ORIGINAL RESEARCH article

# Bibliometric analysis of diabetic retinopathy research using optical coherence tomography (2020-2025): A VOSviewer study

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**Abstract:** Diabetic retinopathy (DR) is a major cause of vision loss, and Optical Coherence Tomography (OCT) has become an essential imaging tool for its diagnosis and management. With the growing volume of OCT-related DR research, bibliometric analysis offers valuable insights into global publication trends, collaborative networks, and influential contributors. This study utilizes VOSviewer to map and analyze co-authorship patterns in DR-OCT research from 2020 to 2025. A bibliometric analysis was conducted using the search terms "Diabetic Retinopathy AND Tomography AND Optical Coherence" across six major databases: Web of Science, Scopus, PubMed, Dimensions, Lens.org, and Google Scholar, on April 14, 2025, covering publications from 2020 to 2025. English-language articles and review articles were included. Bibliographic data were exported in CSV format and analyzed using VOSviewer (v1.6.10) to generate visual maps for co-authorship, keyword co-occurrence, citation, co-citation, and bibliographic coupling networks, applying link and total link strength attributes. A total of 1,794 documents were retrieved from Web of Science, 743 from Scopus, and 2,685 from PubMed, with additional records from Dimensions, Lens.org, and Google Scholar. Co-authorship analysis revealed strong collaborative networks, with key contributors including Bandello F., Sivaprasad S, and Sadda SR, as well as institutions such as Sun Yat-sen University, which led in publication output. Citation and co-citation maps identified influential authors, journals (e.g., Ophthalmology, JAMA Ophthalmology), and highly cited works, while bibliographic coupling highlighted thematic similarities across documents and countries. Keyword co-occurrence analysis revealed research trends centered on imaging technologies, artificial intelligence, and diabetic macular edema, reflecting the evolving priorities in diabetic retinopathy research utilizing OCT. This analysis highlights key authors, research clusters, and international collaborations driving advancements in DR research using OCT. The findings provide a comprehensive overview of the current research landscape guiding future studies, collaborations, and policy decisions in the field of diabetic eye care.

## Introduction

Diabetes mellitus (DM) has diabetic retinopathy (DR) as one of its most frequent microvascular consequences. The leading cause of preventable blindness among working-age adults worldwide is particularly prevalent among individuals between 20 and 70 years of age. A recent meta-analysis projected that about 103 million individuals worldwide are currently living with DM, and this figure is expected to increase to 161 million by 2045, significantly. In the Western Pacific, the Middle East, North Africa, and Sub-Saharan Africa, middle to low-income regions are witnessing a disproportionately higher rate of weight gain, with projected increases of 20.6% to 47.2% predicted for 2030 [1-3]. Diabetic retinopathy is one of the most common microvascular complications of DM, and it remains the primary cause of preventable blindness among working-age adults worldwide, specifically in individuals aged 20 to 70 years [4]. It is estimated that about 103 million people globally are presently living with DR, and this figure is predicted to significantly increase to 161 million by 2045. Disproportionately, the burden is escalating in low- and middle-income areas, such as the Western Pacific, the Middle East, North Africa, and Sub-Saharan Africa, with projected increases in prevalence rates of 20.6% to 47.2% by 2030 [5]. DR contributes significantly to visual disability. It is estimated that nearly 30 million individuals suffer from vision-threatening diabetic retinopathy (VTDR), which poses a substantial public health and socioeconomic burden. The global prevalence of DR-related blindness has increased by about 19% over the past two decades. In 2010, DR was responsible for 2.6% of all cases of blindness and 1.9% of moderate-to-severe visual impairment (MSVI), a notable increase from 2.1% and 1.3%, respectively, in 1990. The direct healthcare costs associated with DR are considerable; in the United States alone, these were estimated to be $493 million annually as early as 2004. This growing burden underscores the urgent need for improved understanding, surveillance, and management strategies [6].

The early diagnosis and monitoring of DR have greatly improved with advancements in ocular imaging, notably optical coherence tomography (OCT). OCT provides non-invasive, high-resolution, cross-sectional imaging of the retina, making it a crucial instrument in contemporary ophthalmology. Although a substantial amount of research has been conducted that combines DR, tomography, and OCT, to date, no comprehensive bibliometric analysis has been undertaken to systematically assess global research patterns, key publications, and emerging areas of focus in this field of overlap [7]. The early diagnosis and monitoring of DR have greatly improved with advancements in ocular imaging, notably OCT [8]. OCT provides non-invasive, high-resolution, cross-sectional imaging of the retina, making it a crucial instrument in contemporary ophthalmology. Although a substantial amount of research has been conducted that combines DR, tomography, and OCT, to date, no comprehensive bibliometric analysis has been undertaken to systematically assess global research patterns, key publications, and emerging areas of focus in this field of overlap. A quantitative method known as bibliometric analysis evaluates the scientific output of research fields using statistical and network-based approaches. This tool facilitates the identification of publication trends, notable authors and institutions, regions of high research intensity, and interconnected research communities [9]. The Web of Science (WoS) Core Collection offers a comprehensive platform for retrieving relevant peer-reviewed publications and enables data exportation for further processing using specialized tools such as VOSviewer. VOSviewer enables a detailed visual examination of co-authorship relationships, keyword co-occurrence, citation patterns, co-citation networks, and thematic clusters. This study sought to address the lack of a comprehensive bibliometric review by systematically examining the scientific literature on Diabetic Retinopathy, Tomography, and Optical Coherence in the context of DR research, where imaging modalities are increasingly significant. We provide insights into publication trends, research collaborations, and emerging directions in the field, using data from WoS between 2020 and 2025 and analyzed with VOSviewer version 1.6.10. This study not only illustrates prevailing research trends but also informs future strategies for clinical innovation and policy development in DR imaging and diagnosis.

## Materials and methods

*Data sources and search strategy:* A bibliometric analysis was carried out using the search query Diabetic Retinopathy AND Tomography AND Optical Coherence to examine global research trends from 2020 to 2025. The search was carried out on 14 April 2025. Relevant bibliographic information, such as publication year, language, journal title, authors, affiliations, keywords, document type, and abstracts, was extracted and exported in a CSV file format, along with the corresponding citation counts. The literature was sourced from several trustworthy databases, namely the Web of Science Core Collection, Scopus, PubMed, Dimensions.ai, Lens.org, and Google Scholar. The final analysis only included filters for document types (e.g., articles and review articles) and English-language publications. A total of 1,794 documents were retrieved from Web of Science, consisting of 1,463 original research articles and 222 review articles. Scopus yielded 743 review articles as the search conducted by a user affiliated with Universiti Teknologi Malaysia (**Figure 1**).

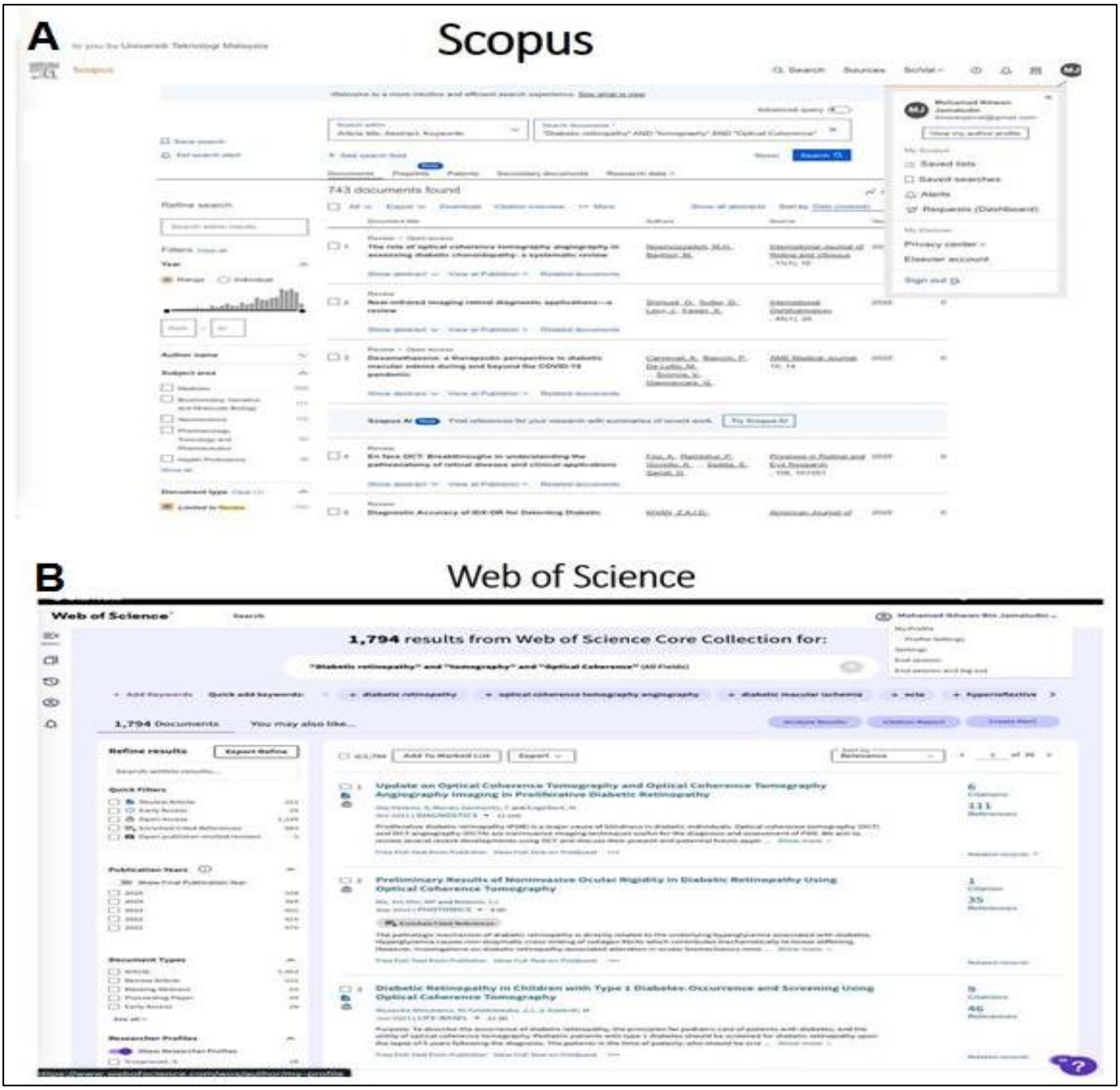


**Figure 1**: Data extraction and processing from (A) Scopus and (B) Web of Science

PubMed produced 2,685 results, with a focus on impactful articles relating to optical coherence tomography angiography in diabetic retinopathy (**Figure 2**). Dimensions, on the other hand, provided results filtered by year, researcher, and category, showcasing key research areas such as biomedical sciences and ophthalmology. The search by Lens.org yielded 2,771 results, comprising simple families (1,312), extended families (1,201), patent citations (1,942), patient citations (1,126), and total patient citations (5,131). A search on Google Scholar found 174,000 relevant publications. Due to the absence of exportable structured metadata, the results comprised duplicates and grey literature, and were not applied for detailed bibliometric analysis (**Figure 3**).

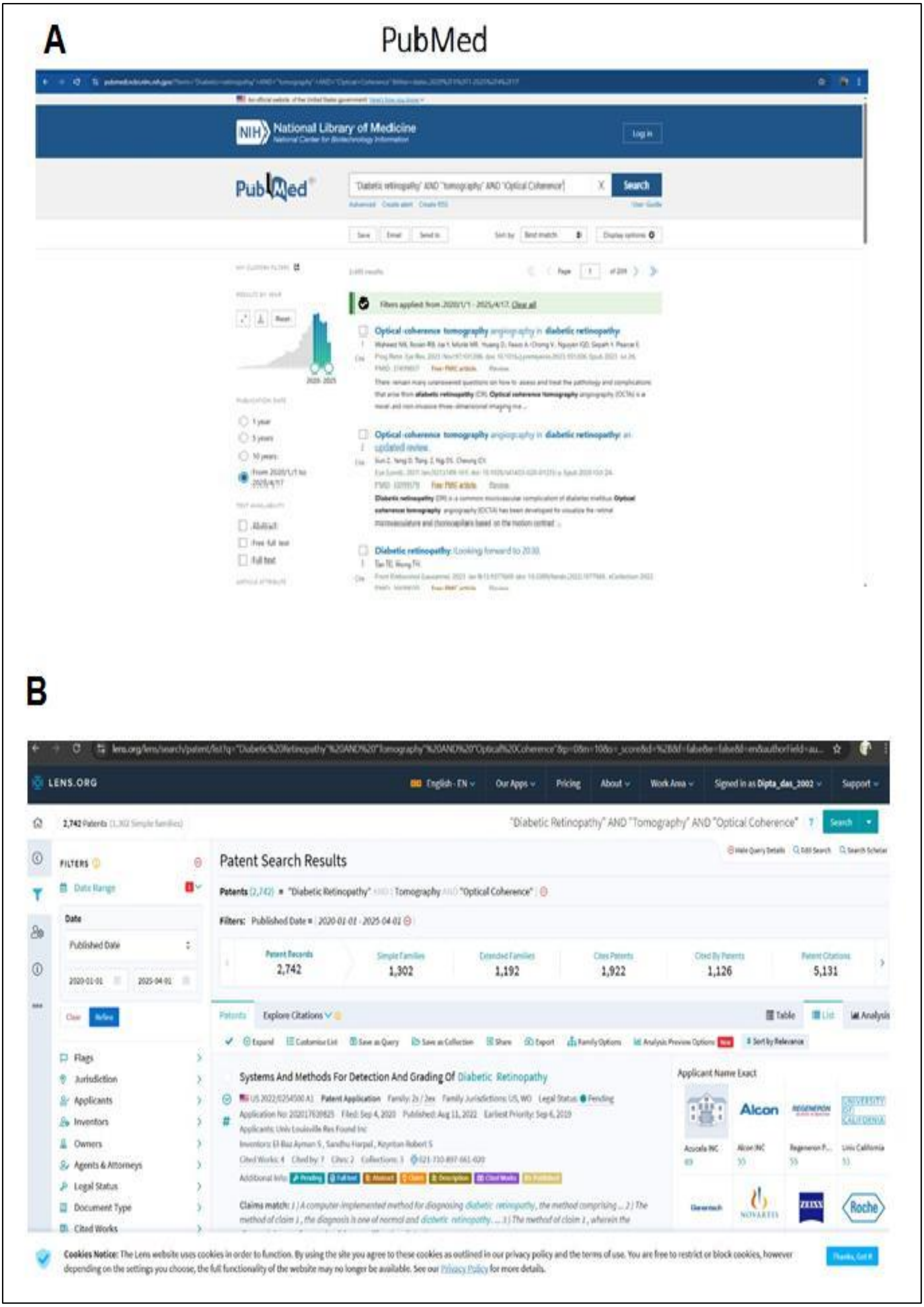


**Figure 2:** Data extraction and processing from A: PubMed and B: Lens

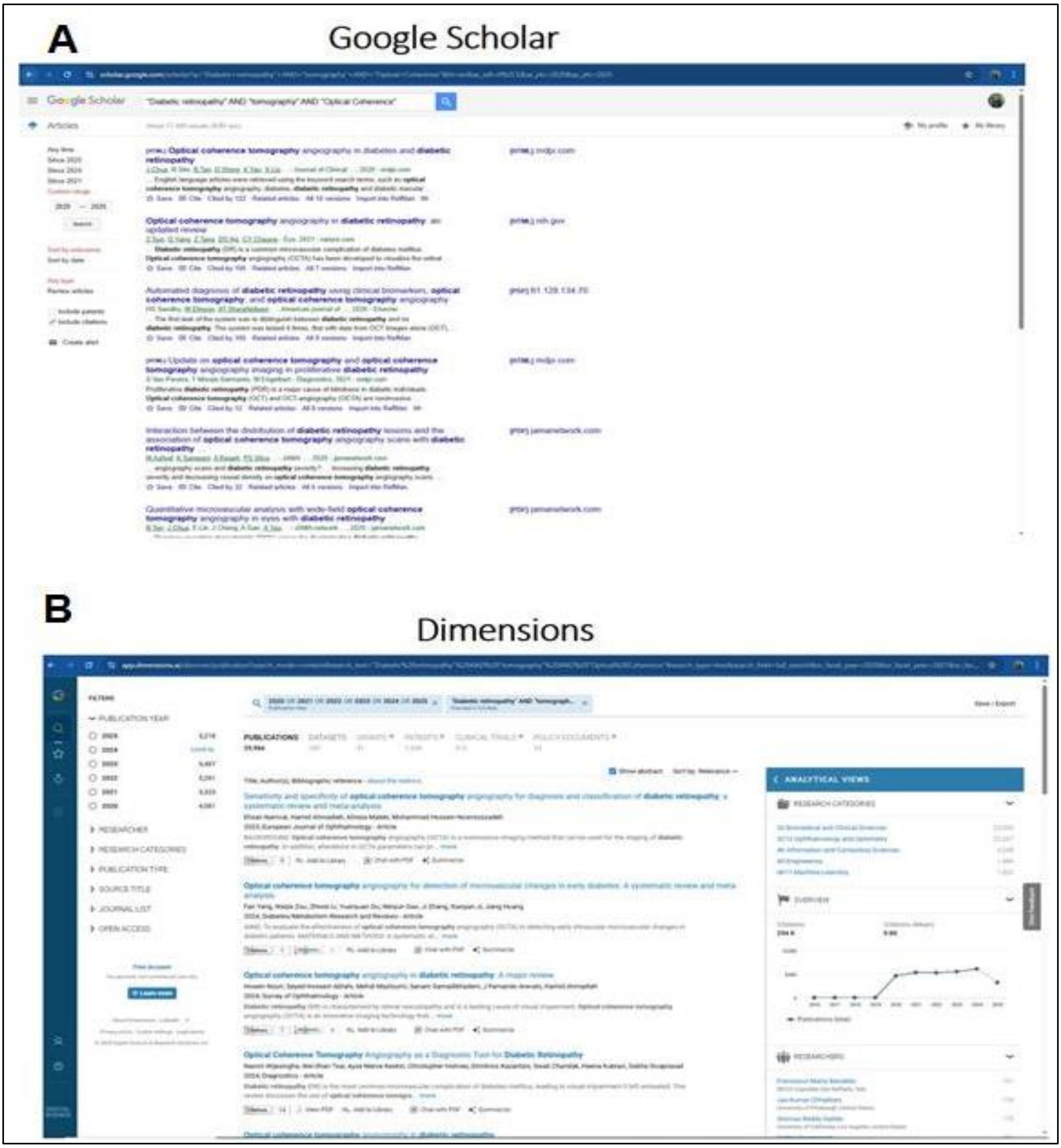


**Figure 3:** Data extraction and processing from A: Google Scholar and B: dimensions

*Bibliometric and visualization analysis:* The dataset was examined with VOSviewer (version 1.6.10), a program specifically designed for creating and illustrating bibliometric maps. Analyses of the following types were conducted: co-authorship analyses to chart collaboration patterns among authors and institutions, and co-occurrence analyses of keywords to pinpoint research hotspots and thematic clusters. Analysis of citations to determine the most influential publications. Publications were analyzed using bibliographic coupling to identify thematic similarity based on common reference points. Co-citation analysis was applied to detect frequently cited pairs of documents. Thematic analysis to illustrate the development of research areas over time. Two standard weight attributes were employed in network analysis: the Links Attribute, which denotes the quantity of co-authorships, co-occurrences, or co-citations between items. The total link strength attribute signifies the overall magnitude of these connections. All network maps were generated using the default VOSviewer settings, with clusters automatically colored to emphasize their related themes.

## Results

*Dimension (co-authorship):* Three network visualizations of co-authorship analysis using VOSviewer, categorized by different levels of collaboration.

*Co-authorship (authors):* This network shows individual researchers connected by co-authorship links. Clusters of nodes represent groups of authors who frequently collaborate such as Wang, Wei and Chhablani, Jay. Colors denote different research groups or clusters, and the size of each node reflects the number of publications or the strength of collaborations (**Figure 4A**).

*Co-authorship (organizations):* Graph visualizes collaboration among institutions. Each node represents a university or research organization, with links indicating joint publications. Larger nodes, sculling as Sun Yat-Sen University, Ircs Ospedale San Raffaele, University of Illinois at Chicago, signify higher publication volume or collaboration frequency. Distinct clusters show institutional partnerships, often within regions or countries (**Figure 4B**).

*Co-authorship (countries):* The map displays international collaboration in scientific research. Countries are nodes, with the size indicating publication output or international collaboration strength. The United States, China, South Korea, Australia, and Turkey are central hubs, indicating extensive global research collaboration. The colored lines show co-authorship links, and color clusters represent regional or thematic alliances. Overall, the figure highlights how scientific collaboration spans individual, institutional, and national levels, revealing key contributors and networks in a specific research domain (**Figure 4C**).

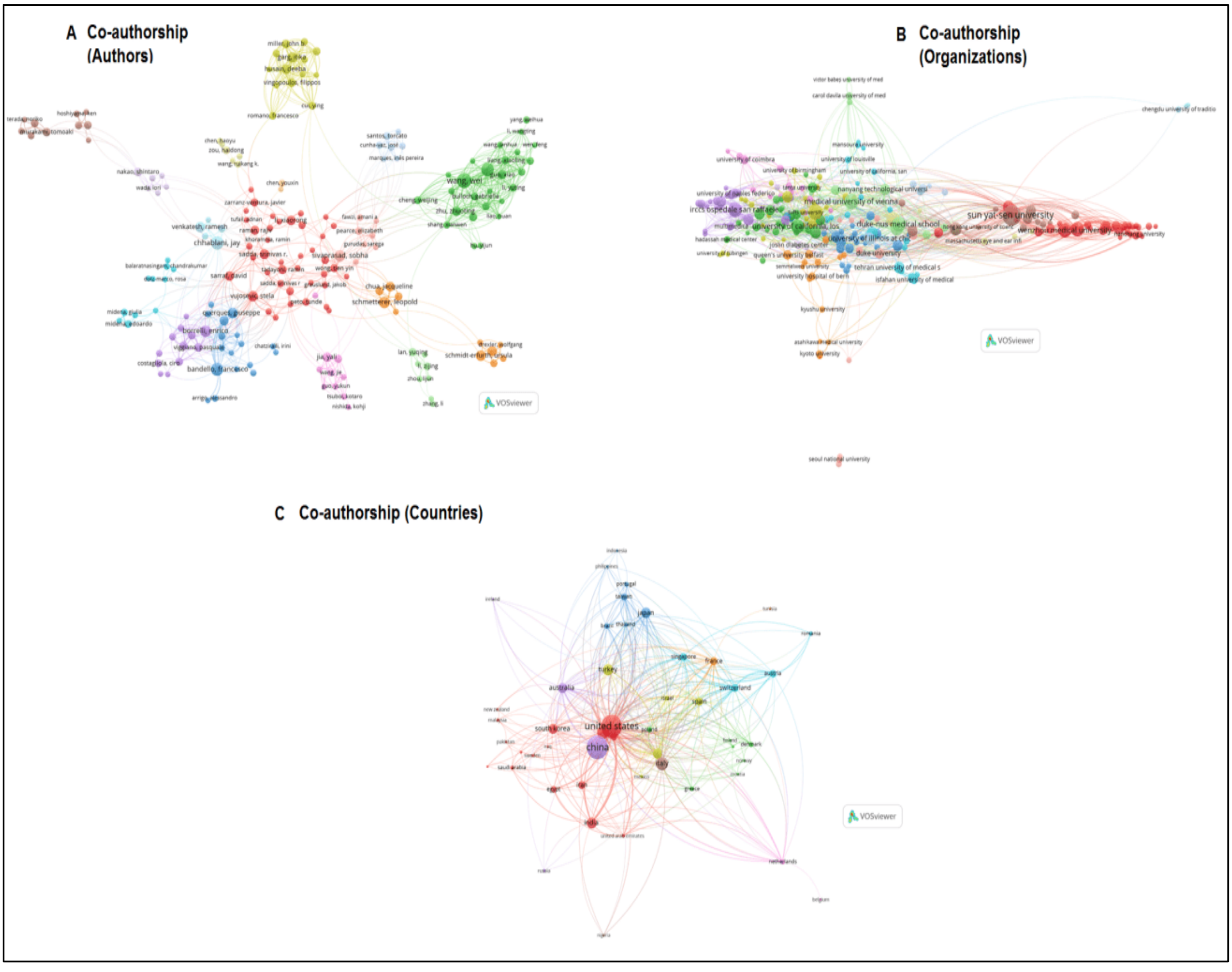


**Figure 4:** Dimension (co-authorship) network visualization A: authors, B: organizations, C: countries

*Citation (sources):* This map shows journals or publication sources and how often they cite or are cited by others. Larger nodes represent more highly cited journals such as Photodiagnosis and Photodynamic Therapy, Retina, Scientific Reports, eye, Diagnostics, and International Ophthalmology. Clusters group journals by subject areas or shared citation patterns, highlighting fields with dense citation interconnectivity (**Figure 5B**).

*Citation (authors):* Authors are linked here based on how often they are cited by others. Larger nodes indicate highly cited authors, and clusters show groups of researchers working in similar areas or citing each other frequently. This view identifies the most influential researchers in a field as Garg, Itika; Wang, Wei; Chhablani, Jay; Jia, Yali (**Figure 5C**).

*Citation (organizations):* Institutions (e.g., universities, research centers) are shown with citation links between them. Central institutions with larger nodes, such as Sun Yat-sen, University Medical University of Vienna, University of Turin, and IRCCS Ospedale San Raffaele, are cited more frequently, indicating academic impact. Clusters suggest collaborative or disciplinary proximity (**Figure 5D**).

*Citation (countries***)***:* This network illustrates how countries cite each other's research. Nodes represent countries, and edges show citation flows. China, the United States, Italy, United Kingdom appear central, indicating their dominant roles in global research influence. Clusters often correspond to regional or linguistic groupings (**Figure 5E**).

*Bibliographic coupling (network visualization):* This figure presents five bibliographic coupling network maps generated by VOSviewer, each illustrating how research entities are related based on shared references. Bibliographic coupling occurs when two items cite one or more documents in common. The denser and more central a node, the stronger its bibliographic connections. Overall, this figure captures the structure of scholarly communication through shared references, highlighting intellectual linkages among documents, authors, journals, institutions, and countries **(Figure 6**).

*Bibliographic coupling (documents):* This map displays individual documents (papers) that share common references. Nodes represent conceptual similarities between documents based on shared references Zhou 2023, Tan 2023, Islam 2022, You 2022, Gao 2022b, Tang 2023, Sampson 2022, Sheng 2022 specific publications, and their connections indicate shared citations. Clusters (color-coded) show groups of papers that are thematically or topically related (**Figure 6A**).

*Bibliographic coupling (sources):* This network illustrates coupling between journals or publication sources. Each node of Retina, Investigative Ophthalmology, Retina, Translational vision Science, Scientific reports is a source (e.g., journal), and lines indicate shared reference patterns across sources. Journals with similar thematic content tend to cluster together (**Figure 6B**).

*Bibliographic coupling (authors):* Authors with larger nodes such as Tan 2023, Tang 2023, Zhou 2023, You 2022, Sampson 2022, Sheng 2022, Islam 2022 observed in this graph, are connected based on shared bibliographic references. Authors with similar research interests or citation patterns form clusters. This map helps identify influential researchers working in related areas (**Figure 6C**).

*Bibliographic coupling (organizations):* **Figure 6D** shows the relationships between research institutions, whereas a larger node is observed in Medical University of Vienna, the University of California, Sun Yat-Sen University, Shanghai Jiao Tong Universityal, Wenzhou Medical University, Chinese University of Hongkong, the University of Toronto, and Duke University. Institutions that publish work citing similar references appear more closely connected. The clusters reflect collaborative or thematic proximity between institutions.

*Bibliographic coupling (countries):* **Figure 6E**, here, countries are linked based on the bibliographic coupling of the documents they produce. Countries that contribute publications citing similar sources are more tightly connected. Major publishing countries like the US, China, the UK, Turkey, Italy, and Australia appear central in the network, indicating their influence and widespread engagement with shared scientific literature.

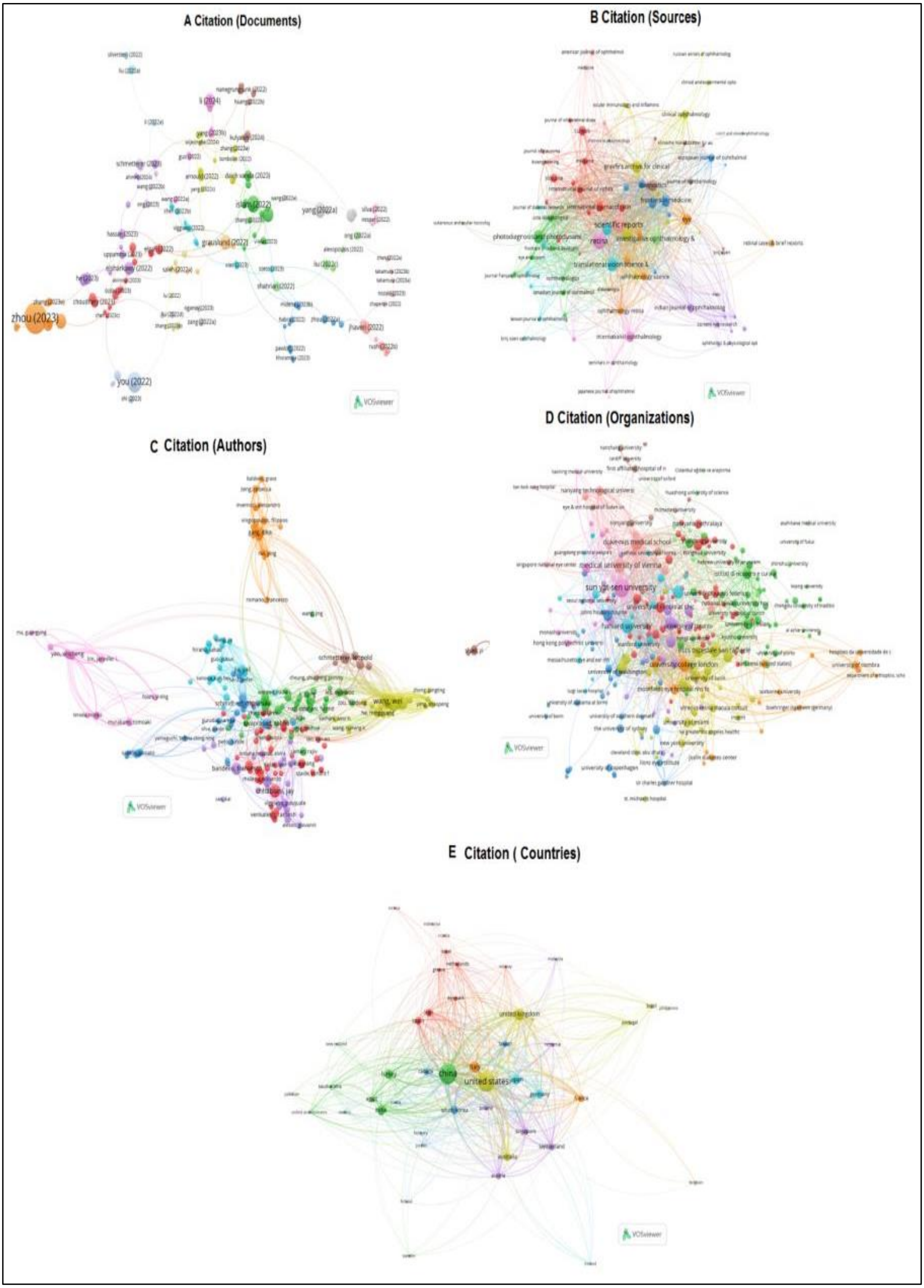


**Figure 5:** Dimension citation network visualization A: documents, B: sources, C: authors, D: organizations, and E: countries

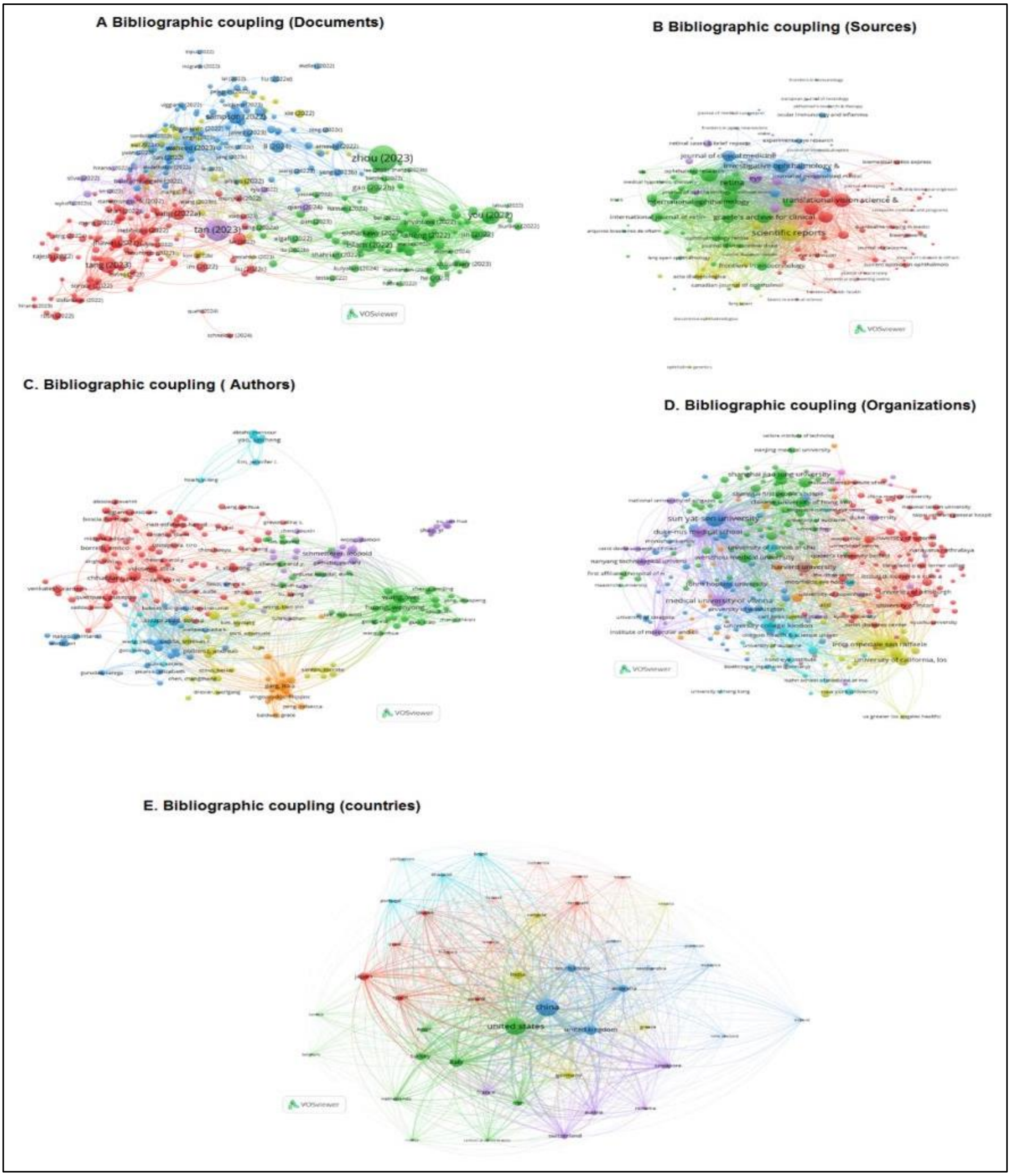


**Figure 6:** Dimension bibliographic coupling A: document, B: sources, C: authors, D: organizations, and E: countries

*Dimension co-citation (network visualization):* The visual shows two main clusters: A dense red cluster of interconnected authors and a green cluster featuring a few dominant authors with extensive citation links to the core group. These authors are likely pioneers or key contributors to advances in optical coherence tomography and diabetic retinopathy research. Together, the three co-citation analyses reveal: The foundational references and journals underpinning the field. The structure of scholarly communication. Influential researchers and intellectual clusters are driving current knowledge and innovation. The figure presents three visualizations generated by VOSviewer for co-citation analysis in the research domain of diabetic retinopathy, tomography, and optical coherence. Each subfigure represents a different unit of co-citation: (**Figure 7**).

*Co-citation (cited sources):* This map shows co-citation relationships between journals or sources. Larger nodes represent sources with higher co-citation frequency. Notable dominant sources include: Investigative Ophthalmology and Visual Science. Progress in Retinal and Eye Research, Ophthalmology, American Journal of Ophthalmology. Retina, Eye, PLoS one, Biomedical optics express, Ophthalmology, Retina. The clustering highlights different research areas such as retinal imaging, clinical ophthalmology, and biomedical optics. Blue and green clusters emphasize clinical and imaging-related literature, while the red cluster shows foundational or general science sources (**Figure 7A**).

*Co-citation (cited authors):* This figure depicts co-citation patterns of individual authors. Nodes represent cited authors, with the node size indicating the total number of co-citations. There is a strong co-citation network centered around authors such as (Garvin, Mona); (Markopoulos, Antonios); (Cardoso, M Jorge); (Melbourne, Andrew); who appear to be highly influential in the domain (**Figure 7B**).

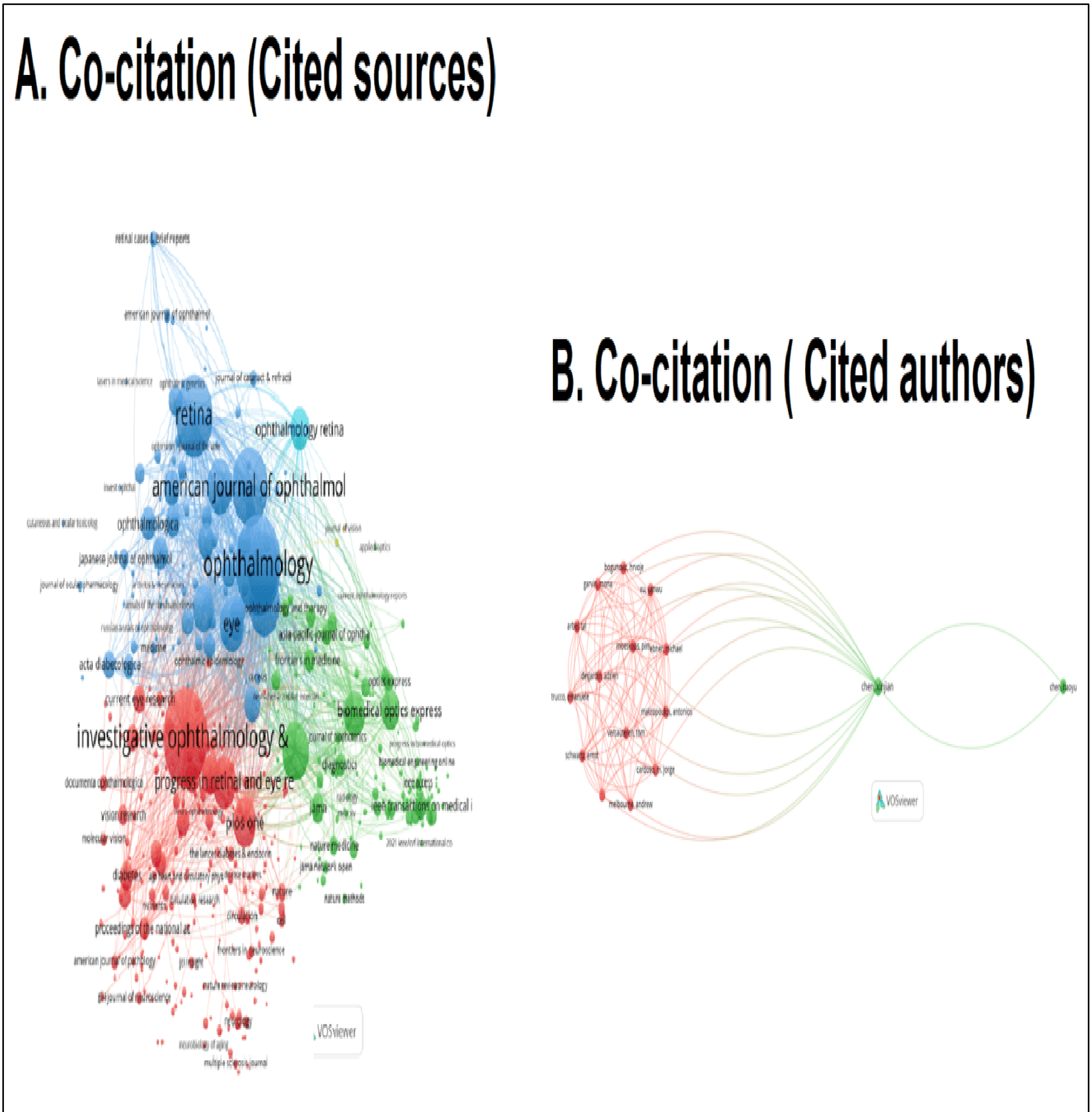


**Figure 7:** Dimension co-citation (network visualization). A: cited sources and B: cited author

### Lens

*Co-authorship and co-occurrence network visualization:* Lens visualizations help identify influential papers, journals, and authors. Color-coded clusters reveal collaboration or thematic groupings. Node size and position can be interpreted as indicators of influence and connectivity within the research network. The figure displays four 'VOS viewer network visualizations' related to 'collaboration and keyword co-occurrence' in a research domain (likely ophthalmology/vision science). Each panel highlights relationships among authors or keywords based on bibliometric data.

*Co-authorship (authors):* Network of collaborating authors. Clusters: Different colors represent author groups who frequently co-author papers. Large nodes like Francesco D'Aloisio, Soha El-Sayed, and Mario, Romano and Hamid, Riazi and Esfahan, Francesco and Bandello, Yali and Jia, Sobha and Sivprasad, Nadia and K Waheed, Mariacristina and Parravano suggest central or prolific authors. Each cluster likely represents a research team or institution. Interpretation: Strong co-authorship patterns suggest active collaborations and shared research themes (**Figure 8A**).

*Co-occurrence (all keywords):* All keywords (from titles/abstracts) that frequently appear together. Key terms: Central and large: diabetic retinopathy, optical coherence tomography, humans, male, female, aged, Optical coherence, Adult, Aged, Diabetic macula Edema, Macular edema/diagnosis, retinal vessels, Humans, Fluorescein angiography/method, Fluorescein angiography, Diabetic retinopathy/diagnosis, cross-sectional studies, visual acuity. Indicates focus on disease, diagnostic techniques, and demographic characteristics. Dense connections: Show high thematic overlap across studies (**Figure 8B**).

*Co-occurrence (author keywords):* **Figure 8C** shows Keywords provided by authors. Focus topics: Prominent: optical coherence tomography, diabetic retinopathy, humans, Fluorescein angiography method, retinal vessels, Diabetic Macular Edema, Vascular endothelial growth. Reflects trending or emphasized concepts by authors themselves. Clusters: Represent subtopics like imaging, AI, segmentation, or disease-specific analysis.

*Co-occurrence (MeSH keywords):* **Figure 8D** shows: Medical Subject Headings (MeSH) terms from indexed databases like PubMed. Core concepts: Humans, diabetic retinopathy, fluorescein angiography, female/male, diagnostic imaging Fundus oculi, aged, male, female, adult, visual acuity, intravitreal injection. Clustering: Green cluster: Clinical diagnosis, imaging methods. Red cluster: Patient-specific terms (e.g., gender, age). Blue cluster: Techniques or pathology.

*Lens (citation) network visualization:* This image contains three citation network visualizations created using VOSviewer, a tool commonly used for bibliometric mapping. Each visualization represents citation relationships in academic research, categorized by documents, sources (journals), and authors.

*Citation (documents):* **Figure 9A** shows how individual research documents (papers) cite each other. Each node represents a single document, labeled with the first author and year (Be Bouma 2022, Danuta M Samson 2022, Tien-En Tan 2023, Zihan Sun 2020, Ashish Markan 2020, Morgan Heisler 2020, Zhengwei Yang 2022, Fang Yao Tang 2020, Tien-En Tan 2023, Danutam Sampson 2022, Harpal Sandhu 2020, Zhengwei Yang 2022). Links between nodes indicate citation relationships. Different colors represent clusters of related documents, likely grouped by shared themes or citation patterns. Larger nodes likely represent documents with higher citation counts.

*Citation (sources):* **Figure 9B** maps citation relationships between journals or publication sources. Each node is a journal (e.g., Scientific Reports, BMC Ophthalmology, American Journal of Ophthalmology, Graef's Archive for Clinical, International Journal of Retina, Acta Diabetologica). Lines between journals represent citation flows, showing which journals tend to cite one another. The size of each node likely reflects the number of citations received. The prominent placement and size of Scientific Reports suggest it is a central, frequently cited source in this network.

*Citation (authors):* This visualization maps citation links between authors. Each node represents an author, and the links indicate how frequently authors cite each other. Colored clusters show communities of authors working on similar or related topics. Authors like Francesca Bandello, Sobha Sivaprasad, and Hamid Rezaei Safahani, Tomoak Murakami, Jay Chhablaniare central in their respective clusters, suggesting influence in their fields (**Figure 9C**).

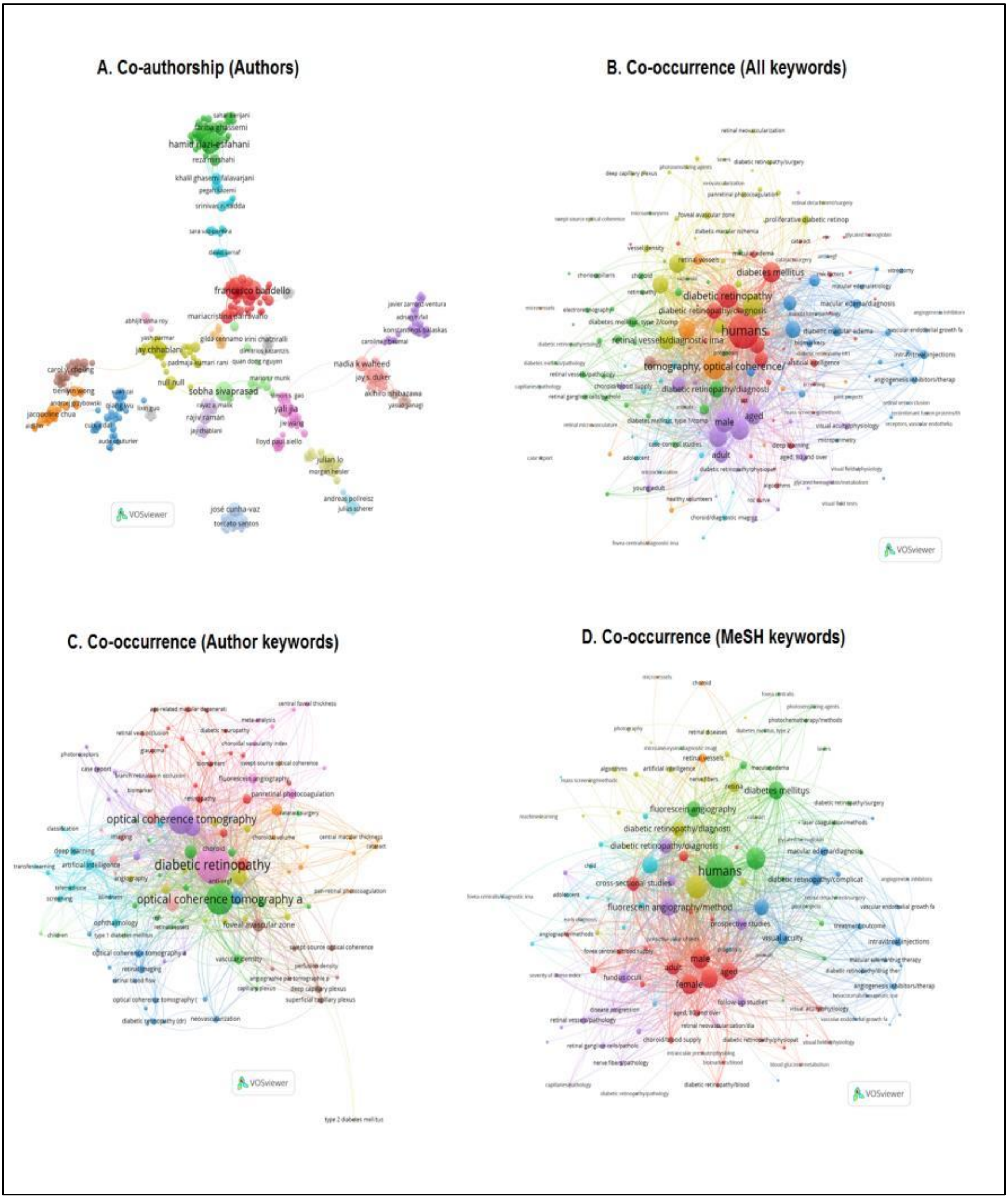


**Figure 8:** Lens (co-authorship and co-occurrence network visualization). A: authors, co-occurrence (All keywords), co-occurrence (authors keyword), and co-occurrence (MeSH keywords)

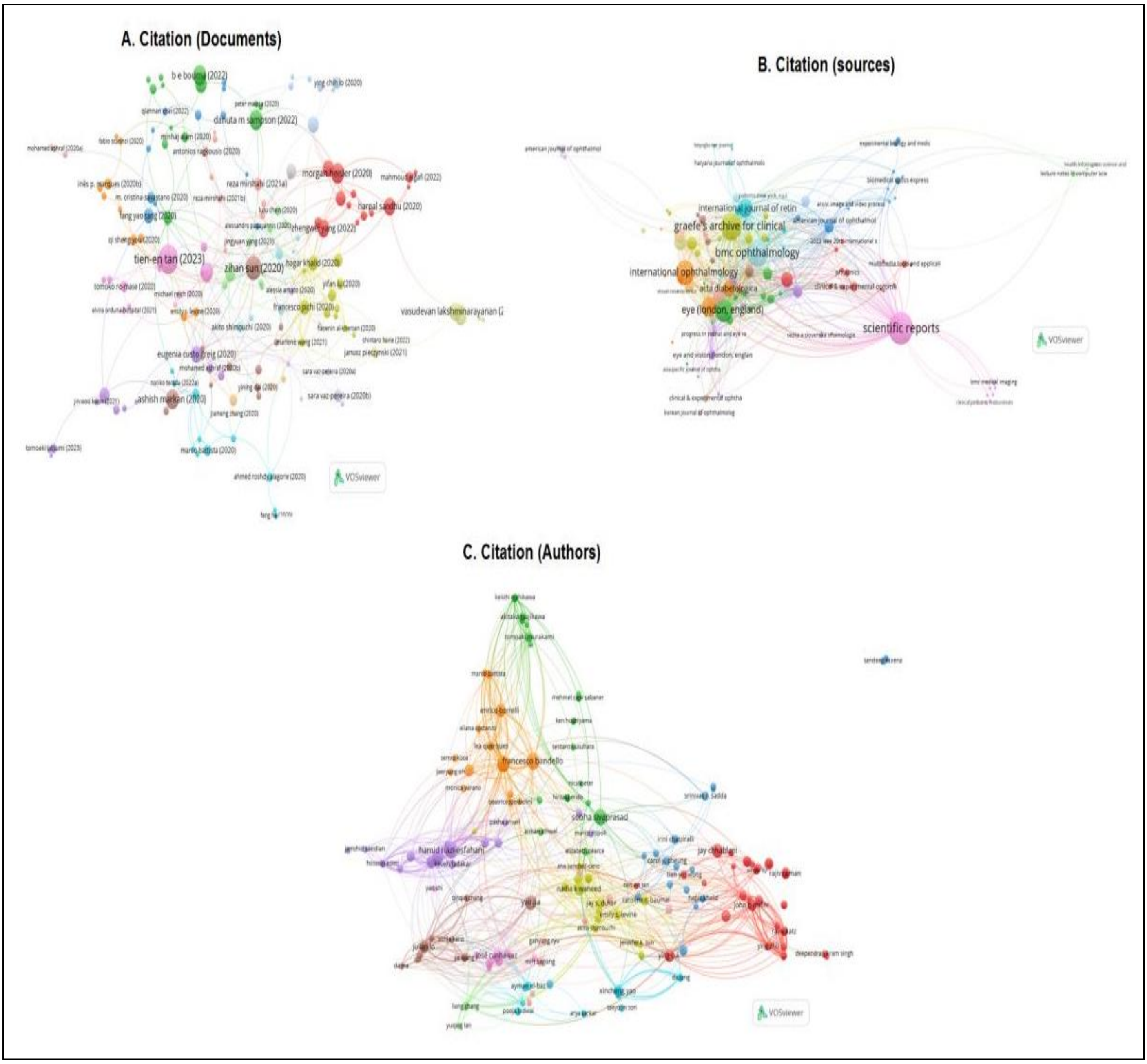


**Figure 9:** Lens (citation) network visualization, A: documents, B: sources, and C: authors

## PubMed

*PubMed (co-authorship) network visualization:* **Figure 10** contains two co-authorship PubMed network visualizations generated using VOSviewer, which highlight collaborative relationships in academic publishing. The networks are organized by authors and organizations. Highly connected nodes reflect central players in the field, either individuals or institutions. Clustering reveals collaborative ecosystems, such as labs, national or regional networks, or thematic research groups.

*Co-authorship (authors):* Co-authorship network map focused on authors, generated using VOSviewer. Represents how individual researchers collaborate through co-authored academic publications, likely within a specific scientific field (such as ophthalmology or vision research). Nodes represent individual authors. Links between nodes indicate co-authorships. Colors identify clusters of closely collaborating authors, likely working on similar topics or within the same research groups. Authors like Francesco Bandello and Sobha Sivaprasad appear centrally located and highly connected, indicating frequent collaboration and a central role in the research network. Isolated groups or peripheral clusters (e.g., the orange cluster on the far right with Wang Yan, Xie Wenyao) suggest independent or regionally focused teams (**Figure 10A**).

*Co-authorship (organizations):* Network illustrates collaborations between institutions or organizations based on co-authorship in published research. Structure: Nodes represent research organizations or departments (e.g., department of ophthalmology, the vision research foundation). Edges (lines) show collaborative ties when authors from different institutions have co-authored papers. Color clusters represent groups of organizations with strong internal collaboration. Some organizations are highly interconnected (e.g., major ophthalmology departments), while others are more isolated (e.g., Vision Research Foundation, Ch and Shri Bhagwan Mahavir Vitreoret). Each circle's node represents a single author. The size of a node reflects the number of publications or collaborations. Larger nodes indicate more prolific or more connected authors. Lines between nodes indicate co-authorship relationships the more frequent the collaborations, the stronger or more prominent the connection. Different color clusters signify collaborative clusters or communities, typically representing groups of researchers working closely together (e.g., labs, institutions, or thematic teams). Authors in the same color cluster are more interconnected. Central Authors: Bandello, Francesco, Borrelli, Enrico, and Parravano, Mariacristina appear prominently in the center, with many connections, suggesting they are key hubs in the co-authorship network. Other central figures include Chhablani, Jay, Wong, Tien Yin, and Sivaprasad, Sobha, all appear to bridge multiple collaborative communities. Distinct Clusters: The yellow cluster on the far right (e.g., Murakami, Tomoaki, and Yoshimura, Nagahisa) appears more isolated, possibly indicating a geographically or institutionally focused group with limited external collaboration. The green and blue clusters on the left show interconnected collaboration, likely within large research teams or multi-institution consortia. Cross-cluster links: Many authors have ties across different clusters, indicating interdisciplinary collaboration or shared projects between distinct research teams (**Figure 10B**).

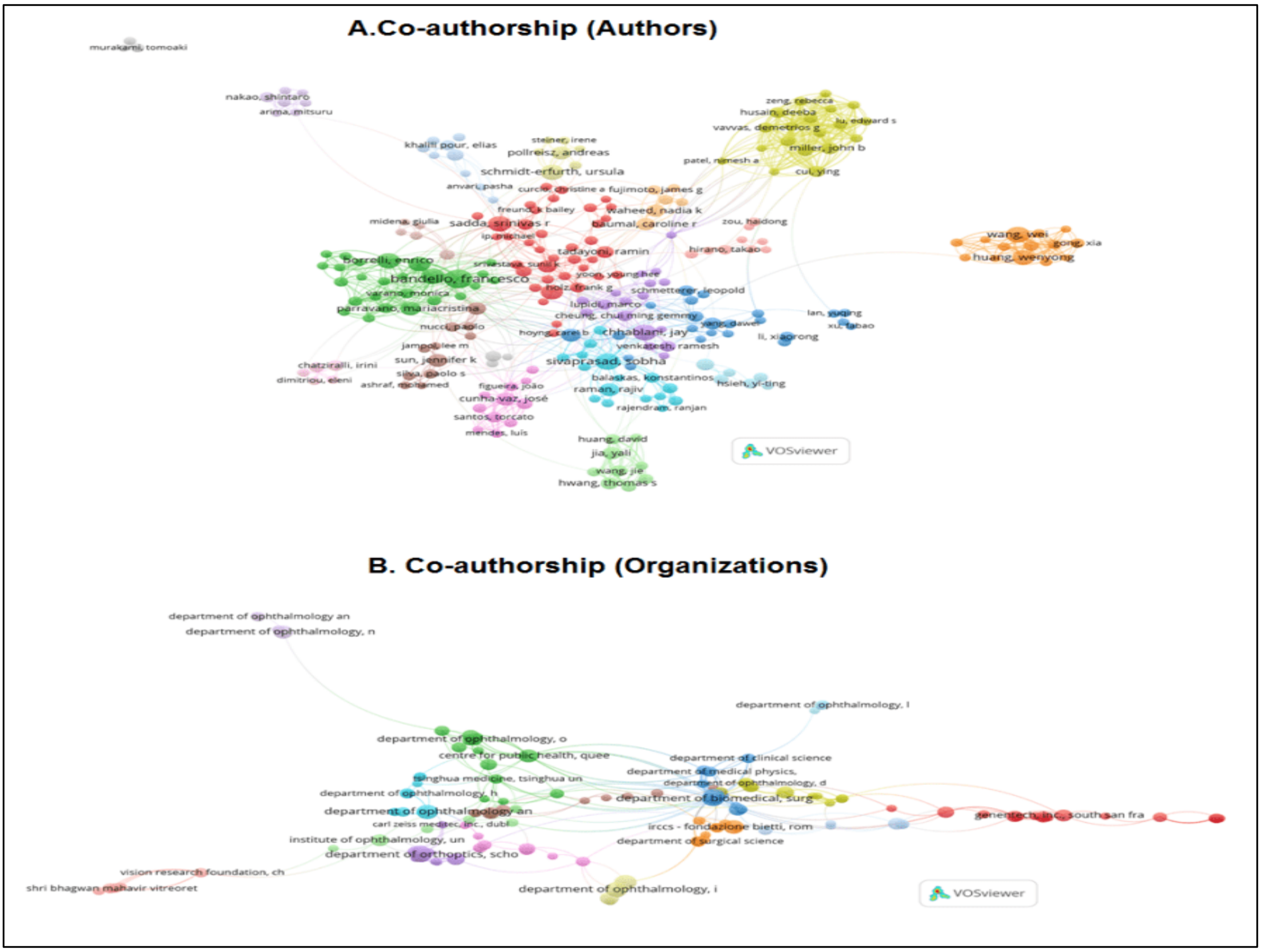


**Figure 10:** PubMed (co-authorship) network visualization. A: authors and B: organizations

*Co-occurrence network visualization:* The image contains three network visualizations generated using VOSviewer software, showing keyword co-occurrence patterns in the context of research on diabetic retinopathy and optical coherence tomography. Each subfigure represents a different type of keyword analysis based on publications from 2020 to 2025: Overall, the co-occurrence analysis highlights key concepts and thematic relationships in the field, offering insights into research trends and focal points within diabetic retinopathy studies involving tomography and optical coherence technology.

*Co-occurrence (all keywords):* This network map displays the relationships among all keywords used in the analyzed literature. The clusters are color-coded, representing different thematic groups. The keyword humans appears as the most central and frequently occurring term, indicating its dominant role across publications. Other notable terms include fluorescein, angiography, retina, and macular edema, retrospective studies, intravitreal injection, angiogenesis inhibition, and visual acuity (**Figure 11A**).

*Co-occurrence (author keywords):* The map reveals how author preferences shape topic emphasis and connectivity (**Figure 11B**) and focuses specifically on keywords assigned by authors. “Diabetic retinopathy,” “optical coherence tomography,” and “diabetic macular edema” are the most prominent and interconnected keywords, forming dense clusters that reflect core research themes.

*Co-occurrence (MeSH keywords):* This map is based on Medical Subject Headings (MeSH) terms, providing a standardized view of topic relationships. DR is again a central node, closely linked to terms such as humans, male, visual acuity, and macular edema. The clustering suggests consistent thematic structures aligned with clinical research and biomedical indexing (**Figure 11C**).

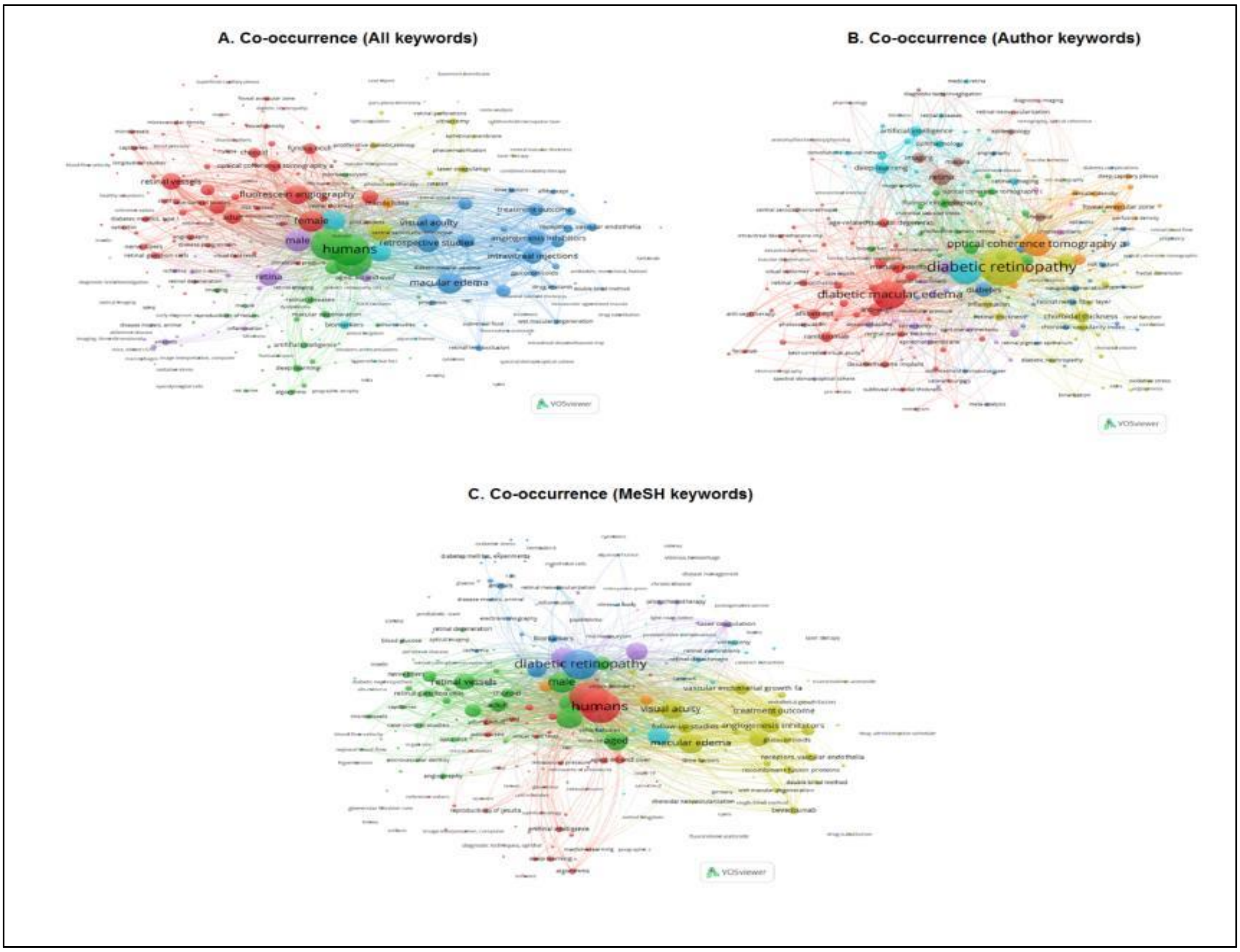


**Figure 11:** Co-occurrence network visualization A: all keywords, B: author keywords, and C: MeSH keywords

### Scopus

*Co-authorship network visualization:* **Figure 12** shows individual researchers collaborating through co-authored academic publications, likely within a specific scientific field (such as ophthalmology or vision research). Nodes (Circles): Each node represents a single author. The size of a node reflects the number of publications or collaborations. Larger nodes indicate more prolific or more connected authors. Edges (Lines): Lines between nodes indicate co-authorship relationships. The more frequent the collaborations, the stronger or more prominent the connection. Colors (Clusters): Different colors signify collaborative clusters or communities, typically representing groups of researchers working closely together (e.g., labs, institutions, or thematic teams). Authors in the same color cluster are more interconnected. Central Authors: Bandello, Francesco, Borrelli, Enrico, and Parravano, Mariacristina appear prominently in the center, with many connections, suggesting they are key hubs in the co-authorship network. Other central figures include Chhablani, Jay, Wong, Tien Yin, and Sivaprasad, Sobha all appear to bridge multiple collaborative communities. Distinct Clusters: The yellow cluster on the far right (e.g., Murakami, Tomoaki, and Yoshimura, Nagahisa) appears more isolated, possibly indicating a geographically or institutionally focused group with limited external collaboration. The green and blue clusters on the left show interconnected collaboration, likely within large research teams or multi-institution consortia. Cross-cluster links: Many authors have ties across different clusters, indicating interdisciplinary collaboration or shared projects between distinct research teams.

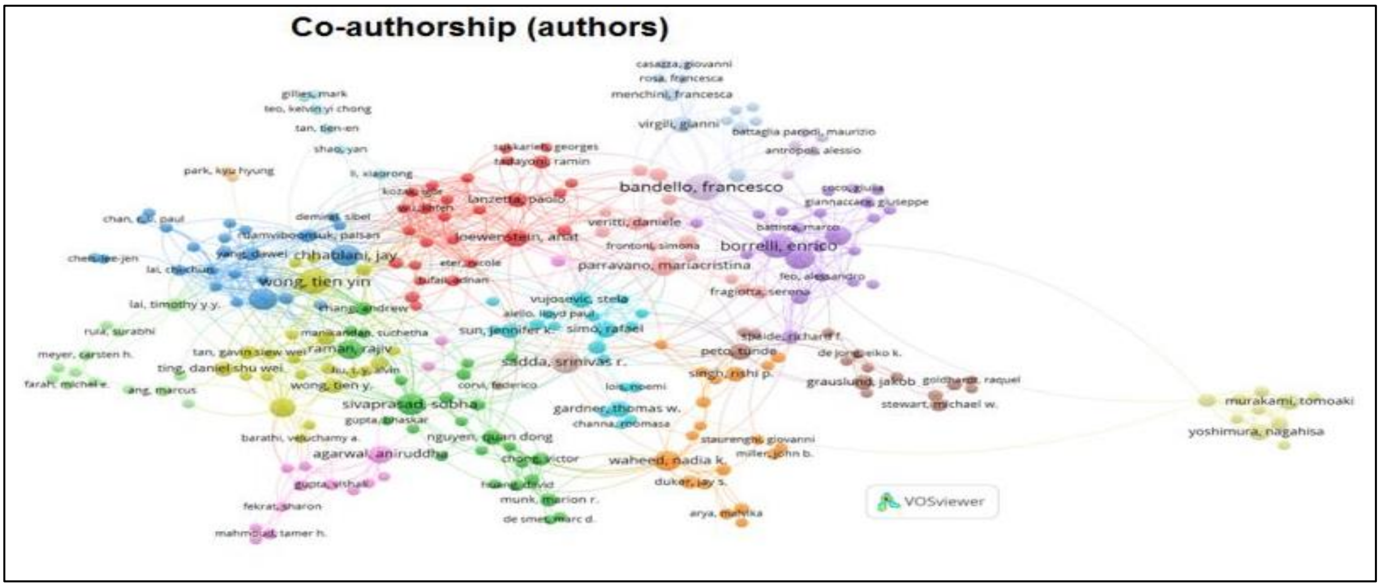


**Figure 12:** SCOPUS (co-authorship) network visualization

### Google Scholar

*Co-authorship network visualization:* Here's a breakdown of what is observed in **Figure 13**: Title: Co-authorship (authors) indicating the network maps academic or research collaborations based on co-authored works. Nodes (Dots): Each dot represents an **individual author. Edges (Lines): Lines between authors indicate co-authorship; the thicker the line, the stronger or more frequent the collaboration. Clusters (Colors): Blue cluster (left): Includes authors like Bandello Francesco, Borrelli Enrico, and Battista Marco. This group shows strong internal collaboration. Green cluster (center): A tightly knit group around Nadin Francesco, Borghetti Federico, Chatzi Irini, and Amato Alessia, among others. Red cluster (right): Another group centered around Cicinelli Maria Vittoria with co-authors like Balestra Estefania, Grassi Maria Oliva, and Alessio Giovanni. Bandello Francesco appears to be a central connecting figure between the blue and green Clusters. Cicinelli Maria Vittoria plays a central role in the red cluster. There are fewer connections between the red and blue clusters, implying limited collaboration across these groups. The network likely reflects collaboration patterns within a specific research area or institution.

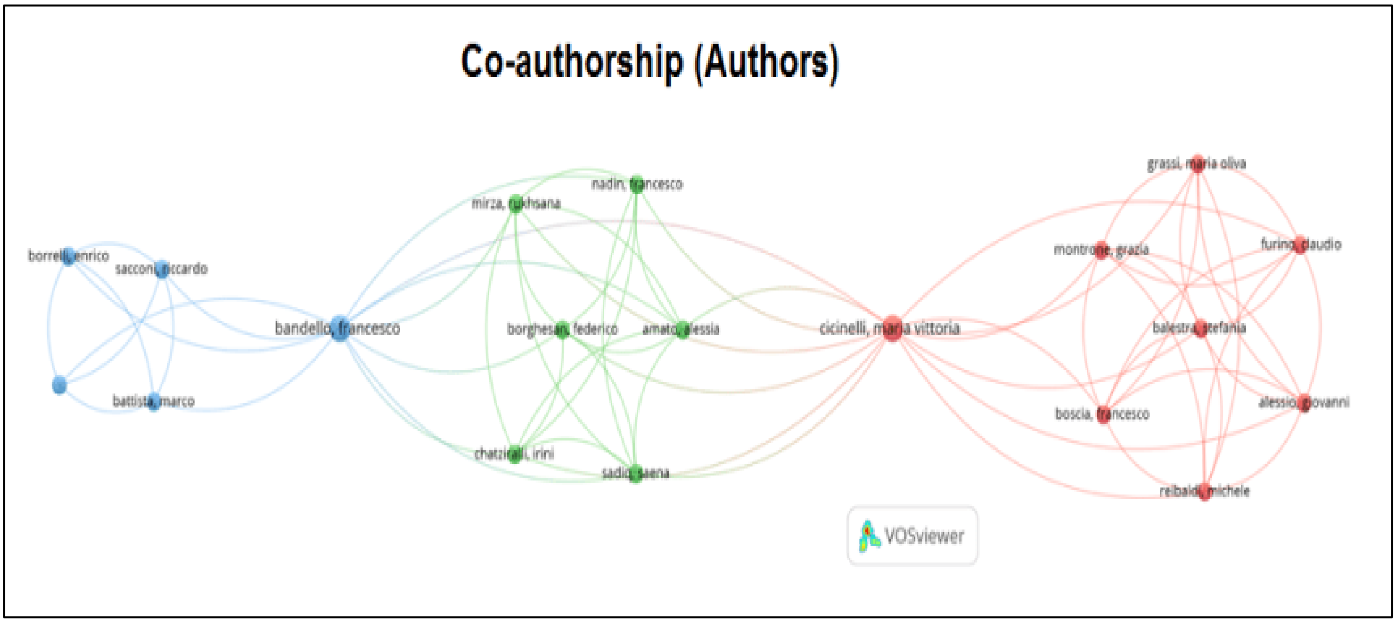


**Figure 13:** Google Scholar co-authorship network visualization

*Web of Science coauthorship network:* Visualization co-authorship network derived from scientific publications. Each node (circle) represents an author, and edges (lines) between them indicate co-authorship on one or more papers. The color-coded clusters reflect groups of authors who frequently collaborate with each other. Red Cluster (right): A tightly connected network of researchers including Garg, Itika, Miller, Joan W., Cui, Ying, and Husain, Deebaka. This group is indicative of a strong collaborative research team. Blue Cluster (center-right): Led by Bandello, Francesco and Sacconi, Riccardo, showing a moderately dense collaborative group. Green Cluster (center): Centered around Cunha-Vaz, Jose and Sadda, Srinivas R., bridging between multiple other groups. Yellow Cluster (left-center): Includes Sivaprasad, Sobha and Schmetterer, Leopold, suggesting another core collaboration hub. Light Blue Cluster (far left): Isolated collaboration circle around Drexler, Wolfgang. Purple Cluster (bottom center): A small but closely connected group with Jia, Yali and Guo, Yukun. Brown Cluster (bottom right): Lan, Yuqing, shows limited connectivity, indicating either emerging collaboration or independent research. Bridging author: Sadda, Srinivas R. appears to be a bridge between several major clusters, playing a central role in collaborative links across groups. Zarranz-Ventura, Javier, and Vujošević, Stela also connect multiple clusters (**Figure 14**).

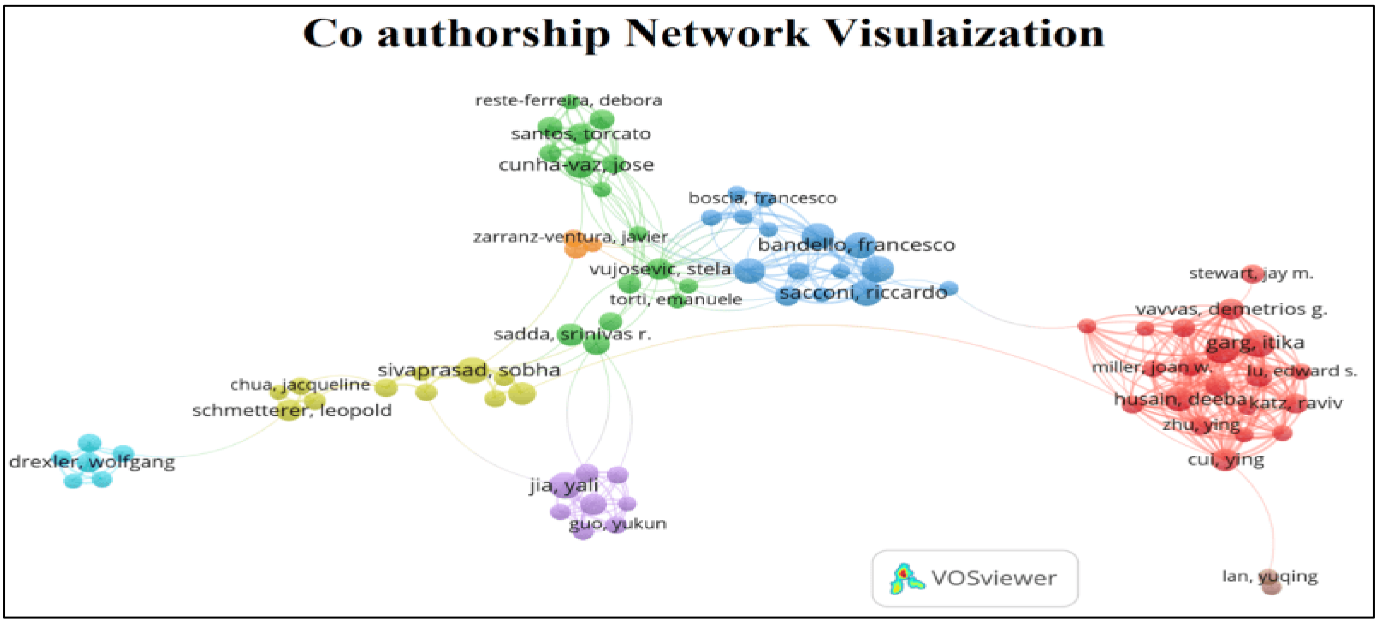


**Figure 14:** Google Scholar co-authorship network visualization

## Discussion

Diabetic retinopathy remains a leading cause of vision loss and blindness among the working-age population, stemming from the widespread global burden of DM. According to the American Academy of Ophthalmology, 93 million people globally suffer from DR, and this number is projected to increase significantly in parallel with rising diabetes prevalence, estimated to reach 592 million by 2035 [1]. DR affects about 77.3% of individuals with type 1 diabetes and 25.1% of those with type 2 diabetes, with a considerable proportion at risk of developing vision-threatening complications such as diabetic macular edema. Clinically, these complications often require laser therapy or vitrectomy in advanced stages, emphasizing the importance of early detection and intervention [10].

Recent advances in optical coherence tomography angiography (OCTA) have transformed the early diagnosis and monitoring of DR. Research shows that even diabetic patients without clinically evident DR exhibit early morphological and perfusional changes in the retinal microvasculature, particularly around the peripapillary region. OCTA reveals subtle but critical changes in vessel density and nerve fiber layer thickness before clinical symptoms manifest. Patients with micro-albuminuria, for instance, already show signs of impaired retinal circulation detectable by OCTA, offering potential for early identification and management of microvascular damage. This bibliometric analysis offers a multidimensional understanding of global research dynamics in DR, tomography, and OCT technologies from 2020 to 2025. By employing VOSviewer across five major databases-Web of Science, Scopus, PubMed, Google Scholar, and Lens we identified key trends, influential contributors, collaborative networks, and thematic evolutions in this domain [11].

*Clinical integration and technological trends:* Since its clinical introduction in 2014, OCTA has played an increasingly pivotal role in DR research and patient care. Spectral-domain OCTA (SD-OCTA) and Swept-source OCTA (SS-OCTA) have become core diagnostic tools, with SS-OCTA providing superior scanning speed, deeper tissue penetration, and broader scanning areas due to its use of longer wavelengths and higher laser power. These innovations allow clinicians and researchers to detect subtle retinal changes that are undetectable by traditional fundoscopy or even fluorescein angiography. Standardized OCTA segmentation into superficial, deep, outer retinal, and choriocapillaris layers enables a more detailed analysis of disease progression. While ultra-wide-field OCTA offers expansive imaging, its current limitations in clinical settings include longer acquisition times and sensitivity to motion artifacts [4].

*Global research collaboration patterns:* Co-authorship network analyses reveal a robust and internationally integrated research community. Prominent figures such as Francesco Bandello, Sobha Sivaprasad, and Enrico Borrelli emerge as central researchers in author collaboration networks. Institutions like Sun Yat-sen University (**Figure 5D**), Moorfields Eye Hospital, and the Vision Research Foundation are frequently engaged in multi-author, multinational studies. The United States and China dominate national collaboration networks, which mirrors their status as countries with the highest diabetes burden [4] (**Figure 5E**). Notably, these two nations contribute a significant share of global DR-related publications, and this is further supported by citation centrality seen in the institutional networks, especially those affiliated with Sun Yat-sen University.

*Citation and impactful research:* Citation analysis highlights the centrality of high-impact journals such as Ophthalmology, Scientific Reports, and Investigative Ophthalmology and Visual Science in disseminating cutting-edge research. Highly cited documents by Zhou [12] and (**Figure 5A**), and reflect emergent themes in OCTA imaging, deep learning, and non-invasive diagnostics. The prominence of authors like Bandello and Sivaprasad in citation networks further confirms their influence in shaping research priorities. At the institutional level, frequent citations of Sun Yat-sen University underscore its substantial contributions to high-impact research in DR diagnostics [12].

*Intellectual foundations and bibliographic connections:* Co-citation and bibliographic coupling networks reveal the underlying structure of the research landscape [13]. Foundational literature often clusters around clinical trials, imaging innovations, and methodological advances. Journals such as The Lancet, JAMA Ophthalmology, and American Journal of Ophthalmology are frequently co-cited, indicating their role in forming the knowledge base of the field. Bibliographic coupling further indicates that clusters of authors and institutions share common literature, suggesting thematic alignment in research focused on imaging modalities, segmentation algorithms, and DR biomarkers (**Figure 7B**).

*Thematic evolution and research priorities:* Keyword co-occurrence analysis provides insight into prevailing and emerging research themes [14]. Frequently co-occurring terms include diabetic retinopathy, optical coherence tomography, deep learning, diabetic macular edema, and segmentation, reflecting strong interests in AI integration, early-stage diagnostics, and image-based classification. The dominance of demographic keywords like humans, male, female, and aged points to continued interest in population-based and epidemiological studies. PubMed's MeSH-based networks show clinical relevance, while author keywords from Scopus and Google Scholar emphasize technology-driven approaches, including machine learning, vascular density, and biomarkers (**Figure 8B**).

*Database-specific insights:* Comparative analysis across databases reveals consistent patterns with subtle distinctions. PubMed emphasizes clinical terms and indexing precision via MeSH headings [15] (**Figure 10A**). Scopus and Google Scholar networks reveal broader author-level collaborations, including contributions from emerging regions. The Lens database offers a translational view, linking academic research with innovation and patent data (**Figure 11A**). These findings underscore the importance of integrating multiple bibliographic sources for a comprehensive bibliometric perspective.

*Implications and future perspectives:* This study highlights that global research on diabetic retinopathy is not only expanding rapidly but also becoming more interdisciplinary and technologically advanced. Imaging techniques, particularly OCTA, have become central to research and clinical practice, enabling the detection of preclinical microvascular and neurodegenerative changes. The integration of AI and machine learning into DR diagnostics is another key direction, aiming to enhance prediction, grading, and treatment outcomes. However, the current bibliometric trends also reveal underrepresentation in areas such as long-term treatment outcomes, neurovascular mechanisms, and real-world population-specific data. Future research should address these gaps, with greater emphasis on translational studies, cost-effective diagnostic tools, and the inclusion of underserved populations in research and clinical practice. Further bibliometric studies may explore the roles of funding sources, policy frameworks, and open-access dissemination in shaping global DR research. In summary, bibliometric mapping is an essential approach for understanding how scientific knowledge evolves, who the major contributors are, and where future research can be effectively directed within the dynamic and growing field of diabetic retinopathy and imaging technologies.

*Conclusion:* This bibliometric analysis provides a comprehensive overview of the global research landscape on diabetic retinopathy and optical coherence tomography from 2020 to 2025. Through co-authorship, citation, co-citation, bibliographic coupling, and keyword co-occurrence networks, this study highlights the most influential contributors, emerging research themes, and structural patterns of collaboration in the field. The network visualizations clearly identify prolific authors, leading institutions, and dominant countries particularly the United States and China as key players driving innovation and publication output.

Clusters of closely connected researchers and organizations reveal how scientific communities are formed, while areas of limited collaboration suggest opportunities for strengthening cross-disciplinary and international partnerships. By mapping these relationships and intellectual foundations, this analysis serves as a valuable tool for academic networking, strategic research planning, and identifying collaboration opportunities. It not aids scholars and institutions in locating potential partners but also supports policymakers and funding bodies in making informed decisions to promote impactful and collaborative science.

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