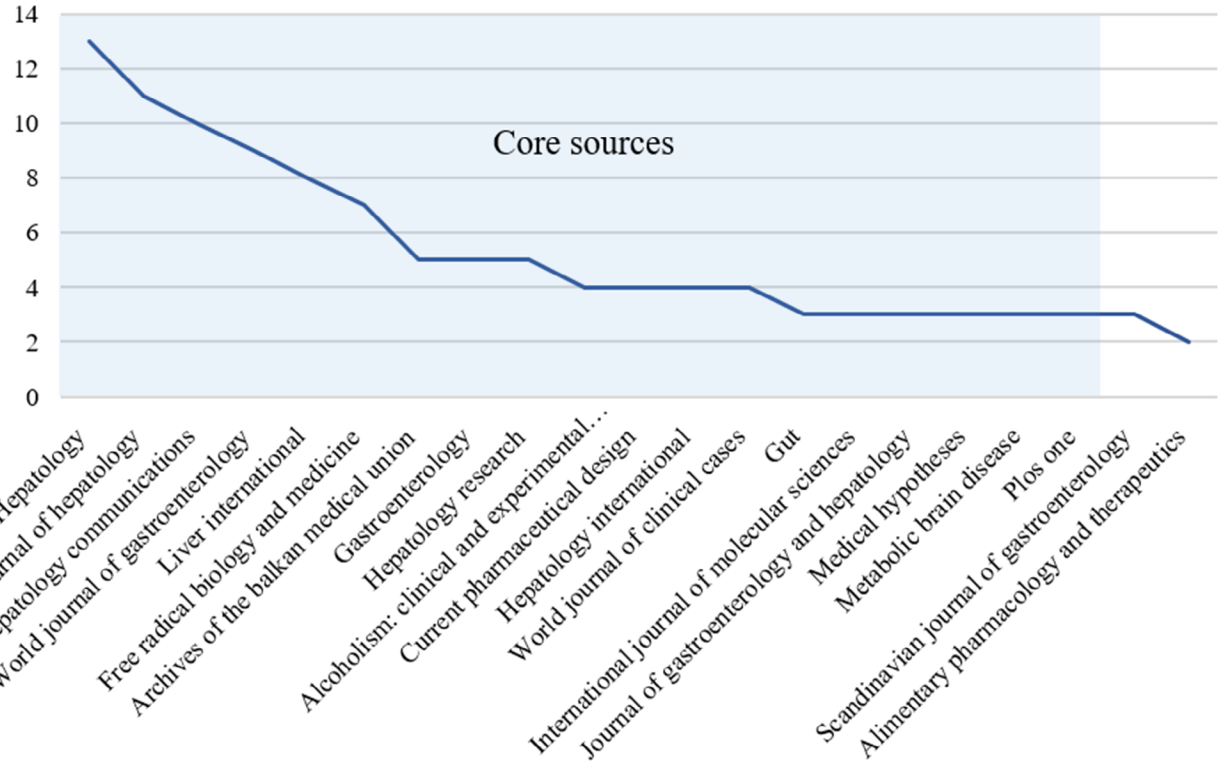

Figure 5. Core sources by Bradford's law.

Table 5. Most relevant sources

Rank	Journal	Articles	CiteScore 2023	IF 2023	Category
1	Hepatology	13	25.9	13.0	Gastroenterology & Hepatology (Q1)
2	Journal of Hepatology	11	28.0	26.8	Gastroenterology & Hepatology (Q1)
3	Hepatology Communications	10	7.2	5.7	Gastroenterology & Hepatology (Q2)
4	World Journal of Gastroenterology	9	7.8	4.3	Gastroenterology & Hepatology (Q2)
5	Liver International	8	11.2	6.0	Gastroenterology & Hepatology (Q2)
6	Free Radical Biology and Medicine	7	14.0	8.9	Biochemistry & Molecular Biology/ Medicine (misc) (Q1)
7	Archives of the Balkan Medical Union	5	0.23	0.21	Medicine (misc) (Q4)
8	Gastroenterology	5	28.4	22.7	Gastroenterology & Hepatology (Q1)
9	Hepatology Research	5	4.8	3.9	Gastroenterology & Hepatology (Q3)
10	Alcoholism: Clinical and Experimental Research	4	6.8	3.8	Substance Abuse (Q3)

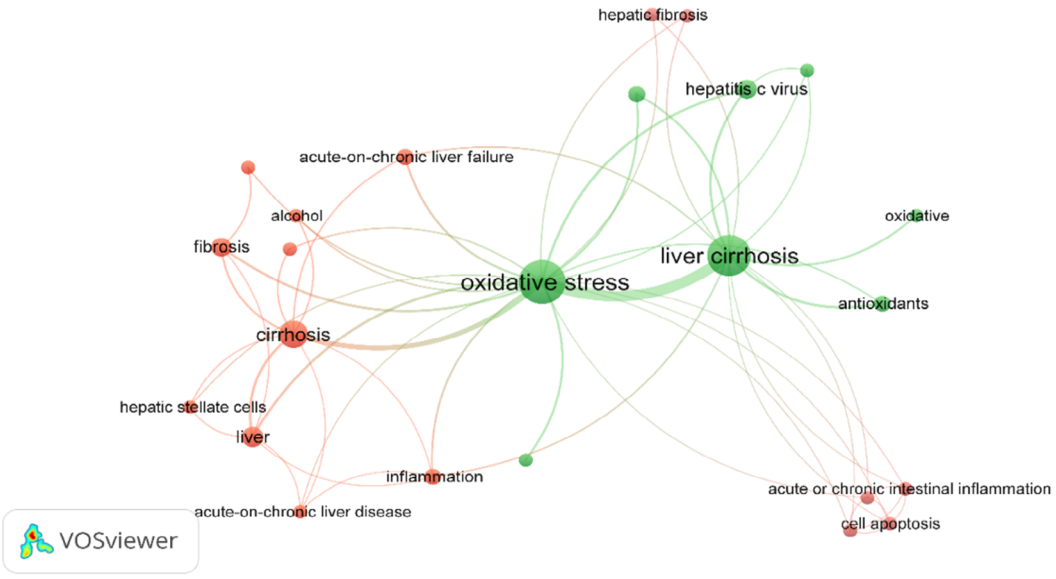

Figure 6. Co-occurrence network of author keywords in oxidative stress and liver cirrhosis research.

"aspartate aminotransferase" 57, "bilirubin" 55, "lipid peroxidation" 51—highlight intensive investigation of enzymatic and oxidative processes. Similarly, "inflammation" 68 and "reactive oxygen metabolite" 67 emphasize the role of inflammatory and lipid-peroxidation cascades. Clinical and mechanistic concepts— "disease severity" 50, "pathogenesis" 38, "liver injury" 37, "fibrogenesis" 27—reflect a focus on the progression and underlying drivers of hepatic damage. Metabolically related terms, notably "insulin resistance" 59 and "diabetes mellitus" 34, remain prominent, illustrating the interplay between metabolic disorders and liver pathology. Molecular-level investigations are evident in frequent mentions of "gene expression" 43, "protein

Table 6. Trend topics

Term	Frequency	Year (Median)
fatty acids	5	2003
selenium	9	2004
oxidation-reduction	6	2004
correlation analysis	9	2005
Smad-3 protein	7	2005
urine level	5	2005
ascorbic acid	17	2006
cells	7	2006
cultured	7	2006

expression" 56, and "signal transduction" 47, all under the overarching theme of "oxidative stress" 313. Additional information on keyword trends is presented in Table 6. Together, these patterns demonstrate a comprehensive, multidimensional research framework in hepatology, integrating patient-centered, biochemical, and molecular approaches.

The top ten most cited studies in oxidative stress and liver cirrhosis research span foundational reviews, mechanistic investigations, and translational diagnostics (Table 7). Sánchez-Valle et al. lead with an integrative review of oxidative pathways and molecular alterations that drive fibrogenesis in the liver (26). Bartsch H follows, detailing how lipid peroxidation and DNA damage under chronic inflammation contribute to carcinogenesis(27). Sanyal A's work on portal hypertension assesses both hemodynamic changes and oxidative biomarkers in cirrhotic complications (28), while Chu H's work offers a microbiota-centric analysis of nonalcoholic fatty liver disease, uncovering key metabolite–host interactions(29). Epidemiological overviews by Zelber-Sagi (30) and Harold E.Seifried (31) synthesize the roles of diet and exercise in the progression of steatohepatitis, while Mehta (32) highlights the potential of antioxidants in managing NAFLD. De Maria N (33) provides early clinical evidence linking reactive oxygen species to hepatitis C activity. Padgett K (34) reveals dysregulated hepatic microRNAs in primary biliary cirrhosis as mediators of oxidative injury. Jain S (35) demonstrates that oxidative stress is evident even in the initial stages of chronic hepatitis C, challenging the assumption that such damage arises only late in the disease. Collectively, these ten works establish the core literature on oxidative mechanisms, fibrotic remodeling, and noninvasive biomarkers in chronic liver disease.

Discussion

The present bibliometric analysis offers a comprehensive overview of research trends in oxidative stress and liver cirrhosis, highlighting key contributions, patterns of international collaboration, and evolving scientific interests. Our findings demonstrate a steady increase in publication output, with an annual growth rate of 7.54%, reflecting sustained academic engagement with this topic. The high average citation count (41.41 per document) further underscores the field's scientific impact, particularly in elucidating oxidative mechanisms underlying liver fibrosis and cirrhosis progression. The United States emerged as the leading contributor, accounting for over 50 publications and accumulating 3,175 citations, reinforcing its dominant role in oxidative stress research. This aligns with previous studies indicating that high-income countries often drive scientific advancements in hepatology due to greater research funding and infrastructure (41). However, Mexico exhibited the highest average citations per article (131.6), suggesting that even nations with lower publication volumes can produce highly influential studies. International collaboration MCP was limited (1.572%), with the United Kingdom and Turkey showing the highest proportion of co-authored publications. This finding contrasts with broader trends in biomedical research, where cross-border collaborations have been increasing (28). The relatively low international cooperation in this niche may reflect the specialized nature of oxidative stress studies in cirrhosis, where regional expertise and patient cohorts play a significant role. The University of Barcelona and the University of Washington were the most productive institutions, consistent with their strong emphasis on hepatology and translational research. Notably, fractional authorship analysis revealed that Başa M and Roşoiu N had the highest individual contributions (1.42 fractionalized articles), whereas other

Table 7. The 10 most frequently cited, high-quality papers focusing on oxidative stress in liver cirrhosis research

Rank	Article	1st author	Total Citations	TC per Year	Y_P
1	Role of Oxidative Stress and Molecular Changes in Liver Fibrosis: A Review (36)	Sánchez-Valle V	493	35,21	2012
2	Chronic inflammation and oxidative stress in the genesis and perpetuation of cancer: role of lipid peroxidation, DNA damage, and repair(27)	Bartsch H	423	21,15	2006
3	Portal Hypertension and Its Complications(28)	Sanyal A	285	15,83	2008
4	Small metabolites, possible big changes: a microbiota-centered view of non-alcoholic fatty liver disease(37)	Chu H	268	38,29	2019
5	Nutrition and physical activity in NAFLD: An overview of the epidemiological evidence(30)	Zelber-Sagi S	258	17,20	2011
6	Nonalcoholic fatty liver disease: predisposing factors and the role of nutrition(38)	Cave M	249	13,11	2007
7	Nonalcoholic Fatty Liver Disease: Pathogenesis and the Role of Antioxidants[32]	Mehta K	223	9,29	2002
8	Association between reactive oxygen species and disease activity in chronic hepatitis C(39)	De M N	216	7,20	1996
9	Primary biliary cirrhosis is associated with altered hepatic microRNA expression(34)	Padgett K	194	11,41	2009
10	Oxidative stress in chronic hepatitis C: not just a feature of late-stage disease(40)	Jain S	190	7,92	2002

leading authors, such as Häussinger D and Zhang Y, demonstrated consistent productivity over time. This suggests that while collaborative research dominates the field, certain researchers maintain a substantial independent impact. Bradford's law identified Hepatology, Journal of Hepatology, and Hepatology Communications as core journals, collectively contributing over one-third of the analyzed articles. The predominance of Q1-ranked journals, at 70%, indicates that oxidative stress in liver cirrhosis is a high-impact topic within gastroenterology and hepatology. This aligns with prior bibliometric studies showing that oxidative mechanisms are central to understanding liver disease progression (29). Keyword analysis revealed that "liver cirrhosis," "oxidative stress," and "human" were the most frequently used terms, reflecting the clinical and experimental focus of the research. The prominence of terms like "nonalcoholic fatty liver," "lipid peroxidation," and "inflammation" highlights the interplay between metabolic dysfunction, oxidative damage, and fibrogenesis—a key area of investigation in recent years(30). Recent studies have shown that nanoformulated curcumin significantly reduces oxidative damage and improves hepatocyte survival in alcohol-related

liver disease models, making it a promising therapeutic candidate (42–44). This is further supported by recent evidence showing that oxidative stress is a central driver of liver cell injury in alcohol-related liver disease through lipid, protein, and DNA oxidation (42,45). Additionally, the frequent mention of "alanine aminotransferase" and "aspartate aminotransferase" underscores the importance of enzymatic biomarkers in assessing liver injury. The most cited papers (Table 7) emphasize oxidative stress as a critical driver of liver fibrosis, carcinogenesis, and metabolic dysfunction. Sánchez-Valle et al. (2012) and Bartsch H (2006) laid foundational insights into molecular pathways, while more recent works, such as Chu H, explored microbiota-host interactions in NAFLD (31,46,47). This shift toward gut-liver axis research suggests an evolving focus on microbiome-related oxidative mechanisms. This is corroborated by the rising number of studies linking gut microbiota to NAFLD pathogenesis, particularly those exploring dietary and lifestyle influences (48).

Limitations and future directions

While this study provides a robust bibliometric assessment, certain limitations must be acknowledged. First, the analysis was restricted to articles indexed in selected databases, potentially excluding regional journals. Second, citation metrics may favor older publications due to longer accumulation periods. Future research should explore emerging themes, such as the role of mitochondrial dysfunction and antioxidant therapies in cirrhosis management.

Conclusion

This bibliometric analysis systematically maps the global research landscape on oxidative stress in liver cirrhosis, revealing key trends, contributors, and thematic clusters. The findings highlight the United States, China, and Italy as leading hubs of productivity, with the University of Barcelona as the most active institution. The evolution of research themes—from molecular mechanisms (e.g., lipid peroxidation, mitochondrial dysfunction) to clinical applications (e.g., antioxidant therapies, biomarkers)—reflects a growing interdisciplinary focus. By identifying collaboration networks and emerging topics, this study provides a foundational roadmap for future research prioritization and international cooperation in the field.

Ethic Approval: Not applicable.

Conflicts of Interest: Each author declares that he or she has no commercial associations (e.g. consultancies, stock ownership, equity interest, patent/licensing arrangement etc.) that might pose a conflict of interest in connection with the submitted article.

Authors Contribution: Conceptualization: S.K., K.B. Project administration and correspondence: K.B. Data curation: K.K. Formal analysis: S.K., K.B. Investigation: K.T. Methodology: K.T. Resources: K.B. Software: K.K., K.T. Supervision: S.K., K.B.Writing – original draft: K.B., M.M. Writing – review and editing: S.K., K.K., K.T. All authors have read and approved the final version of the manuscript.

Declaration on the Use of AI: None.

Consent for Publication: Not applicable.

Acknowledgments: None.

Preprint Note: A previous version of this manuscript was posted as a preprint on Research Square on December 17, 2024 (DOI: https://doi.org/10.21203/rs.3.rs-5648355/v1). The current version, Submitted to Acta Biomedica includes substantial revisions: expanded dataset (up to 2025), revised. Methods section, updated figures, and an updated author list. The preprint remains available online as a transparent, non-peer-reviewed version. This manuscript represents the final peer-reviewed work intended for journal publication.

Funding: This research was funded by the West Kazakhstan Marat Ospanov Medical University, Order No. 13/2-19-38 ATZh dated April 11, 2025. The APC was funded by the same institution.

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Received: 10 June 2025
Accepted: 23 July 2025
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