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AIMS AND SCOPE
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RESPONSIBLE EDITORS FOR THIS ISSUE
Production Editor: Yu-Xi Chen; Production Department Director: Xiang Li; Cover Editor: Jia-Ru Fan.
Mapping global research trends: Nutrition associations with nonalcoholic fatty liver disease - a Scopus bibliometric analysis

Muna Shakhshir, Sa'ed H Zyoud

Abstract

BACKGROUND
Several bibliometric analyses have been carried out to identify research hotspots and trends in nonalcoholic fatty liver disease (NAFLD) research. Nonetheless, there are still significant knowledge gaps that must be filled to advance our understanding of and ability to treat NAFLD.

AIM
To evaluate, through bibliometric and visual analysis, the current status of related research, related research frontiers, and the developmental trends in the field of diet and NAFLD.

METHODS
We retrieved publications about diet and NAFLD published between 1987 and 2022 from Scopus. Next, we used VOSviewer 1.6.20 to perform bibliometric analysis and visualization.

RESULTS
We found a total of 1905 studies, including 1637 (85.93%) original articles and 195 (10.24%) reviews, focused on the examination of NAFLD and its correlation with diet that were published between 1987 and 2022. Among the remaining five types...
of documents, 38 were letters, notes, editorials, meeting minutes, or brief surveys, representing 1.99% of the total documents. The countries with the most publications on this topic were China \((n = 539; 28.29\%)\), followed by the United States \((n = 379; 19.90\%)\), Japan \((n = 133; 6.98\%)\), and South Korea \((n = 127; 6.6\%)\). According to the citation analysis, the retrieved papers were cited an average of 32.3 times and had an \(h\)-index of 106, with 61014 total citations. The two main clusters on the map included those related to: (1) Inflammation and oxidative stress; and (2) Dietary interventions for NAFLD.

CONCLUSION
This was the first study to use data taken from Scopus to visualize network mapping in a novel bibliometric analysis of studies focused on diet and NAFLD. After 2017, the two domains that received the most attention were “dietary interventions for NAFLD” and “inflammation and oxidative stress implicated in NAFLD and its correlation with diet.” We believe that this study provides important information for academics, dietitians, and doctors, and that additional research on dietary interventions and NAFLD is warranted.

Key Words: Dietary; Nutrition; Bibliometric; Nonalcoholic fatty liver; Scopus; VOSviewer

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Core Tip: The objective of this study was to assess the current landscape of research in the field of diet and nonalcoholic fatty liver disease (NAFLD) by employing bibliometric and visual analyses. This study is the first to utilize Scopus data for visualizing network mapping in a novel bibliometric examination of diet and NAFLD studies. Post-2017, the primary areas of focus were “dietary interventions for NAFLD” and “inflammation and oxidative stress associated with nonalcoholic fatty liver disease and its relationship with diet”. These findings indicate a significant level of attention toward research in this domain, reflecting its alignment with the latest scientific advancements. We argue that our study offers valuable insights to scholars, dietitians, and medical practitioners, emphasizing the importance of further investigation into dietary interventions and NAFLD.

INTRODUCTION
Addressing the detrimental impact of nonalcoholic fatty liver disease (NAFLD) is becoming an increasing public health concern given the increasing incidence of diabetes and obesity globally[1-3]. NAFLD is a prevalent chronic liver disease in Western societies and is intricately linked to metabolic irregularities such as central obesity, dyslipidemia, hypertension, elevated blood sugar levels, and abnormal liver function tests[4]. According to the latest GLOBOCAN report, NAFLD is the primary risk factor for the onset of liver cancer and is the third leading cause of cancer-related mortality[5].

Consuming a diet abundant in saturated fatty acids (found in full-fat dairy products, ultra-processed foods, coconut and palm oils, and red meat) and sugars inundates the liver with fatty acids, exacerbating liver damage and promoting enlargement, dysfunction, systemic inflammation, and dysbiosis of adipose tissue. In contrast, achieving a 10% reduction in body weight through lifestyle changes, including the adoption of a low-fat hypocaloric diet in conjunction with regular exercise, facilitates the improvement of steatosis and inflammation and the reversal of fibrosis in patients with NAFLD[6].

During the past decade, extensive investigations have been conducted on the connections among nutrients, food, dietary patterns, and NAFLD. Understanding the role of nutrition in the treatment of patients with NAFLD represents a significant challenge. This is especially important given that lifestyle changes, including dietary adjustments, exercise, and weight loss, have been shown to be effective in the management of NAFLD. Calorie-restricted diets have shown long-term benefits, leading to improvements in various aspects of NAFLD[7]. There have been significant advancements in the treatment of NAFLD in recent years, with a focus on lifestyle modification, pharmacotherapy, and ongoing clinical trials to address the lack of approved therapies[8-11]. Lifestyle changes, including dietary modification, regular physical activity, and gradual weight loss, are considered cornerstones of NAFLD management[12-14]. These modifications have shown potential in reversing liver damage, depending on the stage of the disease[15]. Although there are currently no approved drugs for the long-term treatment of NAFLD, ongoing efforts are focused on developing pharmacological agents to improve the metabolic status of the liver and reduce cell stress, inflammation, and fibrosis[8-11]. Several agents are in pivotal trials, and it is expected that the first therapies will be approved in the coming years[8,16].

Several studies have conducted bibliometric analyses to understand the research trends and hotspots in NAFLD research. These analyses have examined the number of publications, countries/regions, institutions, authors, journals, references, and keywords related to NAFLD[17-22]. The global research profile of NAFLD indicates that the United
States, China, Italy, and Japan have been the leading contributors to the literature on NAFLD[18,19,22-25]. The research topics in this field include medicine, biochemistry, genetics, molecular biology, pharmacology, toxicology, pharmaceutics, and nursing. The development of knowledge related to NAFLD has been influenced by landmark findings that have shaped current paradigms. However, key knowledge gaps still need to be addressed in order to improve the understanding and treatment of NAFLD.

**MATERIALS AND METHODS**

**Study design**
We performed a cross-sectional bibliometric study investigating publications pertaining to NAFLD and diet.

**Database**
We chose the Scopus database as the sole repository for evaluating the global scientific output regarding nutrition and its association with NAFLD because of its comprehensive coverage and advanced search capabilities. Google Scholar is the most extensive database for accessing a large number of relevant publications on any given topic compared to other databases, such as Web of Science, SciVerse Scopus, or PubMed[26-30]. However, Google Scholar does not provide metric analysis. The Scopus database is a comprehensive collection of more than 24000 indexed publications covering several scientific disciplines and includes extensive metric analysis capabilities. Therefore, Scopus was utilized in the current investigation despite its lower quantity of indexed articles compared to Google Scholar[31-33]. In bibliometric research, researchers typically rely on a single database because of the difficulties of applying bibliometric indicators and conducting literature mapping across multiple databases[34]. Scopus, which encompasses nearly all of PubMed’s content and boasts twice the number of indexed journals as Web of Science, is regarded as a comprehensive and encompassing publication from both PubMed and Web of Science[28].

**Search strategies**
We used advanced search functions with specific keywords in the Scopus online database to find publications on the topic of NAFLD and diet. Our approach included using different terms for both diet and NAFLD, as follows.

**Step 1:** In the first step, relevant terms for NAFLD were extracted from the Medical Subject Headings (MeSH) database in PubMed and subsequently entered into the Scopus database. The following terms were used in the title of the article: “NAFLD OR nonalcoholic fatty liver OR nonalcoholic fatty liver OR nonalcoholic steatohepatitis OR nonalcoholic steatohepatitis OR nonalcoholic fatty liver OR nonalcoholic fatty liver OR nonalcoholic steatohepatitis”.

**Step 2:** Following the previous step, we refined our search by limiting identified publications to those incorporating the terms “diets” and associated expressions in their titles. The following terms were used in the title search: “TITLE (nutri*) OR TITLE (diet*) OR TITLE (eat*) OR TITLE (feeding) OR TITLE (food*)”. We selected terms associated with diet from the existing bibliometric literature on diet[35-38] and MeSH from PubMed.

**Step 3:** The research focused exclusively on peer-reviewed scientific journal articles, excluding books, book chapters, retracted articles, and errata. In addition, searches were performed with no restriction on the language of the publications.

**Step 4:** Due to the rapid update cycle of the database, literature retrieval was performed on a specific day, November 28, 2023. Consequently, the study considered publications from the entire previous year, up to December 31, 2022.

**Validation of the search query**
The current investigation validated the search query using two distinct criteria. Initially, two experts in bibliometric sciences assessed the 100 most cited documents and those with even numerical identifiers (120, 140, 160, 180, etc) in the retrieved document list. The authors meticulously examined the documents presented in an Excel spreadsheet to detect any false-positive results. In case of disagreement, the principal investigator made the final judgement. The absence of false-positive results served as an indicator of validity, and the author refined the search query iteratively until both reviewers agreed on its absence.

After validating the data, the experts were instructed to compare the publication counts of the top 30 active authors on diet and NAFLD with the actual number of relevant articles attributed to them in their Scopus profiles. To assess the significance and correlation, the results obtained from both methods were tested for correlation. The correlation test revealed a robust correlation coefficient (r = 0.982), and the statistical significance (P < 0.001) emphasized the precision of the search query. This dual-method approach aimed to confirm the absence of false-negative outcomes, drawing inspiration from established bibliometric studies[31,36,39-41].

Importantly, the title search methodology, which included keywords, was used to enhance the reliability of the approach, as opposed to a title/abstract/keyword search. Consequently, the title search methodology emerged as a reliable method with minimal occurrences of false-positive documents, in contrast to the title/abstract/keyword search [31,33,38,40], which yielded numerous false positives without a specific focus on diet or NAFLD.
Data analysis and visualization

We extracted key information from articles meeting specific criteria, including the title, research institution, country/region, year of publication, publication type, journal, funding agencies, number of citations, 2022 impact factor (IF), and the Hirsch index (h-index). The h-index, denoting papers published and cited ≥ h, indicates high-quality output from researchers[42]. Microsoft Excel 2019 was used to create tables, and SciVal was used for bibliometric analysis, categorizing the data into production, impact, and collaboration indicators. The Impact Index Per Article is shown for the top 10 most cited papers drawn from the Reference Citation Analysis (RCA) database. RCA, a publicly accessible citation analysis database covering various disciplines, is owned by Baishideng Publishing Group Inc., with its headquarters located in Pleasanton, CA, United States[43-45].

VOSviewer (version 1.6.20; Leiden University, the Netherlands) facilitated the data processing and visualization. VOSviewer is a widely used tool for generating bibliometric network maps that was developed by Van Eck and Waltman [46,47] and Waaijer et al[48]. In this study, co-authorship analysis of countries and co-occurrence analysis of terms in titles and abstracts were performed. Two types of visualization maps were generated, depicting networks or overlays with different meanings. Nodes represent elements such as countries, while links denote relationships. The node and link sizes reflect factors such as publications or occurrences. Colors distinguish clusters as hot topics or corresponding average appearing years in these knowledge maps.

RESULTS

General description of the retrieved publications

Between 1973 and 2022, our comprehensive global search identified a substantial collection of 23124 documents related to NAFLD, as evidenced by their titles. Within this body of scholarly work, 1905 articles published from 1987 to 2022 specifically examined NAFLD and its correlation with diet. The vast majority of these publications were articles - 1637 documents or 85.93% of the total publications. We found a total of 195 reviews, comprising 10.24% of the publications. The remaining five publication types, including letters, notes, editorials, meeting minutes, and brief surveys, collectively contributed 38 documents, representing 1.99% of the total.

Growth and productivity trends

Over the course of the study period, there was a consistent increase in the number of publications addressing the relationship between diet and NAFLD. Figure 1 illustrates this upward trend, starting from a single publication in 1987 and reaching 289 by 2022. The initial phase, spanning from 1987 to 2004, represents a plateau in the field’s development, marked by the publication of 16 papers. The subsequent stage, from 2005 to 2012, reflects a period of gradual growth, with an average annual increase of approximately 27 publications. The third stage, spanning from 2013 to 2022, signifies a rapid development phase, with an annual publication count of approximately 167, constituting more than 87% of the total included studies. Statistical analysis through linear regression validated this trend, revealing a robust positive correlation ($R^2 = 0.9411, P < 0.001$) between the annual publication count and the corresponding publication year.

Top active countries

Research efforts on NAFLD and its association with dietary factors were actively undertaken in more than 93 countries between 1987 and 2022. The primary focus of the investigation led to the collective publication of 1517 articles by the top ten contributing nations, including 79.55% of the total contributions in this scientific domain (as shown in Table 1). China demonstrated preeminence in this endeavor, contributing significantly with 539 articles (28.29%), followed by the United States with 379 articles (19.90%), Japan with 133 articles (6.98%), and South Korea with 127 articles (6.67%).

Moreover, noteworthy trends in international collaboration were observed, particularly involving the United States, China, and the United Kingdom. These countries had the highest engagement in collaborative research involving scholars from diverse geographical locations. A visual representation of the intricate web of international research collaborations pertaining to insulin resistance and NAFLD spanning the period from 1987 to 2022 is shown in Figure 2. This figure presents a network mapping chart depicting the connections among key participating countries.

Top ten active institutions

Table 2 presents a comprehensive listing of the ten most prolific institutions engaged in research pertaining to NAFLD and diet over the period spanning from 1987 to 2022. These leading academic and research entities collectively contributed significantly, with 9.81% of the overall body of published articles ($n = 187$) in this field. Shahid Beheshti University of Medical Sciences in Iran was the largest contributor, publishing 39 articles (2.05%), followed by the Ministry of Education of the People’s Republic of China in China, with 36 articles (1.89%), and the Huazhong University of Science and Technology in China, with 27 articles (1.42%). China had five institutions on the list, Iran had three, and Brazil and Spain each had one.

Top ten funding agencies

A comprehensive analysis of the 1029 retrieved publications, which constituted 54.02% of the dataset, revealed a substantial reliance on funding. Table 3 delineates the primary contributors in terms of funding for research on NAFLD and its association with dietary factors from 1987 to 2022. These top 10 funding agencies collectively played a pivotal role, contributing 27.19% ($n = 518$) of the entire body of published articles. The National Natural Science Foundation of China,
Table 1 List of the top 10 countries publishing research on diet and nonalcoholic fatty liver disease from 1987 to 2022

<table>
<thead>
<tr>
<th>Ranking</th>
<th>Country</th>
<th>Number of documents</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td>China</td>
<td>539</td>
<td>28.29</td>
</tr>
<tr>
<td>2nd</td>
<td>United States</td>
<td>379</td>
<td>19.90</td>
</tr>
<tr>
<td>3rd</td>
<td>Japan</td>
<td>133</td>
<td>6.98</td>
</tr>
<tr>
<td>4th</td>
<td>South Korea</td>
<td>127</td>
<td>6.67</td>
</tr>
<tr>
<td>5th</td>
<td>Italy</td>
<td>117</td>
<td>6.14</td>
</tr>
<tr>
<td>6th</td>
<td>Iran</td>
<td>114</td>
<td>5.98</td>
</tr>
<tr>
<td>7th</td>
<td>Brazil</td>
<td>74</td>
<td>3.88</td>
</tr>
<tr>
<td>8th</td>
<td>Spain</td>
<td>72</td>
<td>3.78</td>
</tr>
<tr>
<td>9th</td>
<td>United Kingdom</td>
<td>67</td>
<td>3.52</td>
</tr>
<tr>
<td>10th</td>
<td>Germany</td>
<td>60</td>
<td>3.15</td>
</tr>
</tbody>
</table>

Table 2 List of the top 10 institutions publishing research on diet and nonalcoholic fatty liver disease from 1987 to 2022

<table>
<thead>
<tr>
<th>Ranking</th>
<th>Institute</th>
<th>Country</th>
<th>No. of documents</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td>Shahid Beheshti University of Medical Sciences</td>
<td>Iran</td>
<td>39</td>
<td>2.05</td>
</tr>
<tr>
<td>2nd</td>
<td>Ministry of Education of the People’s Republic of China</td>
<td>China</td>
<td>36</td>
<td>1.89</td>
</tr>
<tr>
<td>3rd</td>
<td>Huazhong University of Science and Technology</td>
<td>China</td>
<td>27</td>
<td>1.42</td>
</tr>
<tr>
<td>4th</td>
<td>Iran University of Medical Sciences</td>
<td>Iran</td>
<td>23</td>
<td>1.21</td>
</tr>
<tr>
<td>5th</td>
<td>Tehran University of Medical Sciences</td>
<td>Iran</td>
<td>22</td>
<td>1.15</td>
</tr>
<tr>
<td>6th</td>
<td>Tongji Medical College of Huazhong University of Science and Technology</td>
<td>China</td>
<td>21</td>
<td>1.10</td>
</tr>
<tr>
<td>7th</td>
<td>Instituto de Salud Carlos III</td>
<td>Spain</td>
<td>20</td>
<td>1.05</td>
</tr>
<tr>
<td>8th</td>
<td>Tianjin Medical University</td>
<td>China</td>
<td>20</td>
<td>1.05</td>
</tr>
<tr>
<td>9th</td>
<td>Universidade de São Paulo</td>
<td>Brazil</td>
<td>19</td>
<td>1.00</td>
</tr>
<tr>
<td>10th</td>
<td>Shanghai University of Traditional Chinese Medicine</td>
<td>China</td>
<td>19</td>
<td>1.00</td>
</tr>
</tbody>
</table>

1Gap is left in the next ranking number when specific institutions are given the same number.

Table 3 List of the top 10 funding agencies with the most publications on diet and nonalcoholic fatty liver disease from 1987 to 2022

<table>
<thead>
<tr>
<th>Ranking</th>
<th>Funding agency</th>
<th>Country</th>
<th>No. of documents</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td>National Natural Science Foundation of China</td>
<td>China</td>
<td>246</td>
<td>12.91</td>
</tr>
<tr>
<td>2nd</td>
<td>National Institutes of Health</td>
<td>United States</td>
<td>88</td>
<td>4.62</td>
</tr>
<tr>
<td>3rd</td>
<td>National Institute of Diabetes and Digestive and Kidney Diseases</td>
<td>United States</td>
<td>84</td>
<td>4.41</td>
</tr>
<tr>
<td>4th</td>
<td>Japan Society for the Promotion of Science</td>
<td>Japan</td>
<td>48</td>
<td>2.52</td>
</tr>
<tr>
<td>5th</td>
<td>National Research Foundation of Korea</td>
<td>South Korea</td>
<td>42</td>
<td>2.20</td>
</tr>
<tr>
<td>6th</td>
<td>Ministry of Science and Technology, Taiwan</td>
<td>Taiwan</td>
<td>28</td>
<td>1.47</td>
</tr>
<tr>
<td>7th</td>
<td>National Cancer Institute</td>
<td>United States</td>
<td>26</td>
<td>1.36</td>
</tr>
<tr>
<td>8th</td>
<td>National Institute on Alcohol Abuse and Alcoholism</td>
<td>United States</td>
<td>25</td>
<td>1.31</td>
</tr>
<tr>
<td>9th</td>
<td>National Key Research and Development Program of China</td>
<td>China</td>
<td>24</td>
<td>1.26</td>
</tr>
<tr>
<td>10th</td>
<td>National Institute of Environmental Health Sciences</td>
<td>United States</td>
<td>22</td>
<td>1.15</td>
</tr>
</tbody>
</table>
Shakhshir M et al. NAFLD and nutrition

Figure 1 Growth trend of publications on diet and nonalcoholic fatty liver disease from 1987 to 2022.

Figure 2 Mapping international research collaborations in diet and nonalcoholic fatty liver disease: A comprehensive overview from 1987 to 2022. The intricate network of collaboration among prominent countries in the field was explored. The map highlights connections based on a minimum of 20 publications per country. Of the 93 active countries, 19 met this threshold, with the node size reflecting the number of publications. This map was created by VOSviewer software version 1.6.20.

Based in China, emerged as the most prominent funding agency, supporting 246 articles (12.91%). The National Institutes of Health in the United States was second (88 articles; 4.62%), and the National Institute of Diabetes and Digestive and Kidney Diseases in the United States was third (84 articles; 4.41%).

Top ten most active journals
As shown in Table 4, the foremost decile of journals/source titles collectively contributed to approximately 20.41% of the aggregate publications concerning research on NAFLD and its association with dietary factors. *Nutrients*, which had an IF
Table 4 List of the top 10 journals publishing research on diet and nonalcoholic fatty liver disease from 1987 to 2022

<table>
<thead>
<tr>
<th>Ranking</th>
<th>Journal</th>
<th>Frequency</th>
<th>%</th>
<th>IF</th>
</tr>
</thead>
<tbody>
<tr>
<td>1&lt;sup&gt;st&lt;/sup&gt;</td>
<td>Nutrients</td>
<td>120</td>
<td>6.30</td>
<td>5.9</td>
</tr>
<tr>
<td>2&lt;sup&gt;nd&lt;/sup&gt;</td>
<td>Journal of Nutritional Biochemistry</td>
<td>37</td>
<td>1.94</td>
<td>5.6</td>
</tr>
<tr>
<td>3&lt;sup&gt;rd&lt;/sup&gt;</td>
<td>International Journal of Molecular Sciences</td>
<td>36</td>
<td>1.89</td>
<td>5.6</td>
</tr>
<tr>
<td>4&lt;sup&gt;th&lt;/sup&gt;</td>
<td>PLoS One</td>
<td>35</td>
<td>1.84</td>
<td>3.7</td>
</tr>
<tr>
<td>5&lt;sup&gt;th&lt;/sup&gt;</td>
<td>Food and Function</td>
<td>30</td>
<td>1.57</td>
<td>6.1</td>
</tr>
<tr>
<td>5&lt;sup&gt;th&lt;/sup&gt;</td>
<td>Hepatology</td>
<td>30</td>
<td>1.57</td>
<td>14.0</td>
</tr>
<tr>
<td>7&lt;sup&gt;th&lt;/sup&gt;</td>
<td>Scientific Reports</td>
<td>29</td>
<td>1.52</td>
<td>4.6</td>
</tr>
<tr>
<td>8&lt;sup&gt;th&lt;/sup&gt;</td>
<td>World Journal of Gastroenterology</td>
<td>27</td>
<td>1.42</td>
<td>4.3</td>
</tr>
<tr>
<td>9&lt;sup&gt;th&lt;/sup&gt;</td>
<td>Frontiers in Nutrition</td>
<td>23</td>
<td>1.21</td>
<td>5.0</td>
</tr>
<tr>
<td>10&lt;sup&gt;th&lt;/sup&gt;</td>
<td>Liver International</td>
<td>22</td>
<td>1.15</td>
<td>6.7</td>
</tr>
</tbody>
</table>

<sup>1</sup>Gap is left in the next ranking number when specific journals are given the same number;
<sup>2</sup>Impact factor based on Clarivate Analytics Journal Citation Reports 2022. IF: Impact factor.

of 5.9 in 2023, emerged as the most prolific source, with 120 publications. Thirty-seven publications were published in the Journal of Nutritional Biochemistry, with an IF of 5.6 in 2023, and 36 were published in the International Journal of Molecular Sciences, with an IF of 5.6 in 2023.

**Analysis of citations**

Through the implementation of citation analysis, it was ascertained that the collected articles had an average of 32.03 citations, resulting in an h-index of 106 and a cumulative total of 61014 citations. Within this corpus of articles, 122 had no citations and 124 had more than 100 citations each. The citation count for these articles ranged from 0 to 1058. Table 5 lists the top ten publications related to NAFLD and its correlation with diet, accounting for a cumulative total of 5927 citations. The citation range for these publications was from 378 to 1058.<sup>[49-58]</sup> The Impact Index Per Article of the 10 most cited articles ranged from 16.7 to 102.4.

**Research themes**

We analyzed the content of the 1905 publications with VOSviewer 1.6.20 software. We constructed term co-occurrence network maps to delineate prominent themes within the research area, as shown in Figure 3. These maps visually represent the connections among the terms found in the titles and abstracts of the publications pertaining to diet and NAFLD from 1987 to 2022. We applied a minimum-term occurrence threshold of 50, resulting in the identification of 236 terms out of a total of 31407 within this domain. Subsequently, we grouped these terms into two distinct clusters, each assigned a unique color. The size of individual nodes in the map corresponds to the frequency with which a term was employed across multiple publications. As depicted in Figure 3, the two primary clusters were: The “inflammation and oxidative stress” cluster (shown in red) highlights the association between high-fat diets and increased inflammation and oxidative stress, contributing to the development and progression of NAFLD. The “dietary interventions for NAFLD” cluster (shown in green) emphasizes the exploration of various dietary patterns, including the Mediterranean diet, low-carbohydrate diets, and intermittent fasting, for their potential to ameliorate histologic components of fatty liver disease. The green cluster includes key dietary factors linked to disease pathogenesis and progression, such as intake of high fructose corn syrup and carbohydrates.

**Future research direction analysis**

In Figure 4, VOSviewer used a color assignment to distinguish each term, determined by its mean frequency across all retrieved publications. The color palette indicates the temporal distribution of term occurrences, with blue signifying earlier instances and yellow denoting more recent occurrences. Subsequent to 2017, the predominant focus within this domain centered on “inflammation and oxidative stress implicated in NAFLD and its correlation with diet” and “dietary interventions for NAFLD”. The majority of significant issues in this field have increased in recent years.

**DISCUSSION**

This descriptive study and quantitative analysis focused on worldwide research publications associated with diet and NAFLD. Given the evolving epidemiology of morbidity and mortality related to NAFLD, it is crucial to assess both the quantity and quality of research in this domain. This bibliometric analysis aimed to reveal significant milestones and advancements in the field, identify existing gaps, recognize emerging trends, and guide the trajectory of future research.
### Table 5 List of the top 10 most cited papers related to diet and nonalcoholic fatty liver disease from 1987 to 2022

<table>
<thead>
<tr>
<th>Ref.</th>
<th>Title</th>
<th>Journal</th>
<th>Cited by</th>
<th>Impact index per article</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bedogni et al [49], 2005</td>
<td>Prevalence of and risk factors for nonalcoholic fatty liver disease: The dionysos nutrition and liver study</td>
<td>Hepatology</td>
<td>1058</td>
<td>45.7</td>
</tr>
<tr>
<td>Romero-Gómez et al [54], 2017</td>
<td>Treatment of NAFLD with diet, physical activity and exercise</td>
<td>Journal of Hepatology</td>
<td>748</td>
<td>102.4</td>
</tr>
<tr>
<td>Musso et al [53], 2005</td>
<td>Dietary habits and their relations to insulin resistance and postprandial lipemia in nonalcoholic steatohepatitis</td>
<td>Hepatology</td>
<td>627</td>
<td>24.2</td>
</tr>
<tr>
<td>Bugianesi et al [50], 2005</td>
<td>A randomized controlled trial of metformin versus vitamin E or prescriptive diet in nonalcoholic fatty liver disease</td>
<td>American Journal of Gastroenterology</td>
<td>607</td>
<td>24.9</td>
</tr>
<tr>
<td>Vos et al [56], 2017</td>
<td>NASPGHAN Clinical Practice Guideline for the Diagnosis and Treatment of Nonalcoholic Fatty Liver Disease in Children: Recommendations from the Expert Committee on NAFLD (ECOn) and the North American Society of Pediatric Gastroenterology, Hepatology and Nutrition (NASPGHAN)</td>
<td>Journal of Pediatric Gastroenterology and Nutrition</td>
<td>556</td>
<td>79.4</td>
</tr>
<tr>
<td>Ryan et al [55], 2013</td>
<td>The Mediterranean diet improves hepatic steatosis and insulin sensitivity in individuals with nonalcoholic fatty liver disease</td>
<td>Journal of Hepatology</td>
<td>508</td>
<td>42.5</td>
</tr>
<tr>
<td>Zelber-Sagi et al [58], 2007</td>
<td>Long-term nutritional intake and the risk for nonalcoholic fatty liver disease (NAFLD): A population based study</td>
<td>Journal of Hepatology</td>
<td>426</td>
<td>22.5</td>
</tr>
<tr>
<td>Wouters et al [57], 2008</td>
<td>Dietary cholesterol, rather than liver steatosis, leads to hepatic inflammation in hyperlipidemic mouse models of nonalcoholic steatohepatitis</td>
<td>Hepatology</td>
<td>391</td>
<td>22.9</td>
</tr>
<tr>
<td>Huang et al [51], 2005</td>
<td>One-year intense nutritional counseling results in histological improvement in patients with nonalcoholic steatohepatitis: a pilot study</td>
<td>American Journal of Gastroenterology</td>
<td>378</td>
<td>16.7</td>
</tr>
</tbody>
</table>

1The impact index per article is based on Reference Citation Analysis. Source: Baishideng Publishing Group Inc (Pleasanton, CA 94566, United States).

in the field. NAFLD is the main cause of liver disease[59], and it affects 47 patients per 1000 people worldwide[60]. The prevalence of NAFLD has grown over time, from a reported 26% in studies from 2005 or earlier to 38% in studies from 2016 or later. It is more prevalent in men (40%) than in women (26%) [60]. This explains the increasing number of publications pertaining to diet and NAFLD from 2005 to 2012 and the subsequent increase from 2013 to 2022, which indicates an era of rapid development with an annual publication count of approximately 167. The remarkable growth trends and growth patterns in publications on the relationship between nutrition and NAFLD can be attributed to several important factors. These include the exponential growth in global scientific research on NAFLD since the 2010s, which suggests an increase in interest in the field[18,19,24]. The number of related research papers has increased dramatically as a result of the growing prevalence of NAFLD worldwide, reflecting the growing impact of this disease[61]. The idea that nutrition control is the main intervention in NAFLD may have led to interest in the relationship between nutrition and NAFLD [62]. Future research on NAFLD will be guided by a detailed awareness of the research trends and hotspots produced by bibliometric analysis[22,63].

The prevalence of NAFLD varies strongly by global region and with genetic and socioeconomic variables[64]. America and Eastern Asia are among the most diverse and multicultural regions where the prevalence of NAFLD exceeds 40%[65,66]. Southeast Asia, including Japan, China and South Korea, demonstrated preeminence in this endeavor, in addition to the United States. The high incidence of NAFLD in China, which exceeds that of the United States and Europe, has led to a significant focus on the disease in China, and is one of the main causes of many publications on the relationship of nutrition with NAFLD[67]. Research in this field may be motivated by the possibility that nonsynonymous mutations in genes regulating lipid metabolism in the Chinese population may result in an increased genetic risk of NAFLD[68]. In terms of NAFLD research, the United States is one of the most productive countries[69]. Research in the United States has shifted from adiponectin and morbid obesity to metabolic syndrome, genetics, and microbiology, indicating that it is a wide and dynamic field of research[69].

A highly cited research article, which serves as the foundation and aligns with numerous subsequent studies, was published by Bedogni et al[49] in Hepatology in 2005. The article described associations between NAFLD and various aspects of metabolic syndrome. A review article published in 2017 recommended lifestyle modification strategies, including dietary habits and physical activity, as a primary approach for managing NAFLD[54]. Examining the co-occurrence of keywords offers valuable insights into the central themes and potential directions for future research within this field. Keywords often emphasize the key topics addressed in a publication. Of the 31407 terms retrieved, 236 met the predefined threshold. Therefore, the analysis of associated keywords is beneficial for clarifying essential concepts and laying the groundwork for investigations in the field of NAFLD and diet.
Figure 3 Visualization of terms in publications on diet and nonalcoholic fatty liver disease. To elucidate the interconnections among terms within the title and abstract sections of publications related to diet and nonalcoholic fatty liver disease spanning the years 1987 to 2022, a network visualization map was constructed using VOSviewer software version 1.6.20. A minimum-term occurrence threshold of 50 was applied, leading to the identification of 236 terms of a total of 31407 in this domain. These terms were then grouped into two distinct clusters, each denoted by a unique color. The size of individual nodes on the map reflects the frequency with which a term was used across various publications.

Figure 4 Visualization of term analysis in publications on diet and nonalcoholic fatty liver disease (1987-2022). This network visualization map presents an in-depth analysis of terms extracted from the titles and abstracts of publications focusing on diet and nonalcoholic fatty liver disease. The map highlights the frequency of term usage, depicting earlier instances in blue and later occurrences in yellow. The map was created by VOSviewer software version 1.6.20.

“Inflammation and oxidative stress implicated in NAFLD and its correlation with diet” has specifically emerged as the predominant focus of our study, where more than half of the world’s population is at risk of developing NAFLD, nonalcoholic steatohepatitis, or cirrhosis in the next few decades[70]. The increased prevalence of NAFLD is driven by the increasing presence of metabolic factors, visceral adiposity, and sedentary lifestyles in people of all ages and from different ethnic groups[2]. Visceral obesity is an important risk factor for the onset of NAFLD, regardless of body mass index.
An excessive intake of carbohydrates in the diet may be linked to the overproduction of triglycerides in the liver, particularly in obese individuals. Moreover, a high carbohydrate diet and visceral adiposity in lean Asians with a normal body mass index play important roles in atherogenic dyslipidemia, hypertension, insulin resistance, type 2 diabetes and, ultimately, clusters of metabolic syndromes that have been implicated in the development of NAFLD and progression to liver disease[2,71]. The accumulation of ectopic fat, including liver fat, leads to tissue malfunction and impaired production of adipokines, which in turn encourages the release of additional proinflammatory cytokines. In addition, the development of oxidative stress results from an imbalance between the generation of reactive oxygen species and antioxidant defenses[72]. Genetic and epigenetic variables (e.g., palatin-like phospholipase domain-containing 3 and transmembrane 6 superfamily member 2 gene variants) play roles in the accumulation of too much fat or in the inability of the human body to break down fat efficiently[73].

For the treatment of fatty liver disease, no drugs have been licensed to cure this disease directly, and new drugs are often expensive and may have adverse effects after prolonged use[74]. “Dietary Interventions for NAFLD”, emerged as a key cluster within this domain. Thus, dietary adjustments and lifestyle modifications are the principal means of treating and preventing NAFLD. An unbalanced diet, sedentary lifestyle, and high access to food are considered key players in induced NAFLD. The significant consumption of added fructose, refined carbohydrates, and a high-fat diet leads to abdominal obesity, abnormal hepatic lipid buildup in the cytoplasm in 5% of hepatocytes, and steatosis[73,75]. Thus, prolonged consumption of fructose, fat, and refined carbohydrates leads to inflammation and cellular stress, which exacerbates the disease and makes hepatic diseases irreversible[76].

In contrast, hepatic steatosis can be reversed through an improved gut-liver axis, an antioxidant defense system that can shield hepatic cells from the damaging effects of reactive oxygen species, including those produced in the gastrointestinal tract as byproducts of routine cellular metabolic processes, the microbiota, and/or diet[77]. A balanced diet characterized by low saturated fat content and high antioxidant and fiber levels[58], a weight reduction of 10%, and adherence to diet and/or training therapy is linked to histological improvement, resolution of liver fat necroinflammation, and fibrosis[58-60]. Therefore, additional research should focus on investigating the effects of different dietary patterns, from their potential to improve the histologic components of fatty liver disease to their role in the development and progression of the illness from added sugars and refined carbohydrates.

The most recent nutritional guidelines for NAFLD emphasize lifestyle modifications such as eating a balanced diet, keeping a healthy weight, and exercising more. The inadequacies of NAFLD diet therapy are being addressed, and new avenues for study are being opened up, by the development of pharmaceutical therapies that aim to hit distinct molecular targets and pathways. However, lifestyle modifications remain an essential component of treatment. To address the epidemic burden of NAFLD, more research is required in addition to the development of noninvasive biomarkers, the clarification of biological pathways, the updating of screening techniques, the preparation of long-term clinical trials to identify therapeutic targets and assess the safety of new treatment options, and so on.

**Strengths and limitations**

This bibliometric investigation is the first comprehensive exploration of distribution trends and primary research priorities within the field of diet and NAFLD. A key strength of our study lies in the use of Scopus, a large literature database that has broader coverage than alternative databases. The study spans multiple years of analysis, aiming to identify pertinent literature on NAFLD. However, as with previous bibliometric studies, ours has several limitations. Primarily, despite Scopus being the largest available database, the search for studies was exclusively conducted within it. This choice may limit the generalizability of our findings, as certain documents published in unindexed journals might have been missed. Second, the accuracy and comprehensiveness of the chosen keywords significantly influence the reliability of the retrieved data. Consequently, some crucial and impactful articles may have been omitted from our representative list owing to the use of related terms in their titles. Notably, our search focused solely on terms such as “nutrition” and “NAFLD” and related terms in the title search, potentially missing publications with these terms in the abstract or text. Despite these acknowledged limitations, we are confident that our findings represent the global performance of research on NAFLD and diet.

**CONCLUSION**

This study is the first to visualize network mapping in a novel bibliometric analysis of diet and NAFLD studies conducted over the past 35 years using data from Scopus. High-income countries, especially China, the United States, and Japan, have made important contributions to the literature on the association between diet and NAFLD. Since 2017, the two areas of this domain that have received the most attention are “dietary interventions for NAFLD” and “inflammation and oxidative stress implicated in NAFLD and its correlation with diet.” These findings suggest that research in this area has received a great deal of attention and is up to date with the latest findings in science. We believe that this study provides important information for academics, dietitians, and doctors, and that additional research on dietary intervention and NAFLD is warranted.

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FOOTNOTES

Author contributions: Zyoud SH designed the study, collected the data, analyzed the data, made major contributions to the literature search and interpretation, and drafted the manuscript; Shakhshir M contributed to the conceptualization and methodology of the study, was involved in the interpretation of the data, authored the manuscript and made revisions to the final draft; All authors provided a critical review and approved the final manuscript before submission.

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REFERENCES

1. Powell EE, Wong VW, Rinella M. Non-alcoholic fatty liver disease. Lancet 2021; 397: 2212-2224 [PMID: 33894154 DOI: 10.1016/S0140-6736(20)32511-3].


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