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Article

Research Collaboration in Viral Hepatitis: A Network Analysis of 60,720 Publications over Two Decades

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Abstract: **Aim:** This study aims to analyze the structure of the co-authorship network in viral hepatitis research from 2000 to 2023 using data from the Web of Science (WoS) Core Collection. The objective is to identify key researchers, evaluate the collaborative dynamics, and understand the evolution of scientific contributions in this field. **Method:** This study utilized network analysis techniques to evaluate 60,720 publications related to viral hepatitis research indexed in the WoS Core Collection between 2000 and 2023. The analysis was conducted using Python (Version 3.10.5) in the PyCharm development environment (Software Version 2022.1.3). The co-authorship networks were assessed using macro-level indicators such as network density (the ratio of actual to possible connections), clustering coefficient (degree of node clustering), number of components (distinct connected subgroups), and average path length (average distance between nodes). Micro-level indicators including degree centrality (importance based on the number of connections), closeness centrality (proximity to other nodes), and betweenness centrality (frequency of a node on the shortest paths between others) were also analyzed. **Result:** The findings reveal that the viral hepatitis research network is characterized by low network density, indicating sparse overall collaboration. However, the clustering coefficient is high, suggesting strong collaborations within small, cohesive groups. Over the years, researchers such as Stefan Zeuzem, Maria Buti, and Fabien Zoulim have played pivotal roles, serving as central figures in the network. A noticeable increase in network density and clustering from 2020-2023 suggests growing collaboration in recent years. **Conclusion:** This study underscores the importance of international collaboration in advancing viral hepatitis research. Key researchers have emerged as influential contributors, facilitating global research activities. Network analysis provides valuable insight into the structure of these collaborations and helps identify potential areas for future research and partnerships to combat viral hepatitis globally. The results of this study should be used to reduce global healthcare disparities, promote research collaboration, and address viral hepatitis as a global public health problem.

Keywords: gastroenterology; viral hepatitis; co-authorship network analysis; network analysis; research collaboration; research trend analysis; research trends; key researchers; research strategies; internal medicine; planning future collaborative studies

Introduction

Background and Objectives

Viral hepatitis represents a significant global health challenge, with millions of people affected by hepatitis viruses annually, leading to severe liver conditions such as cirrhosis, liver cancer, and liver failure. The primary viruses responsible for viral hepatitis are hepatitis A, B, C, D, and E, with hepatitis B and C being the leading causes of chronic infection and related mortality. According to the World Health Organization (WHO), approximately 296 million people were living with chronic hepatitis B, and 58 million with chronic hepatitis C globally as of 2019. The significance of viral hepatitis research is evident in the continuous search for effective treatments, prevention strategies, and public health interventions to control the spread of these infections. International collaboration is therefore essential [1,2].

In Western countries, significant advancements have been made in both understanding the virology of hepatitis and developing antiviral therapies. However, access to treatment remains uneven, with disparities in healthcare delivery between developed and developing regions [3]. In

Asia, and particularly Japan, the burden of hepatitis B and C is pronounced due to historical patterns of infection and insufficient screening measures in the past. Japan has been a leader in the development of antiviral treatments and public health campaigns, contributing substantially to global research efforts in this field [4].

Given the complexity and widespread impact of viral hepatitis, the role of collaborative research has become increasingly crucial. Collaboration between researchers not only accelerates knowledge discovery but also fosters the development of innovative solutions to tackle global health problems. To understand the dynamics of research collaboration in the field of viral hepatitis, a detailed analysis of co-authorship networks is essential. Network analysis provides insights into how researchers and institutions interact, the extent of collaboration, and how these structures evolve over time. This study aims to explore the structure of collaborative networks in viral hepatitis research, based on the analysis of publications indexed in the Web of Science (WoS) from 2000 to 2023.

Scope of the Study

This study examines publications related to viral hepatitis research indexed in the WoS Core Collection database between 2000 and 2023. A total of 60,720 articles were selected for analysis, providing a comprehensive overview of the collaborative landscape within this specialized field over the past two decades. The dataset ensures the inclusion of the most recent publications (as of September 2024). The analysis will focus on constructing and evaluating co-authorship networks using macro-level indicators such as network density (the ratio of actual to possible connections), clustering coefficient (the degree to which nodes tend to cluster together), number of components (distinct connected subgroups within the network), and average path length (the average distance between nodes). At the micro-level, I will assess degree centrality (the number of direct connections each node has), closeness centrality (how close a node is to all other nodes), and betweenness centrality (the extent to which a node lies on the shortest path between other nodes). These metrics will help illuminate the structure and dynamics of researcher collaborations in this field.

Significance of the Study

This study holds significant value in the context of viral hepatitis research by offering a detailed exploration of the collaborative landscape within this field. Identifying major researchers and institutions involved in viral hepatitis research can help highlight leading contributors and emerging leaders. Furthermore, evaluating the progression of international collaborative research and its impact is essential for understanding how global partnerships contribute to advancements in this area. The analysis of network structures and their evolution over time can reveal critical trends, such as shifts in research focus or the emergence of new collaborative clusters.

By providing a clear picture of the current state of research and collaboration in viral hepatitis, this study not only enhances our understanding of existing networks but also sheds light on future directions and potential areas for new partnerships. The findings underscore the importance of international collaboration in addressing the complex challenges associated with viral hepatitis, highlighting the role of network analysis as a powerful tool for guiding future research strategies and fostering global cooperation.

Material and Methods

The present study investigates the co-authorship patterns in viral hepatitis research articles. I utilized the WoS Core Collection database, conducting a "Topic Search" with the keyword "Viral Hepatitis" to analyze a total of 60,720 articles published between 2000 and 2023 (as of September 2024). In this analysis, I examined who collaborated with whom in co-authoring these papers. I conducted network analysis using the Python programming language (version 3.10.5) within the integrated development environment (IDE) PyCharm (software version 2022.1.3). This study employed methodology-established principles of social network analysis [5]. I carried out the analysis in two main parts:

Macro-level Metrics:

Network Density: Calculated as the ratio of the number of edges to the maximum possible edges Between all nodes.

Clustering Coefficient: Measured the extent to which nodes form clusters by considering the number of edges among neighboring nodes and calculating the average.

Components: Identified and counted the number of subgraphs (components) where nodes are mutually connected.

Average Path Length: Evaluated the average "distance" between nodes by calculating the overall average path length in the network [6].

Micro-level Metrics:

Degree Centrality: Measured the importance of each node by counting the number of edges it has in the network.

Closeness Centrality: Defined as the inverse of the sum of the shortest path lengths from a node to all other nodes, measuring how close each node is to others in the network.

Betweenness Centrality: Assessed the extent to which a node lies on the shortest paths between other nodes, indicating its importance in information transmission within the network [6,7].

The significance of these macro-level metrics in understanding the structure of scientific collaboration networks and these micro-level centrality measures in scientific collaboration networks has been well documented and used [6,7]. Through these analyses, I can identify collaborative relationships and influential researchers in viral hepatitis research. This information may be useful for understanding research trends and planning future collaborative studies.

Results

The study analyzed the co-authorship network of researchers in viral hepatitis research, focusing on the periods from 2000 to 2023. The analysis was conducted using data from the WoS Core Collection and utilized both macro and micro-level network metrics to understand the evolution of collaborative networks in this field.

2000-2009. Network Analysis

The analysis of co-authorship networks for viral hepatitis research between 2000 and 2009 revealed significant findings regarding the collaborative structure. The network density was found to be very low at 0.0002 (Table 1), indicating sparse connections between researchers (Figure 1). Despite this, the average clustering coefficient was relatively high at 0.874 (Table 1), suggesting that those who collaborated tended to form tight-knit groups or clusters (Figure 1). The number of connected components in the network was 3,529 (Table 1), reflecting a fragmented structure with many isolated groups of researchers (Figure 1). The average distance between nodes was reported as infinite, indicating that the network was highly disconnected and did not form a giant component spanning the majority of nodes. [8].

Table 1. Network Metrics.

Metric	2000 - 2009	2010 - 2019	2020 - 2023
Network Density	0.0002	0.0002	0.0003
Average Clustering Coefficient	0.874	0.873	0.911
Number of Components	3529	4452	3575
Average Distance	infinite	infinite	infinite

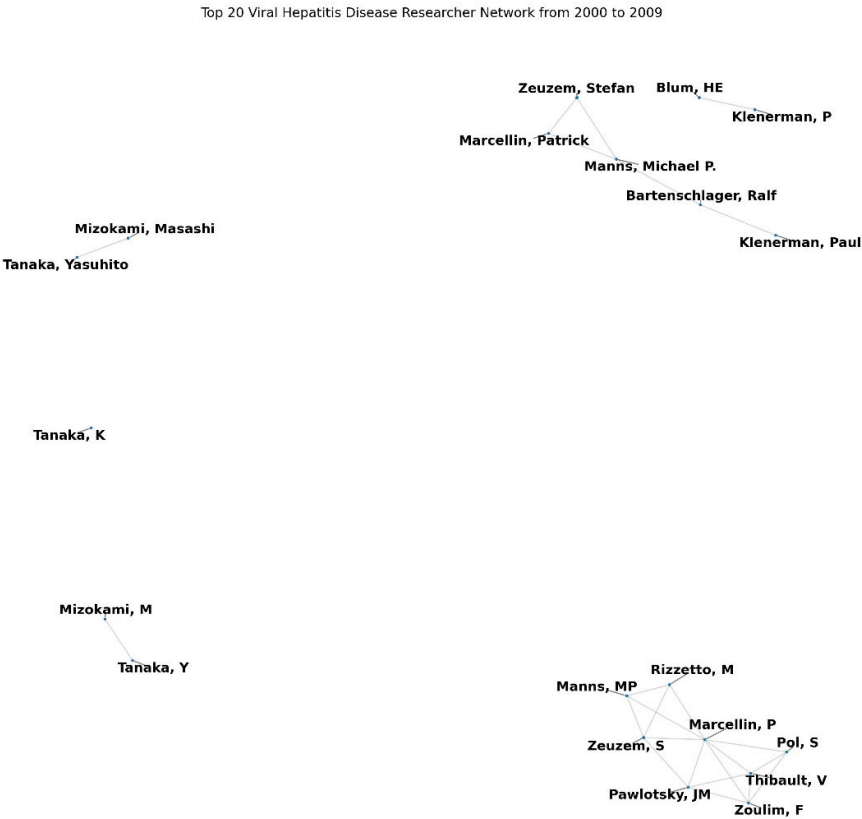


Figure 1. Top 20 Viral Hepatitis Researcher Network from 2000 to 2009.

At the micro level, the analysis of degree centrality identified Stefan Zeuzem and Jean-Michel Pawlotsky were among the top researchers by degree centrality, both appearing multiple times due to variations in name abbreviations. Japanese researchers Masashi Mizokami and Yasuhito Tanaka also ranked prominently, indicating that they were well-connected researchers in the viral hepatitis field during this period (Table 2). For closeness centrality, Ioannis Goulis and Efstratios Akriviadis were the leading researchers by closeness centrality, suggesting that they had short paths to other researchers and could potentially facilitate the spread of information within the network. Stefan Zeuzem and Jean-Michel Pawlotsky also ranked highly in terms of closeness, confirming their central roles in collaboration (Table 3). Betweenness centrality, Akriviadis and Goulis also ranked highest in terms of betweenness centrality, which indicates that they acted as key intermediaries or "bridges" between other researchers. Stefan Zeuzem and Jean-Michel Pawlotsky, once again, appeared in the top ranks, reinforcing their pivotal roles in international research collaboration during this decade (Table 4).

Table 2. Top 20 Nodes by Degree Centrality.

No de	2000 - 2009	Degree Centrality	2010 - 2019	Degree Centrality	2020 - 2023	Degree Centrality
1	Zeuzem, Stefan	0.0041	Zeuzem, Stefan	0.0079	Buti, Maria	0.0145
2	Zeuzem, S	0.0035	Buti, Maria	0.0072	Lazarus, Jeffrey, V	0.0143
3	Pawlotsky, JM	0.0032	Vella, Stefano	0.0061	Poustchi, Hossein	0.0138
4	Manns, MP	0.0032	Dabis, Francois	0.0061	Malekzadeh, Reza	0.0135

5	Klenerman, P	0.0031	Berg, Thomas	0.0060	Hamid, Saeed S.	0.0132
6	Pol, S	0.0030	Zoulim, Fabien	0.0059	Waheed, Yasir	0.0129
7	Blum, HE	0.0030	Sarrazin, Christoph	0.0058	Yuen, Man-Fung	0.0125
8	Marcellin, Patrick	0.0030	Tanaka, Yasuhito	0.0058	Saeed, Umar	0.0107
9	Mizokami, Masashi	0.0029	Kondili, Loreta A.	0.0056	Goleij, Pouya	0.0106
10	Bartenschlager, Ralf	0.0028	Soria, A.	0.0054	Sohrabpour, Amir Ali	0.0104
11	Marcellin, P	0.0027	Wedemeyer, Heiner	0.0054	Merat, Shahin	0.0103
12	Tanaka, Yasuhito	0.0027	Chayama, Kazuaki	0.0052	Yu, Ming-Lung	0.0102
13	Manns, Michael P.	0.0027	Wakita, Takaji	0.0052	Wedemeyer, Heiner	0.0100
14	Tanaka, K	0.0027	Bartenschlager, Ralf	0.0051	Matthews, Philippa C.	0.0099
15	Mizokami, M	0.0026	Chung, Raymond T.	0.0048	Lacombe, Karine	0.0097
16	Klenerman, Paul	0.0026	Baumert, Thomas F.	0.0047	Kao, Jia-Horng	0.0097
17	Zoulim, F	0.0026	Roudot-Thoraval, Francoise	0.0046	Zeuzem, Stefan	0.0095
18	Thibault, V	0.0026	Marcellin, Patrick	0.0046	Elsharkawy, Aisha	0.0094
19	Tanaka, Y	0.0025	Negro, Francesco	0.0044	Cabezas, Joaquin	0.0093
20	Rizzetto, M	0.0025	Colombo, Massimo	0.0044	Banach, Maciej	0.0093

Table 3. Top 20 Nodes by Closeness Centrality.

Node	2000 - 2009	Closeness Centrality	2010 - 2019	Closeness Centrality	2020 - 2023	Closeness Centrality
1	Goulis, I	0.1070	Buti, Maria	0.2371	Yuen, Man-Fung	0.2031
2	Akriviadis, E.	0.1056	Zeuzem, Stefan	0.2360	Buti, Maria	0.2029
3	Zeuzem, S	0.1048	Zoulim, Fabien	0.2310	Jia, Jidong	0.1986
4	Pawlotsky, JM	0.1040	Berg, Thomas	0.2299	Wedemeyer, Heiner	0.1982
5	Neumann, AU	0.1037	Sarrazin, Christoph	0.2296	Asselah, Tarik	0.1975
6	Triantos, C.	0.1030	Wedemeyer, Heiner	0.2296	Kao, Jia-Horng	0.1969
7	Ferrari, C	0.1026	Foster, Graham R.	0.2277	Zeuzem, Stefan	0.1966
8	Schalm, SW	0.1024	Yuen, Man-Fung	0.2275	Xie, Qing	0.1961
9	Esteban, JI	0.1019	Janssen, Harry L. A.	0.2275	Cornberg, Markus	0.1957
10	Dahari, H	0.1017	Manns, Michael	0.2259	Lazarus, Jeffrey, V	0.1954
11	Dhillon, A. P.	0.1010	Chuang, Wan-Long	0.2258	Lampertico, Pietro	0.1948
12	Negro, F	0.1008	Flisiak, Robert	0.2250	Yu, Ming-Lung	0.1946

13	Soulier, A	0.1007	Marcellin, Patrick	0.2250	Hsu, Yao-Chun	0.1945
14	Papatheodoridis, G. V.	0.1006	Hezode, Christophe	0.2242	Chuang, Wan-Long	0.1944
15	Manolakopoulos, S.	0.1006	Vella, Stefano	0.2234	Berg, Thomas	0.1936
16	von Wagner, M	0.1006	Negro, Francesco	0.2232	Aghemo, Alessio	0.1935
17	Vrolijk, JM	0.1004	McHutchison, John G.	0.2230	Tanaka, Junko	0.1932
18	Hezode, C	0.1004	Moreno, Christophe	0.2229	Crespo, Javier	0.1931
19	Missale, G	0.1004	Razavi, Homie	0.2228	Kondili, Loreta A.	0.1927
20	Lurie, Y	0.1002	Papatheodoridis, George	0.2226	Bruggmann, Philip	0.1926

Table 4. Top 20 Nodes by Betweenness Centrality.

Node	2000 - 2009	Betweenness Centrality	2010 - 2019	Betweenness Centrality	2020 - 2023	Betweenness Centrality
1	Akriviadis, E.	0.2278	Buti, Maria	0.0204	Wedemeyer, Heiner	0.0223
2	Goulis, I	0.2277	Zoulim, Fabien	0.0173	Jia, Jidong	0.0179
3	Triantos, C.	0.1427	Zeuzem, Stefan	0.0148	Buti, Maria	0.0154
4	Dhillon, A. P.	0.1115	Foster, Graham R.	0.0128	Zoulim, Fabien	0.0148
5	Neumann, A. U.	0.0989	Vella, Stefano	0.0126	Yuen, Man-Fung	0.0130
6	Suneetha, P. V.	0.0808	Tanaka, Yasuhito	0.0124	Xie, Qing	0.0121
7	Hatzakis, A.	0.0756	Wedemeyer, Heiner	0.0116	Lazarus, Jeffrey, V	0.0109
8	Zeuzem, S	0.0591	Chung, Raymond T.	0.0106	Lacombe, Karine	0.0106
9	Pawlotsky, JM	0.0456	Bartenschlager, Ralf	0.0105	Cornberg, Markus	0.0105
10	Kottilil, Shyam	0.0423	Kondili, Loreta A.	0.0102	Tanaka, Yasuhito	0.0078
11	Dalekos, G. N.	0.0378	Jia, Jidong	0.0095	Janssen, Harry L. A.	0.0073
12	Papatheodoridis, G. V.	0.0378	Alavian, Seyed Moayed	0.0094	Protzer, Ulrike	0.0072
13	Manolakopoulos, S.	0.0378	Wakita, Takaji	0.0093	Merat, Shahin	0.0069
14	Zachou, K.	0.0377	Rice, Charles M.	0.0088	Asselah, Tarik	0.0065
15	Manns, Michael P.	0.0364	Berg, Thomas	0.0085	Wang, Wei	0.0063
16	Neumann, AU	0.0359	Yuen, Man-Fung	0.0084	Lazarus, Jeffrey V.	0.0063
17	Ferrari, C	0.0340	Chen, Pei-Jer	0.0083	Lampertico, Pietro	0.0059
18	Heathcote, E. Jenny	0.0323	Chayama, Kazuaki	0.0083	Mendes-Correa, Maria Cassia	0.0058

19	Bain, V. G.	0.0302	Wei, Lai	0.0078	Shalimar	0.0057
20	Masur, H.	0.0274	Lemon, Stanley M.	0.0076	Kondili, Loreta A.	0.0055

2010-2019. Network Analysis

During the second decade (2010–2019), viral hepatitis research exhibited a similar pattern of low network density (0.0002), again indicating sparse collaboration across the field (Table 1, Figure 2). The average clustering coefficient remained high at 0.873 (Table 1), which suggests the persistence of tightly connected clusters of researchers (Figure 2). The number of components increased to 4,452 (Table 1), reflecting a more fragmented network than the previous decade (Figure 2). Once again, the average distance was infinite, further emphasizing the disconnected nature of the overall network [8].

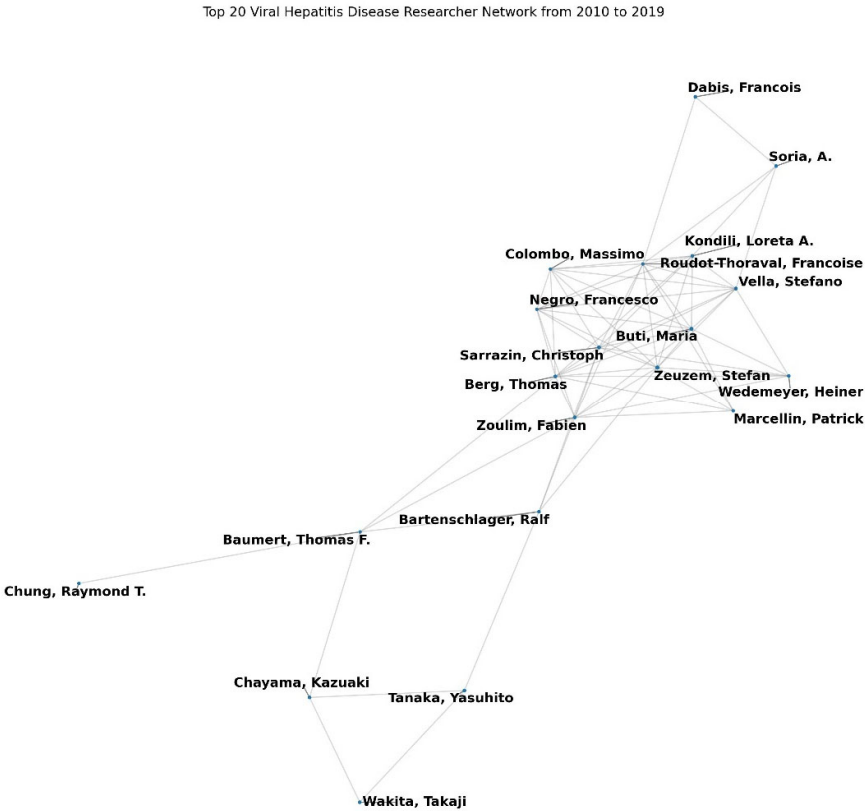


Figure 2. Top 20 Viral Hepatitis Researcher Network from 2010 to 2019.

Stefan Zeuzem remained the most prominent researcher in terms of degree centrality, closely followed by Maria Buti and Stefano Vella. Several new names appeared, such as Thomas Berg, Fabien Zoulim, and Heiner Wedemeyer, marking a shift in the leadership of international collaborations in the field of viral hepatitis (Table 2). Maria Buti and Stefan Zeuzem led in closeness centrality, reinforcing their role in facilitating connections within the research community. Researchers such as Fabien Zoulim, Heiner Wedemeyer, and Graham R. Foster also ranked high, indicating that they played central roles in disseminating information and ideas during this period (Table 3). In terms of betweenness centrality, Maria Buti emerged as the top researcher by betweenness centrality, suggesting her influential role as a bridge within the network. Fabien Zoulim and Stefan Zeuzem followed closely, further demonstrating their importance in connecting otherwise isolated clusters of researchers. Other notable figures include Graham R. Foster and Stefano Vella, who both ranked highly as intermediaries (Table 4).

2020–2023. Network Analysis

The most recent period (2020–2023) saw an increase in network density to 0.0003, indicating a gradual strengthening of collaborative ties in viral hepatitis research (Table 1, Figure 3). The average clustering coefficient also increased to 0.911, suggesting an even higher degree of intra-cluster collaboration (Table 1, Figure 3). The number of components decreased to 3,575, signaling a more integrated network than the previous decade (Table 1, Figure 3). However, the average distance between nodes remained infinite, implying that the network was still relatively disconnected at a global scale [8].

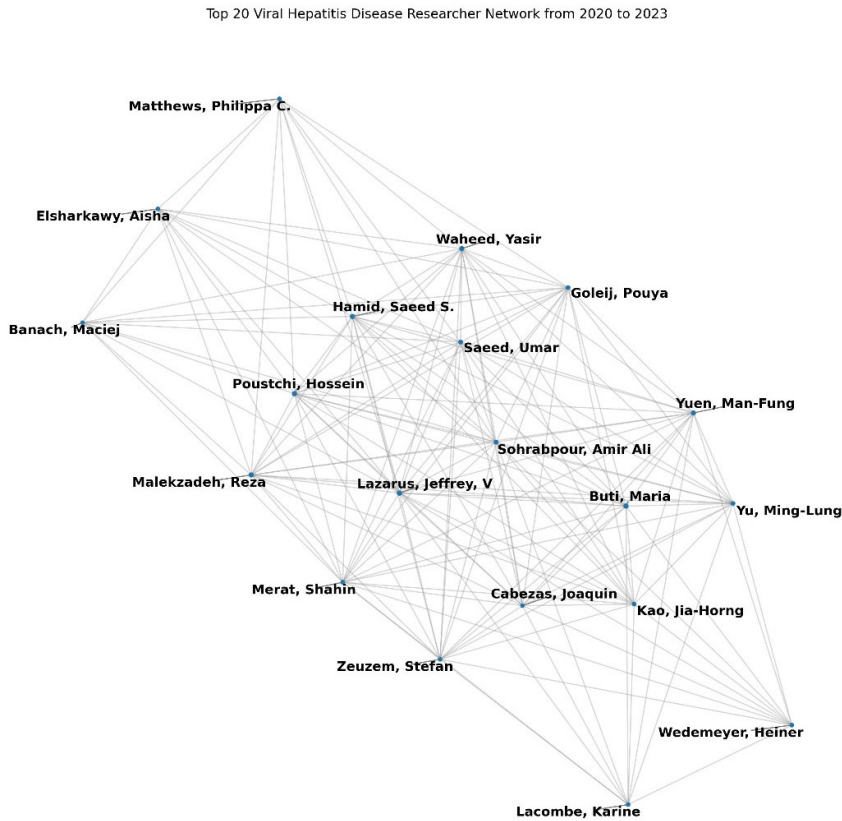


Figure 3. Top 20 Viral Hepatitis Researcher Network from 2020 to 2023.

At the micro level, degree centrality analysis identified Maria Buti continued to hold the top position for degree centrality, indicating her strong connections with other researchers. Jeffrey Lazarus, Hossein Poustchi, and Reza Malekzadeh also emerged as highly connected individuals, reflecting the increasing international collaboration in the field (Table 2). Closeness centrality analysis identified Yuen Man-Fung and Maria Buti were the leading researchers by closeness centrality, highlighting their ability to connect quickly with others in the network. Other top researchers included Jia Jidong, Heiner Wedemeyer, and Tarik Asselah, all of whom played key roles in maintaining efficient communication within the global research community (Table 3). In terms of betweenness centrality, Heiner Wedemeyer took the top spot in betweenness centrality, underscoring his role as a crucial intermediary between various researchers and clusters. Jia Jidong and Maria Buti followed closely, reinforcing their influence as connectors within the network. Fabien Zoulim and Yuen Man-Fung also ranked highly, emphasizing their importance in facilitating cross-cluster collaborations (Table 4).

Discussion

The results of this study provide significant insights into the evolving structure of research collaboration in viral hepatitis from 2000 to 2023. Through the analysis of co-authorship networks,

several key trends and structural characteristics were identified, shedding light on the dynamics of collaborative efforts in the field over two decades.

Fragmentation and Clustering in Early Years (2000–2009)

The first decade (2000–2009) was marked by a highly fragmented network structure, with a low network density of 0.0002, indicating sparse collaboration among researchers. Despite this fragmentation, the high clustering coefficient of 0.874 suggests that within the fragmented subgroups, tight-knit collaborations existed, forming small but cohesive research clusters. The large number of disconnected components (3,529) highlights that viral hepatitis research at this time was composed of many isolated groups, with limited interaction between them.

From a micro-level perspective, researchers such as Stefan Zeuzem, Jean-Michel Pawlotsky, and Masashi Mizokami emerged as central figures within these clusters, ranking highly in degree and closeness centrality. These individuals played key roles in maintaining connections within their respective research communities. Additionally, figures like Ioannis Goulis and Efstratios Akriviadis stood out in terms of betweenness centrality, indicating their critical role as intermediaries who connected otherwise isolated researchers. This underscores the importance of individual researchers in bridging gaps in the collaborative landscape during this period.

Increasing Fragmentation but Rising Centrality (2010–2019)

In the second decade (2010–2019), while the network density remained low at 0.0002, indicating that collaboration levels were still limited, there was an increase in the number of components to 4,452, suggesting greater fragmentation. However, this period also saw a slight increase in collaboration, as indicated by the persistence of a high clustering coefficient (0.873), reflecting strong intra-cluster collaboration among small groups of researchers.

Prominent researchers such as Maria Buti, Thomas Berg, and Fabien Zoulim emerged as key figures in degree and closeness centrality, signaling their influence and central roles in the network. Notably, Maria Buti also rose to prominence in betweenness centrality, suggesting her critical role as a bridge between different research groups. This decade also saw the emergence of new influential researchers, indicating a shift in leadership within the field and the continued development of international collaborative efforts.

Strengthened Collaboration in Recent Years (2020–2023)

The most recent period (2020–2023) shows a marked improvement in the collaborative structure of viral hepatitis research. The increase in network density to 0.0003, along with a rise in the clustering coefficient to 0.911, suggests that collaboration has strengthened, with more connections forming within and between research groups. The decrease in the number of components to 3,575 reflects a more integrated network, although the overall structure remains somewhat fragmented, as indicated by the continued presence of isolated components.

Key researchers such as Maria Buti, Jeffrey Lazarus, and Hossein Poustchi were identified as having high degree centrality, reinforcing their status as central figures in the global viral hepatitis research community. The high closeness centrality of Yuen Man-Fung and Maria Buti indicates that these individuals are well-positioned within the network, able to rapidly connect with others. In terms of betweenness centrality, Heiner Wedemeyer and Jia Jidong emerged as crucial intermediaries, facilitating cross-group collaboration and helping to bridge gaps between clusters.

Evolution of Collaborative Networks and Implications for Future Research

The overall findings of this study demonstrate a gradual but clear trend toward increased collaboration in viral hepatitis research over the past two decades. Although the network has remained fragmented, particularly in the early years, the growing density and higher clustering coefficients in recent years suggest that the field is becoming more interconnected. The rise of

prominent researchers who serve as central hubs and intermediaries highlights the growing importance of international collaborations in tackling global health challenges such as viral hepatitis.

The persistence of isolated clusters and fragmented components, however, suggests that there are still barriers to broader collaboration. Future efforts to foster greater cooperation between currently isolated groups may help to further integrate the global research community and accelerate progress in the field. Initiatives such as international conferences, collaborative grants, and open-access publication platforms may serve as useful tools to break down these barriers and promote more cohesive global research efforts.

The findings from this study highlight several key areas for future research. First, greater focus should be placed on understanding the factors that contribute to the persistence of fragmented components within the network. Identifying the barriers to collaboration—whether they be geographical, institutional, or resource-related—could provide valuable insights for policymakers and research funding agencies. Second, the role of individual researchers as bridges between isolated groups underscores the importance of fostering international collaboration, particularly through support for researchers in developing countries where viral hepatitis remains a significant public health issue.

Finally, as viral hepatitis research continues to evolve, it will be crucial to monitor the impact of major global health initiatives and advances in technology on the structure of research collaboration. By continuing to analyze co-authorship networks, future studies can track the long-term effects of these changes and provide guidance for strategies that will further strengthen global research efforts in the fight against viral hepatitis.

Conclusions

This study has provided an in-depth analysis of research collaboration in viral hepatitis over two decades, based on 60,720 publications indexed in the WoS Core Collection from 2000 to 2023. The findings reveal important structural characteristics of co-authorship networks that have evolved over time, offering valuable insights into how global research collaboration in this field has been shaped.

During the early years (2000–2009), the network was highly fragmented, with low network density and many disconnected components. While there were notable leaders in the field, such as Stefan Zeuzem (Germany) and Jean-Michel Pawlotsky (France), the overall structure indicated that research efforts were concentrated in smaller, tight-knit clusters with limited interaction between them. This reflects the initial stage of international collaboration in viral hepatitis research, with researchers working primarily within national or institutional boundaries.

In the second decade (2010–2019), while network density remained low, there was an increase in the number of components, suggesting growing fragmentation as new researchers and collaborations entered the field. Nevertheless, certain researchers, including Maria Buti (Spain), Fabien Zoulim (France), and Heiner Wedemeyer (Germany), began to emerge as central figures, facilitating international collaborations and fostering greater connectivity across otherwise isolated research clusters.

The most recent period (2020–2023) showed promising signs of greater global collaboration, with a slight increase in network density and a decrease in the number of components, signaling more integrated and connected networks. Researchers such as Maria Buti (Spain), Yuen Man-Fung (Hong Kong), and Heiner Wedemeyer (Germany) played pivotal roles in bridging gaps between different groups and fostering international partnerships, especially in response to the growing global burden of viral hepatitis. These findings demonstrate an increasingly collaborative approach, with enhanced connectivity and more efficient communication pathways across the research community.

Overall, this study underscores the critical role of international collaboration in advancing viral hepatitis research and the importance of key researchers in advancing the field. Viral hepatitis is a global public health problem, and this study also shows that research is being conducted in countries with abundant healthcare resources. However, as healthcare delivery and health challenges continue to demand coordinated research efforts, I hope that understanding the dynamics of co-authorship

networks will provide strategic insights to facilitate future research collaboration and accelerate scientific discovery.

In an N-gram analysis of 6,857 article titles published in the last 10 years (2014-2023) in journals published by the Japanese Society of Internal Medicine, hepatitis B and hepatitis C virus were the top results [9]. Although there may be a difference in temperature for viral hepatitis research between Western and Asian countries, the results suggest that collaborative research should be promoted as a global health issue.

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Ethics Approval Statement: Not applicable for this article.

Conflict of Interest: None.

Abbreviations

WoS, Web of Science; IDE, Integrated Development Environment.

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