Georgian Medical News

ТБИЛИСИ - NEW YORK

ЕЖЕМЕСЯЧНЫЙ НАУЧНЫЙ ЖУРНАЛ

Медицинские новости Грузии

საქართველოს სამედიცინო სიახლენი

GMN: Georgian Medical News is peer-reviewed, published monthly journal committed to promoting the science and art of medicine and the betterment of public health, published by the GMN Editorial Board since 1994. GMN carries original scientific articles on medicine, biology and pharmacy, which are of experimental, theoretical and practical character; publishes original research, reviews, commentaries, editorials, essays, medical news, and correspondence in English and Russian.
GMN is indexed in MEDLINE, SCOPUS, PubMed and VINITI Russian Academy of Sciences. The full text content is available through EBSCO databases.

GMN: Медицинские новости Грузии - ежемесячный рецензируемый научный журнал, издаётся Редакционной коллегией с 1994 года на русском и английском языках в целях поддержки медицинской науки и улучшения здравоохранения. В журнале публикуются оригинальные научные статьи в области медицины, биологии и фармации, статьи обзорного характера, научные сообщения, новости медицины и здравоохранения. Журнал индексируется в MEDLINE, отражён в базе данных SCOPUS, PubMed и ВИНИТИ РАН. Полнотекстовые статьи журнала доступны через БД EBSCO.

GMN: Georgian Medical News – საქართველოს სამედიცინო სიახლენი – არის ყოველთვიური სამეცნიერო სამედიცინო რეცენზირებადი ჟურნალი, გამოიცემა 1994 წლიდან, წარმოადგენს სარედაქციო კოლეგიისა და აშშ-ის მეცნიერების, განათლების, ინდუსტრიის, ხელოვნებისა და ბუნებისმეტყველების საერთაშორისო აკადემიის ერთობლივ გამოცემას. GMN-ში რუსულ და ინგლისურ ენებზე ქვეყნდება ექსპერიმენტული, თეორიული და პრაქტიკული ხასიათის ორიგინალური სამეცნიერო სტატიები მედიცინის, ბიოლოგიისა და ფარმაციის სფეროში, მიმოხილვითი ხასიათის სტატიები.
ჟურნალი ინდექსირებულია MEDLINE-ის საერთაშორისო სისტემაში, ასახულია SCOPUS-ის, PubMed-ის და ВИНИТИ РАН-ის მონაცემთა ბაზებში. სტატიების სრული ტექსტი ხელმისაწვდომია EBSCO-ს მონაცემთა ბაზებიდან.

К СВЕДЕНИЮ АВТОРОВ!

При направлении статьи в редакцию необходимо соблюдать следующие правила:

1. Статья должна быть представлена в двух экземплярах, на русском или английском языках, напечатанная через **полтора интервала на одной стороне стандартного листа с шириной левого поля в три сантиметра**. Используемый компьютерный шрифт для текста на русском и английском языках - **Times New Roman (Кириллица)**, для текста на грузинском языке следует использовать **AcadNusx.** Размер шрифта - **12**. К рукописи, напечатанной на компьютере, должен быть приложен CD со статьей.

2. Размер статьи должен быть не менее десяти и не более двадцати страниц машинописи, включая указатель литературы и резюме на английском, русском и грузинском языках.

3. В статье должны быть освещены актуальность данного материала, методы и результаты исследования и их обсуждение.

При представлении в печать научных экспериментальных работ авторы должны указывать вид и количество экспериментальных животных, применявшиеся методы обезболивания и усыпления (в ходе острых опытов).

4. К статье должны быть приложены краткое (на полстраницы) резюме на английском, русском и грузинском языках (включающее следующие разделы: цель исследования, материал и методы, результаты и заключение) и список ключевых слов (key words).

5. Таблицы необходимо представлять в печатной форме. Фотокопии не принимаются. **Все цифровые, итоговые и процентные данные в таблицах должны соответствовать таковым в тексте статьи**. Таблицы и графики должны быть озаглавлены.

6. Фотографии должны быть контрастными, фотокопии с рентгенограмм - в позитивном изображении. Рисунки, чертежи и диаграммы следует озаглавить, пронумеровать и вставить в соответствующее место текста **в tiff формате**.

В подписях к микрофотографиям следует указывать степень увеличения через окуляр или объектив и метод окраски или импрегнации срезов.

7. Фамилии отечественных авторов приводятся в оригинальной транскрипции.

8. При оформлении и направлении статей в журнал МНГ просим авторов соблюдать правила, изложенные в «Единых требованиях к рукописям, представляемым в биомедицинские журналы», принятых Международным комитетом редакторов медицинских журналов - http://www.spinesurgery.ru/files/publish.pdf и http://www.nlm.nih.gov/bsd/uniform_requirements.html В конце каждой оригинальной статьи приводится библиографический список. В список литературы включаются все материалы, на которые имеются ссылки в тексте. Список составляется в алфавитном порядке и нумеруется. Литературный источник приводится на языке оригинала. В списке литературы сначала приводятся работы, написанные знаками грузинского алфавита, затем кириллицей и латиницей. Ссылки на цитируемые работы в тексте статьи даются в квадратных скобках в виде номера, соответствующего номеру данной работы в списке литературы. Большинство цитированных источников должны быть за последние 5-7 лет.

9. Для получения права на публикацию статья должна иметь от руководителя работы или учреждения визу и сопроводительное отношение, написанные или напечатанные на бланке и заверенные подписью и печатью.

10. В конце статьи должны быть подписи всех авторов, полностью приведены их фамилии, имена и отчества, указаны служебный и домашний номера телефонов и адреса или иные координаты. Количество авторов (соавторов) не должно превышать пяти человек.

11. Редакция оставляет за собой право сокращать и исправлять статьи. Корректура авторам не высылается, вся работа и сверка проводится по авторскому оригиналу.

12. Недопустимо направление в редакцию работ, представленных к печати в иных издательствах или опубликованных в других изданиях.

При нарушении указанных правил статьи не рассматриваются.

REQUIREMENTS

Please note, materials submitted to the Editorial Office Staff are supposed to meet the following requirements:

1. Articles must be provided with a double copy, in English or Russian languages and typed or compu-ter-printed on a single side of standard typing paper, with the left margin of **3** centimeters width, and **1.5** spacing between the lines, typeface - **Times New Roman (Cyrillic)**, print size - **12** (referring to Georgian and Russian materials). With computer-printed texts please enclose a CD carrying the same file titled with Latin symbols.

2. Size of the article, including index and resume in English, Russian and Georgian languages must be at least 10 pages and not exceed the limit of 20 pages of typed or computer-printed text.

3. Submitted material must include a coverage of a topical subject, research methods, results, and review.

Authors of the scientific-research works must indicate the number of experimental biological species drawn in, list the employed methods of anesthetization and soporific means used during acute tests.

4. Articles must have a short (half page) abstract in English, Russian and Georgian (including the following sections: aim of study, material and methods, results and conclusions) and a list of key words.

5. Tables must be presented in an original typed or computer-printed form, instead of a photocopied version. **Numbers, totals, percentile data on the tables must coincide with those in the texts of the articles.** Tables and graphs must be headed.

6. Photographs are required to be contrasted and must be submitted with doubles. Please number each photograph with a pencil on its back, indicate author's name, title of the article (short version), and mark out its top and bottom parts. Drawings must be accurate, drafts and diagrams drawn in Indian ink (or black ink). Photocopies of the X-ray photographs must be presented in a positive image in **tiff format**.

Accurately numbered subtitles for each illustration must be listed on a separate sheet of paper. In the subtitles for the microphotographs please indicate the ocular and objective lens magnification power, method of coloring or impregnation of the microscopic sections (preparations).

7. Please indicate last names, first and middle initials of the native authors, present names and initials of the foreign authors in the transcription of the original language, enclose in parenthesis corresponding number under which the author is listed in the reference materials.

8. Please follow guidance offered to authors by The International Committee of Medical Journal Editors guidance in its Uniform Requirements for Manuscripts Submitted to Biomedical Journals publication available online at: http://www.nlm.nih.gov/bsd/uniform_requirements.html
http://www.icmje.org/urm_full.pdf
In GMN style for each work cited in the text, a bibliographic reference is given, and this is located at the end of the article under the title "References". All references cited in the text must be listed. The list of references should be arranged alphabetically and then numbered. References are numbered in the text [numbers in square brackets] and in the reference list and numbers are repeated throughout the text as needed. The bibliographic description is given in the language of publication (citations in Georgian script are followed by Cyrillic and Latin).

9. To obtain the rights of publication articles must be accompanied by a visa from the project instructor or the establishment, where the work has been performed, and a reference letter, both written or typed on a special signed form, certified by a stamp or a seal.

10. Articles must be signed by all of the authors at the end, and they must be provided with a list of full names, office and home phone numbers and addresses or other non-office locations where the authors could be reached. The number of the authors (co-authors) must not exceed the limit of 5 people.

11. Editorial Staff reserves the rights to cut down in size and correct the articles. Proof-sheets are not sent out to the authors. The entire editorial and collation work is performed according to the author's original text.

12. Sending in the works that have already been assigned to the press by other Editorial Staffs or have been printed by other publishers is not permissible.

**Articles that Fail to Meet the Aforementioned
Requirements are not Assigned to be Reviewed.**

რედაქციაში სტატიის წარმოდგენისას საჭიროა დავიცვათ შემდეგი წესები:

1. სტატია უნდა წარმოადგინოთ 2 ცალად, რუსულ ან ინგლისურ ენებზე,დაბეჭდილი სტანდარტული ფურცლის 1 გვერდზე, 3 სმ სიგანის მარცხენა ველისა და სტრიქონებს შორის 1,5 ინტერვალის დაცვით. გამოყენებული კომპიუტერული შრიფტი რუსულ და ინგ-ლისურენოვან ტექსტებში - **Times New Roman (Кириллица)**,ხოლო ქართულენოვან ტექსტში საჭიროა გამოვიყენოთ **AcadNusx.** შრიფტის ზომა – 12. სტატიას თან უნდა ახლდეს CD სტატიით.

2. სტატიის მოცულობა არ უნდა შედგენდეს 10 გვერდზე ნაკლებს და 20 გვერდზე მეტს ლიტერატურის სიის და რეზიუმების (ინგლისურ,რუსულ და ქართულ ენებზე) ჩათვლით.

3. სტატიაში საჭიროა გაშუქდეს: საკითხის აქტუალობა; კვლევის მიზანი; საკვლევი მასალა და გამოყენებული მეთოდები; მიღებული შედეგები და მათი განსჯა. ექსპერიმენ-ტული ხასიათის სტატიების წარმოდგენისას ავტორებმა უნდა მიუთითონ საექსპერიმენტო ცხოველების სახეობა და რაოდენობა; გაუტკივარებისა და დაძინების მეთოდები (მწვავე ცდების პირობებში).

4. სტატიას თან უნდა ახლდეს რეზიუმე ინგლისურ,რუსულ და ქართულ ენებზე არანაკლებ ნახევარი გვერდის მოცულობისა (სათაურის, ავტორების, დაწესებულების მითითებით და უნდა შეიცავდეს შემდეგ განყოფილებებს: მიზანი,მასალა და მეთოდები, შედეგები და დასკვნები; ტექსტუალური ნაწილი არ უნდა იყოს 15 სტრიქონზე ნაკლები) და საკვანძო სიტყვების ჩამონათვალი (key words).

5. ცხრილები საჭიროა წარმოადგინოთ ნაბეჭდი სახით. ყველა ციფრული, შემა-ჯამებელი და პროცენტული მონაცემები უნდა შეესაბამებოდეს ტექსტში მოყვანილს.

6. ფოტოსურათები უნდა იყოს კონტრასტული; სურათები, ნახაზები, დიაგრამები - დასათაურებული, დანომრილი და სათანადო ადგილას ჩასმული. რენტგენოგრამების ფოტოასლები წარმოადგინეთ პოზიტიური გამოსახულებით **tiff** ფორმატში. მიკროფოტო-სურათების წარწერებში საჭიროა მიუთითოთ ოკულარის ან ობიექტივის საშუალებით გადიდების ხარისხი,ანათლების შედგების ან იმპრეგნაციის მეთოდი და აღნიშნოთ სუ-რათის ზედა და ქვედა ნაწილები.

7. სამამულო ავტორების გვარები სტატიაში აღინიშნება ინიციალების თანდართვით, უცხოურისა – უცხოური ტრანსკრიპციით.

8. სტატიას თან უნდა ახლდეს ავტორის მიერ გამოყენებული სამამულო და უცხო-ური შრომების ბიბლიოგრაფიული სია (ბოლო 5-8 წლის სიდრმით). ანბანური წყობით წარმოდგენილ ბიბლიოგრაფიულ სიაში მიუთითეთ ჯერ სამამული, შემდეგ უცხოელი ავტორები (გვარი, ინიციალები, სტატიის სათაური, ჟურნალის დასახელება, გამოცემის ადგილი,წელი,ჟურნალის №,პირველი და ბოლო გვერდები). მონოგრაფიის შემთხვევაში მიუთითეთ გამოცემის წელი, ადგილი და გვერდების საერთო რაოდენობა. ტექსტში კვადრატულ ფჩხილებში უნდა მიუთითოთ ავტორის შესაბამისი N ლიტერატურის სიის მიხედვით. მიზანშეწონილია, რომ ციტირებული წყაროების უმეტესი ნაწილი იყოს 5-6 წლის სიდრმის.

9. სტატიას თან უნდა ახლდეს: ა) დაწესებულების ან სამეცნიერო ხელმძღვანე-ლის წარდგინება, დამოწმებული ხელმოწერითა და ბეჭდით; ბ) დარგის სპეციალისტის დამოწმებული რეცენზია, რომელშიც მითითებული იქნება საკითხის აქტუალობა, მასალის საკმაობა,მეთოდის სანდოობა, შედეგების სამეცნიერო-პრაქტიკული მნიშვნელობა.

10. სტატიის ბოლოს საჭიროა ყველა ავტორის ხელმოწერა,რომელთა რაოდენობა არ უნდა აღემატებოდეს 5-ს.

11. რედაქცია იტოვებს უფლებას შეასწოროს სტატია. ტექსტზე მუშაობა და შე-ჯერება ხდება საავტორო ორიგინალის მიხედვით.

12. დაუშვებელია რედაქციაში ისეთი სტატიის წარდგენა, რომელიც დასაბეჭდად წარდგენილი იყო სხვა რედაქციაში ან გამოქვეყნებული იყო სხვა გამოცემებში.

აღნიშნული წესების დარღვევის შემთხვევაში სტატიები არ განიხილება.

Содержание:

VASCULAR INTERVENTIONS IN FRAIL ELDERLY PATIENTS: A BIBLIOMETRIC ANALYSIS OF GLOBAL RESEARCH OUTPUT AND CLINICAL OUTCOMES

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Abstract.

Background: Frailty is increasingly recognized as a major determinant of poor outcomes in elderly patients undergoing vascular interventions. With global population aging, the intersection between frailty and vascular disease has become a pressing clinical and research priority. However, research in this domain remains scattered, and no bibliometric synthesis has systematically mapped global trends.

Objectives: This study aimed to (1) analyze global research trends on vascular interventions in frail elderly patients (2000–2025), (2) identify the most productive countries, institutions, authors, and journals, (3) evaluate co-authorship, keyword co-occurrence, and citation impact, and (4) highlight clinical outcomes studied and areas for future research.

Methods: A bibliometric analysis was conducted using PubMed, Medline, and Embase databases covering 2000–2024. The search strategy combined terms such as "vascular intervention," "frail elderly," "endovascular procedures," and "geriatric vascular surgery." A total of 276 relevant publications were included. Bibliometric indicators assessed annual scientific production, source impact (Bradford's Law), author productivity (Lotka's Law), institutional and country-level contributions, keyword evolution, and collaboration networks. Analytical tools included Bibliometrix (R package) for mapping and VOSviewer for visualization.

Results: Research output demonstrated steady growth, with fewer than 10 publications annually before 2005, rising sharply after 2016, and peaking at 28 articles in 2025. The Journal of Vascular Surgery (n=23), *Annals of Vascular Surgery* (n=14), and *Journal of Neurointerventional Surgery* (n=11) were the most prolific sources. Author productivity was highly skewed, with 88.1% contributing only one article, while Pol RA and Brooke BS emerged as leading figures. Sichuan University (43 articles), the University of Utah (34), and Yale University (27) were the most productive institutions. By country, China (298 articles) and Japan (198) dominated total output, surpassing the USA (171). Keyword analysis revealed strong emphasis on "treatment outcomes," "risk factors," and "aged ≥80," but frailty-specific terms were underrepresented. Collaboration mapping showed strong Asia-Pacific ties, while US research remained largely domestic.

Conclusions: This is the first bibliometric study to systematically examine global research on vascular interventions in frail elderly patients. Findings demonstrate accelerated growth since 2016, with Asia emerging as a global leader. Despite rising output, gaps remain in standardized frailty assessment and integration of geriatric principles. Future research should prioritize consistent frailty evaluation, sustained collaborations, and clinical trials aligning vascular care with geriatric best practices.

Key words. Frailty, vascular interventions, elderly, bibliometric analysis, global research trends, endovascular surgery.

Introduction.

The global population is aging at an unprecedented rate, with projections indicating that by 2050, one in six individuals worldwide will be over the age of 65 [1]. This demographic shift has resulted in a substantial rise in frail elderly individuals requiring complex medical and surgical care. Frailty, characterized by reduced physiological reserves, diminished resilience, and heightened vulnerability to stressors, is increasingly recognized as a significant determinant of poor outcomes in older adults undergoing medical or surgical interventions [2].

Vascular diseases, such as peripheral arterial disease (PAD), carotid artery stenosis, and aortic aneurysms, are particularly prevalent in older populations. These conditions often necessitate complex procedures, including open vascular surgery, endovascular aortic repair (EVAR), carotid artery stenting, and angioplasty [3]. The intersection of frailty and vascular disease therefore represents a critical clinical challenge, as these patients are simultaneously at high risk of disease progression and intervention-related complications.

Recent studies have highlighted that frailty is strongly associated with increased mortality, prolonged hospitalization, functional decline, and higher rates of postoperative complications, even when less invasive approaches are employed [4,5]. This suggests that frailty is not only a predictor of adverse outcomes but also

a factor that complicates decision-making for clinicians, who must balance procedural benefits against the heightened risk profile of this vulnerable group.

Despite its clinical importance, research on vascular interventions in frail elderly patients remains scattered across diverse disciplines, including surgery, geriatrics, radiology, and anesthesiology. There is a lack of comprehensive synthesis to map how scientific attention to this field has evolved, which institutions and countries are leading, and what knowledge gaps persist. Bibliometric analysis offers a structured and quantitative approach to evaluate scientific productivity, track research trends, and identify emerging themes and collaborations across disciplines [6].

To date, no comprehensive bibliometric study has systematically mapped the global research output on vascular interventions specifically in frail elderly patients. This study seeks to fill that gap by providing an overview of the literature published between 2000 and 2025, highlighting publication trends, influential contributors, institutional and national productivity, and thematic research priorities.

Objectives.

The objectives of this study are:

1. To analyze the global research trends on vascular interventions in frail elderly patients from 2000 to 2025.

2. To identify the most productive countries, institutions, authors, and journals in this research domain.

3. To examine the co-authorship networks, keyword co-occurrence, and citation impact of relevant publications.

4. To highlight key clinical outcomes studied and suggest areas for future research.

Research Design and Methods.

This study employed a bibliometric analysis to evaluate global research output on vascular interventions in frail elderly patients from 2000 to 2024. The analysis focused on publication trends, key journals, author contributions, institutional and national productivity, keyword evolution, and collaboration networks. Publications were extracted from three major databases: PubMed, Medline, and Embase.

Search Strategy: The search strategy combined keywords such as *"vascular interventions"*, *"frail elderly"*, *"geriatric vascular surgery"*, *"endovascular procedures"*, and *"frailty assessment."* The advanced search function was used to identify relevant literature using the query: ("vascular intervention*" OR "endovascular" OR "vascular surgery") AND ("frail*" OR "elderly" OR "aged" OR "geriatric"). A total of 283 records were initially retrieved. After excluding 7 records during pre-screening (duplicates or irrelevant), 276 articles were screened and assessed for eligibility. All were included in the final bibliometric analysis. The PRISMA flow diagram was revised to accurately reflect these steps.

Inclusion Criteria: Eligible publications included original research articles, reviews, and clinical studies that focused on frail elderly patients ($\geq$ 65 years) undergoing vascular interventions between 2000 and 2024. Conference abstracts, commentaries, and non-English publications were excluded.

Bibliometric Indicators: The following bibliometric indicators were analyzed:

· **Annual scientific production** and trends over time.

· **Journal analysis** using Bradford's Law to identify core journals (Zone 1).

· **Author productivity** and fractionalized contributions based on Lotka's Law.

· **Institutional and country contributions**, leading institutions, and temporal output.

· **Country-level collaboration networks**, including both single-country and multi-country publications.

· **Keyword co-occurrence**, thematic evolution, and network clusters.

· **Collaboration strength**, including both positive and negative scores.

Note: "Country contribution counts" were measured as authorship instances, meaning that if a single article was co-authored by researchers from multiple countries, it was counted once for each country. This explains why the sum of country contributions exceeds the total number of unique articles (n =276).

Analytical Tools: Data were processed using Bibliometrix (R package) for bibliometric mapping and VOSviewer for visualizing keyword clusters and collaboration networks.

Negative collaboration scores indicate fewer co-authorships between two countries than expected based on their publication volumes. This reflects limited joint activity rather than conflict, helping highlight underdeveloped collaboration pathways in the research field.

The analysis of most relevant affiliations in Vascular Interventions for Frail Elderly Patients highlights the leading institutions contributing to research on vascular interventions for frail elderly patients, with Sichuan University emerging as the most prolific (43 articles), followed closely by the University of Utah School of Medicine (34) and National University Health System (28). Notably, Yale, Stanford, and the University of California also rank among the top contributors, reflecting strong engagement from major U.S. academic medical centers. Chinese institution, including Sichuan University, Chongqing Medical University, and Hunan Normal University, demonstrate significant research output, suggesting growing expertise in this field within Asia. European representation appears through Amphia Hospital (Netherlands), while Atrium Health (U.S.) rounds out the list, indicating a geographically diverse yet U.S. and China-dominated research landscape. This distribution underscores the global importance of vascular interventions in aging populations, with academic hospitals leading the way in clinical and translational research. Future collaborations between these top-performing institutions could further advance the field.

The bibliometric analysis of institutional contributions reveals distinct evolutionary patterns in vascular intervention research for frail elderly patients. Yale University School of Medicine demonstrated early but gradual engagement, maintaining consistent single-article output from 2010-2016 before dramatically increasing production to 15 articles annually during
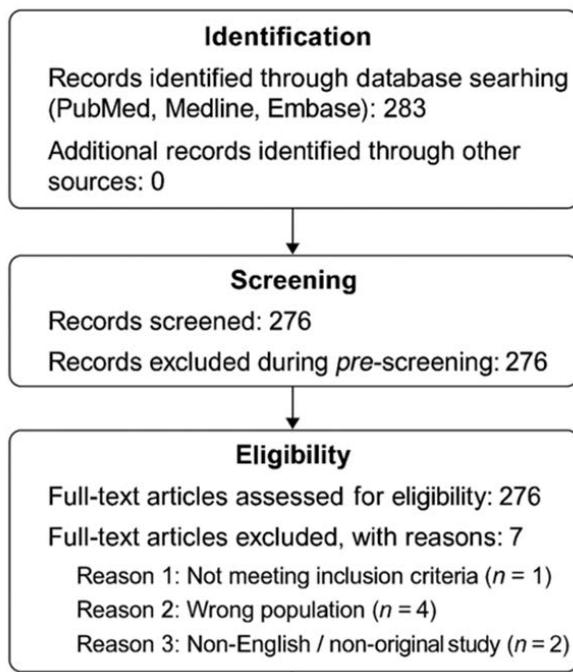
Figure 1. *PRISMA Flow Diagram of Study Selection for Bibliometric Analysis on Vascular Interventions in Frail Elderly Patients (2000–2025).*
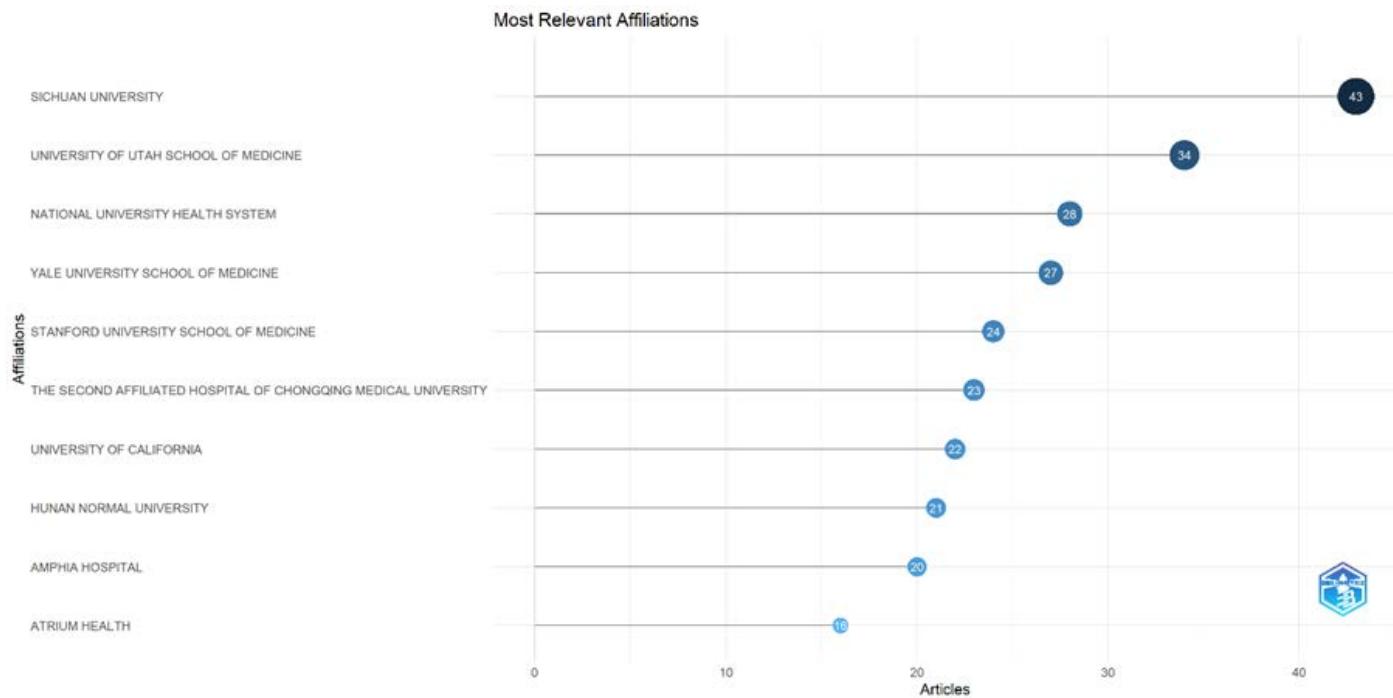
Figure 2. *Most Relevant Institutional Affiliations in Research on Vascular Interventions in Frail Elderly Patients (2000–2025).*

Affiliations' Production over Time
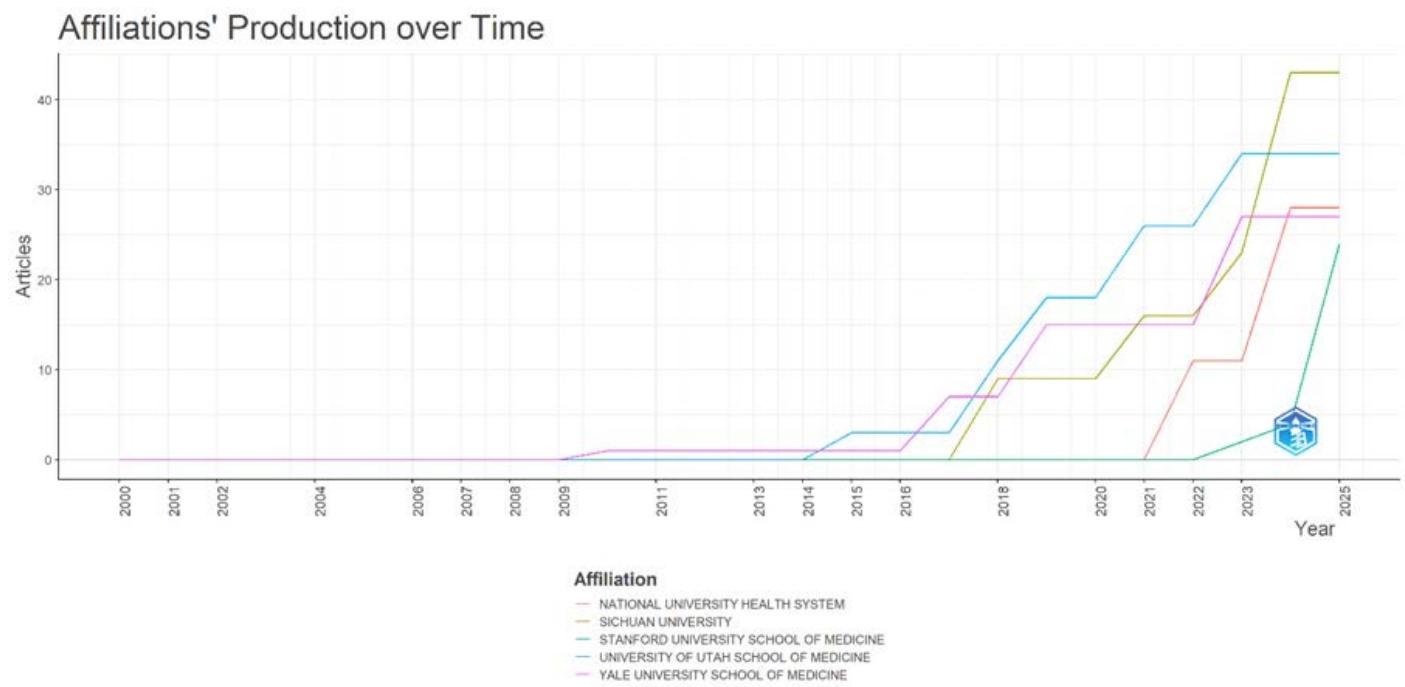
Figure 3. Publication Trends of the Five Most Productive Institutions in Vascular Interventions for Frail Elderly Patients (2000–2025).

Corresponding Author's Countries
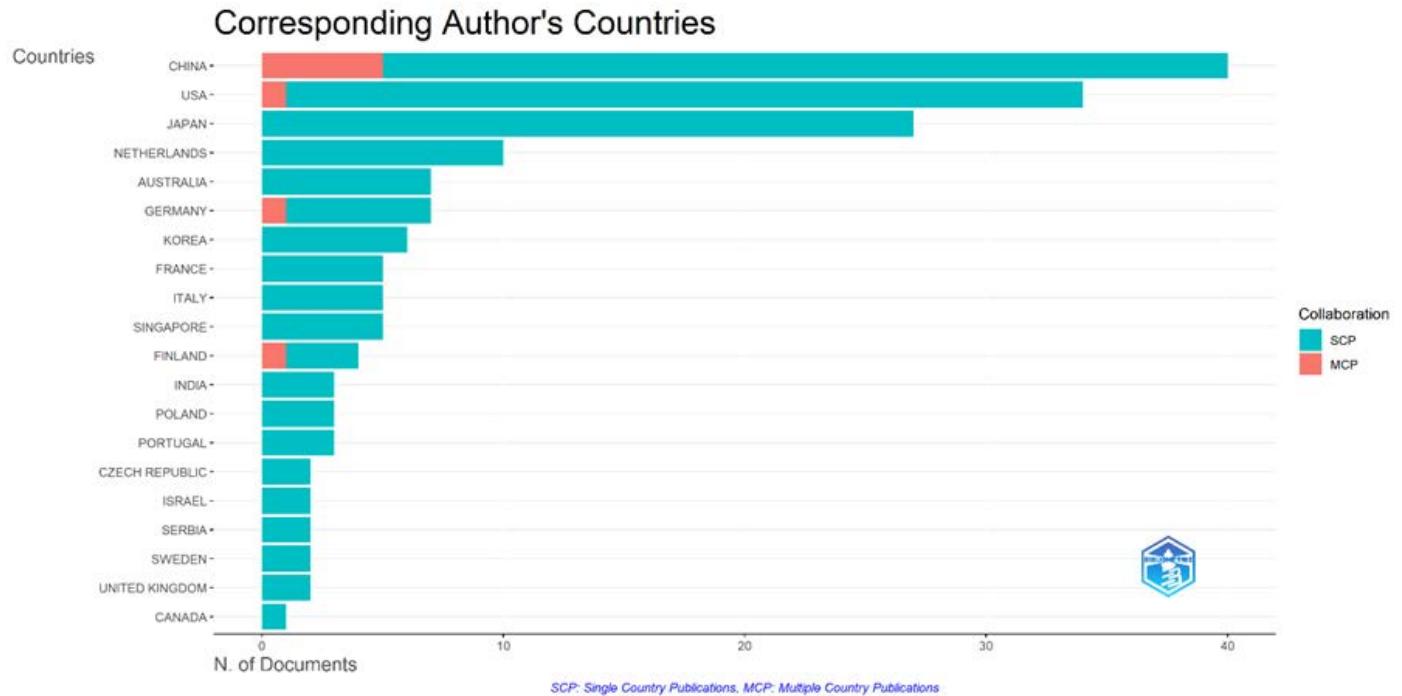
Figure 4. Corresponding Author's Countries and Types of Collaboration (Single-Country vs. Multi-Country Publications) in Vascular Interventions for Frail Elderly Patients (2000–2025).

Country Scientific Production
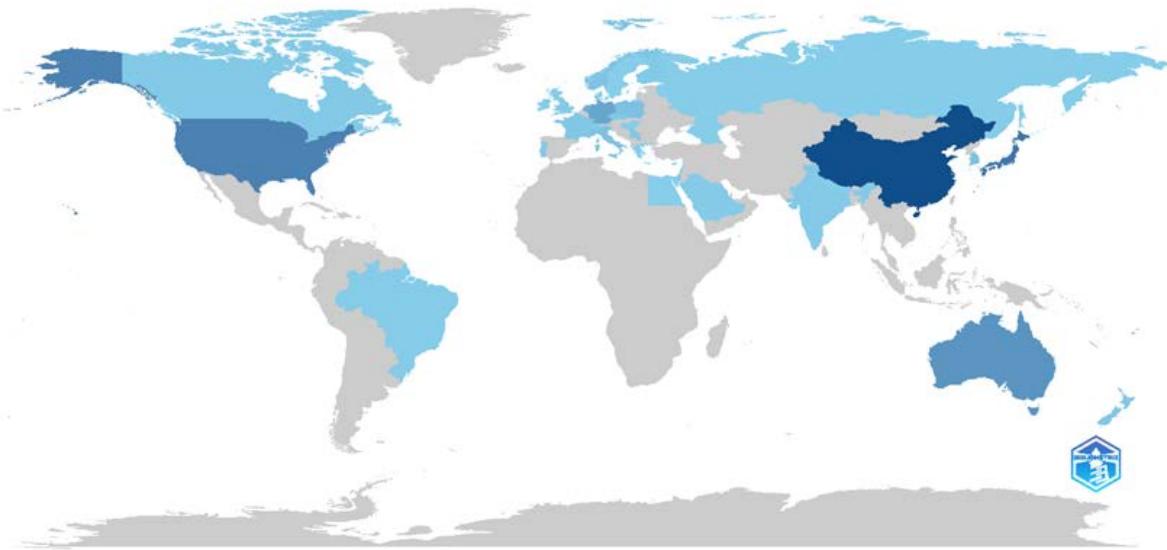
Figure 5. *Global Scientific Production on Vascular Interventions in Frail Elderly Patients (2000–2025).*

Country Production over Time
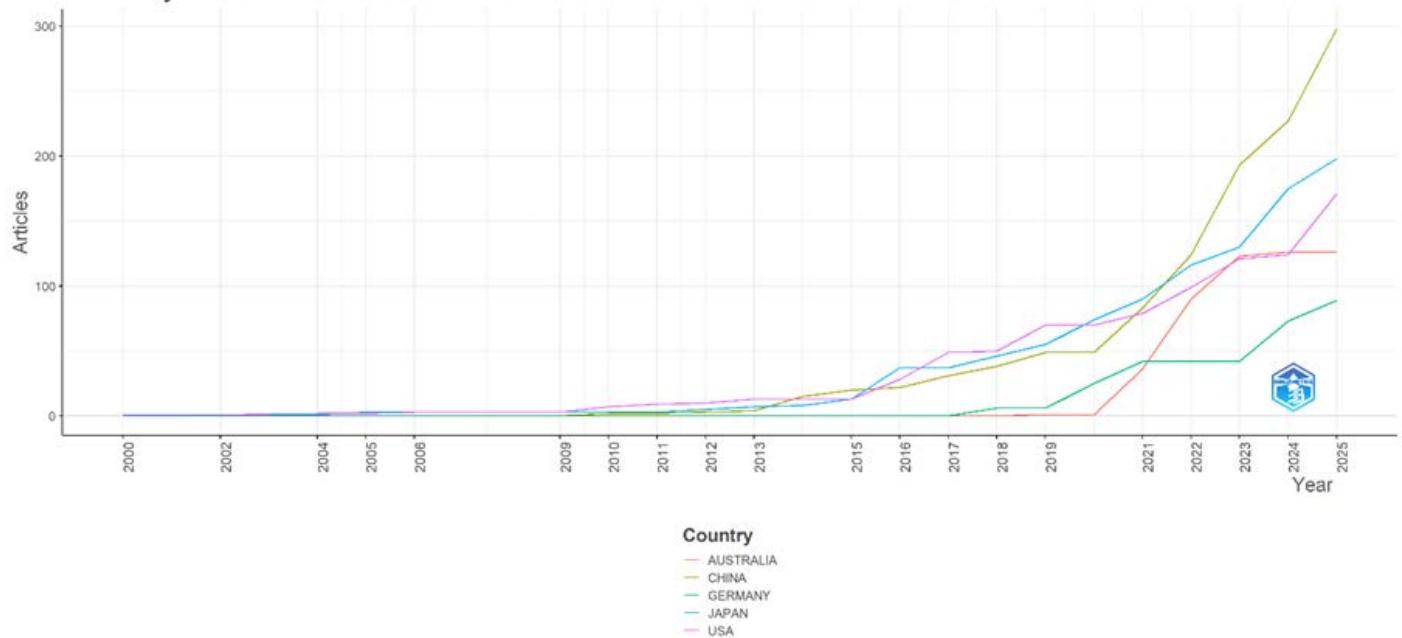
Figure 6. *Publication Trends of the Five Most Productive Countries in Vascular Interventions for Frail Elderly Patients (2000–2025).*

Most Relevant Words

Words' Frequency over Time
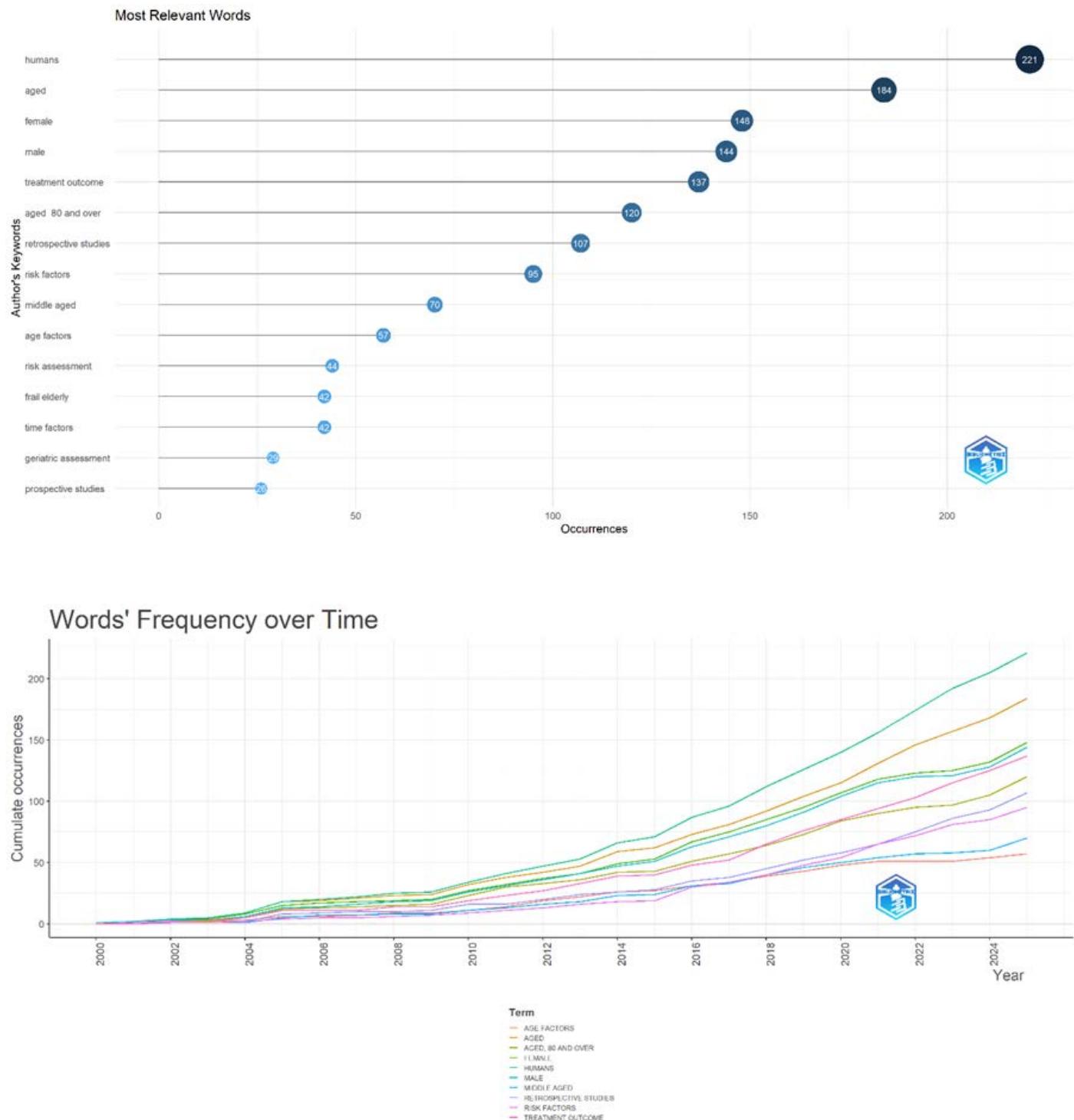
Figure 8. *Cumulative Occurrence Trends of the Most Frequent Keywords in Vascular Interventions for Frail Elderly Patients (2000–2025).*
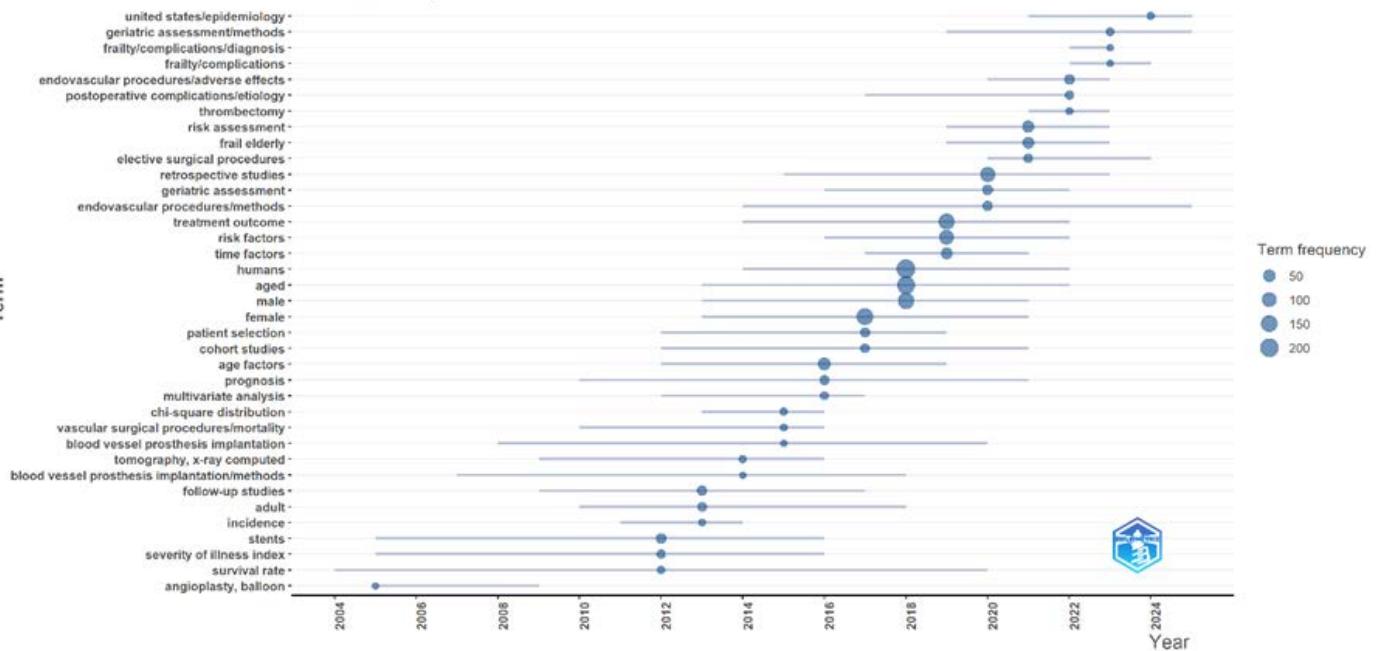
Figure 9. *Trend Topics in Research on Vascular Interventions for Frail Elderly Patients (2000–2025).*
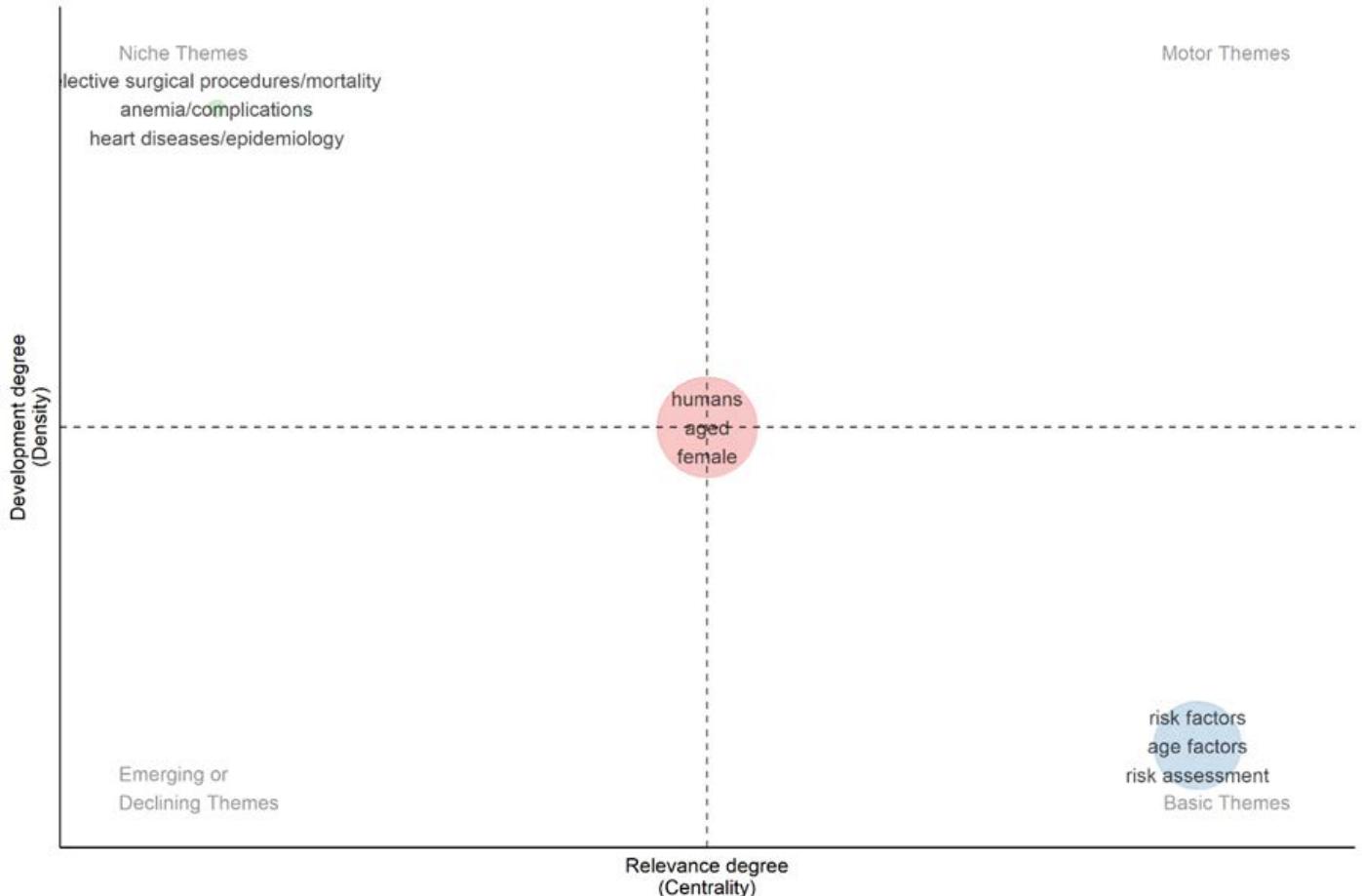
Figure 10. *Thematic Map of Research on Vascular Interventions in Frail Elderly Patients (2000–2025).*

Country Collaboration Map
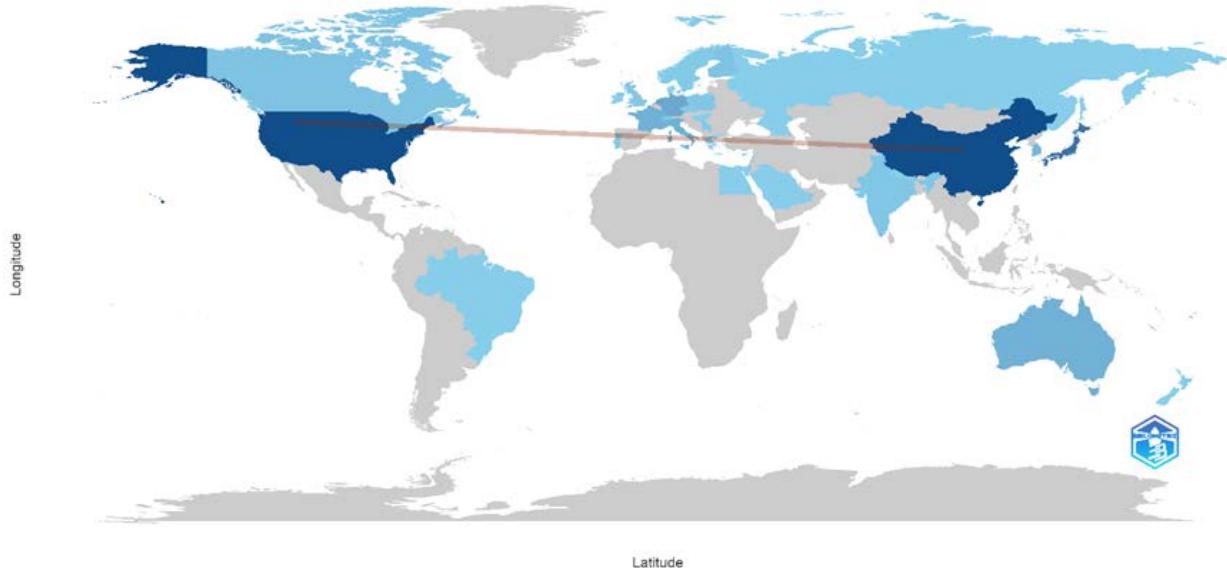
Figure 11. *Country Collaboration Map for Research on Vascular Interventions in Frail Elderly Patients (2000–2025).*

Figure 12. *Keyword Co-occurrence Word Cloud for Research on Vascular Interventions in Frail Elderly Patients (2000–2025).*

Table 1. *Bibliometric Analysis of Vascular Interventions in Frail Elderly Patients (2000–2025).*

Dimension	Key Findings	Details
Annual Scientific Production	Steady growth with peak in 2025	• 2000–2005: <10 papers/year (nascent stage)• 2005: first uptick (9)• 2014: double digits (13)• 2016–2020: rapid rise (15–22/year)• 2025: peak at 28 (reflecting aging, new diagnostics, guidelines)
Core Journals (Bradford's Law Zone 1)	10 journals produced 92 articles	• Journal of Vascular Surgery (23)• Annals of Vascular Surgery (14)• Journal of Neurointerventional Surgery (11)• Advances in Gerontology (8)• AJNR (7)• Eur J Vasc & Endovasc Surgery (7)• Stroke (6)• J Endovascular Therapy (5)• Br J Surgery (5)• Others (6)
Top Authors	Mix of leaders & co-authors	• Brooke BS (9; fractional 1.56)• Wang J (9; 1.07)• Pol RA (7; 2.34 – highest leadership)• Arya S, Kozlov KL, Kraiss LW (7 each)• Aitken SJ, Smith BK (6 each)• Chen Y, Xiang L (5 each; mostly co-authors)
Author Productivity (Lotka's Law)	Highly skewed, dominated by one-time authors	• 1 paper: 88.1% (expected 65.6%)• 2 papers: 8.5% (expected 16.4%)• 3 papers: 1.9% (expected 7.3%)• ≥4 papers: 1.6% (rare)• ≥5 papers: 0.7% (very rare)
Top Institutions	Surge in Asia & US centers	• Sichuan Univ (43)• Univ of Utah (34)• Nat'l Univ Health System (28)• Yale Univ (27)• Stanford Univ (24)• Others: Chongqing, Hunan Normal, Amphia (Netherlands), Atrium Health (US)
Top Contributing Countries (Corresponding Author)	Asia leads, US third	• China (40, 14.5%) – highest collaboration (MCP 12.5%)• USA (34, 12.3%) – mostly domestic (MCP 2.9%)• Japan (27, 9.8%) – 100% single-country• Others: Netherlands, Australia, Germany moderate; UK (2), Canada (1) underrepresented
Total Scientific Output by All Authors (2000–2025)	Dominance of Asia	• China (298), Japan (198), USA (171)• Australia (126), Germany (89)• Singapore (84), South Korea (28)• Poland (28), Serbia (16)• Saudi Arabia (7), Brazil (6)• UK (8), Canada (12), Finland (9), Norway (23)

2019-2022, then surging to 27 articles from 2023 onward. The University of Utah School of Medicine showed a similar but delayed trajectory, beginning in 2015 with 3 articles annually before rapidly escalating to 18 articles by 2019 and peaking at 34 articles from 2023. Most strikingly, Sichuan University emerged as the current dominant force, producing no research until 2018 but then achieving exponential growth - from 9 articles (2018-2020) to 16 (2021-2022) before nearly tripling output to 43 articles in 2024-2025. National University Health System displayed the most concentrated growth pattern, remaining inactive until 2022 before suddenly producing 28 articles by 2024. Stanford's participation was remarkably recent, with virtually no contributions until 2023 followed by rapid expansion to 24 articles in 2025. These trends collectively illustrate a shifting global research landscape, where traditional Western academic centers (Yale, Utah) established early foundations but Asian institutions (Sichuan, National University) have recently assumed leadership through explosive, concentrated research efforts in this clinically crucial field.

The bibliometric analysis of research contributions by Country (Corresponding Author Affiliation) reveals the global distribution of research output in vascular interventions for frail elderly patients, based on the country of the corresponding author. The analysis includes total articles, percentage contribution, and collaboration patterns (SCP = single-country publications; MCP = multi-country publications). China leads with 40 articles (14.5%), followed closely by the USA (34 articles, 12.3%) and Japan (27 articles, 9.8%). These three countries account for ~36.6% of total research output, highlighting their central role in advancing this field. The collaboration trends (MCP vs. SCP) indicate China has the highest MCP rate (12.5%) among major contributors, indicating active international collaborations. The USA shows minimal MCP (2.9%), suggesting predominantly domestic research efforts. Japan, Netherlands, and Australia

have 0% MCP, meaning all their publications are single-country studies. Smaller European nations (Finland, Germany, Greece, Hungary) exhibit higher MCP ratios, reflecting stronger cross-border collaboration.

Greece, Hungary, New Zealand, and Norway have 100% MCP, meaning all their publications involve international partners, likely due to smaller research pools requiring external collaboration. The UK (2 articles, 0.7%) and Canada (1 article, 0.4%) are surprisingly underrepresented despite strong medical research systems.

The bibliometric analysis on global research output in Vascular Interventions for Frail Elderly Patients identified countries by their total scientific production (all authors counted, not just corresponding authors) in vascular interventions for frail elderly patients from 2000–2024, revealing striking geographical trends in research activity. The key findings indicate Asia dominates research volume. China (298 articles) leads by a wide margin, followed by Japan (198), together accounting for nearly 40% of global output. Singapore (84) and South Korea (28) also rank highly, reinforcing Asia's outsized role in this field. Western contributions e.g., the USA (171 articles) ranks 3rd, trailing Japan despite its traditionally strong medical research infrastructure. Australia (126) and Germany (89) are the top European/Western Pacific contributors, surpassing larger nations like France (16) and the UK (8).

Poland (28) and Serbia (16) outperform several Western European countries, suggesting growing expertise in Eastern Europe. Saudi Arabia (7) and Brazil (6) represent rare contributions from the Middle East and Latin America. However, the UK (8 articles) and Canada (12) are surprisingly low, possibly due to differing research priorities or funding gaps in geriatric vascular care. Scandinavia shows modest output (Norway: 23, Finland: 9, Sweden: not listed), despite strong universal healthcare systems.

Bibliometric analysis of country-specific research output in Vascular Interventions for Frail Elderly Patients (2000-2025) reveals three distinct phases in global research productivity. Early Phase (2000-2015) shows US leadership with limited global engagement. The USA dominated early research, producing 1-13 articles annually during this period. Japan showed steady but modest growth (0-13 articles/year). China began contributing only in 2010 with minimal output until 2014. Other nations (Germany, Australia) were virtually absent during this foundational period. Transition Phase (2016-2020): Asian Emergence and US Plateau. The USA accelerated output (28-70 articles/year) but was overtaken by Japan in 2020. Japan surged ahead with exponential growth (37-74 articles/year). China began its remarkable ascent (22-49 articles/year). Germany and Australia initiated research programs but remained minor contributors.

Current Phase (2021-2025) has shown dominance and Research Globalization of China, as it achieved staggering growth (83-298 articles), surpassing all others by 2023. Japan maintained strong output (90-198 articles) but couldn't match China's pace. The USA continued steady growth (79-171 articles) but fell to third position. Germany and Australia showed delayed but dramatic increases: Australia jumped from 1 article (2020) to 126 (2024) and Germany rose from 6 articles (2019) to 89 (2025).

The key findings demonstrate that China's research output grew 150-fold from 2014 (15 articles) to 2025 (298 articles). Japan demonstrated the most consistent growth trajectory over 25 years. The USA transitioned from leader to follower despite maintaining strong output. Australia's research explosion (2021-2023) represents the most rapid late-stage entry. Germany's output is surprisingly recent, with 80% of articles appearing since 2020.

The analysis of keyword frequencies reveals a research landscape primarily focused on clinical outcomes in elderly populations, with "humans" (221 occurrences) and "aged" (184) dominating the literature, reflecting the human clinical focus on older patients. Gender-specific analyses are common, as evidenced by nearly equal mentions of "female" (148) and "male" (144), while "aged 80 and over" (120) highlights particular attention to the oldest patients. Retrospective study designs (107) far outweigh prospective ones (26), indicating heavy reliance on chart reviews rather than controlled trials. Outcome measures center around "treatment outcome" (137), with substantial emphasis on "risk factors" (95) and "risk assessment" (44), demonstrating a preventive orientation. Notably, despite the focus on elderly patients, explicit mentions of "frail elderly" appear relatively infrequently (42), and "geriatric assessment" is mentioned in only 29 instances, suggesting potential underutilization of comprehensive elderly evaluations in this research domain. Technical terms like "endovascular procedures" (17) and "stents" (24) reflect the field's intervention-specific focus, while "length of stay" (21) and "patient selection" (18) indicate parallel interests in healthcare efficiency and appropriate use criteria. The pattern suggests an opportunity to strengthen research through more prospective designs, standardized geriatric assessments, and deeper integration of frailty-specific metrics in vascular intervention studies for elderly populations.

The longitudinal analysis of keyword frequency reveals several important trends in how research on vascular interventions for frail elderly patients has evolved over the past quarter-century: Early Years (2000-2009) indicate foundation building. All terms showed gradual but limited growth, with "humans" and "aged" appearing in only 26 publications by 2009. "Treatment outcome" emerged as an early focus (14 occurrences by 2009). retrospective study designs (11) began outpacing other methodologies. Gender reporting ("female" 20, "male" 19) became standard practice. Acceleration phase (2010-2015) indicate methodological maturation. Annual occurrences doubled for most terms. "Aged, 80 and over" (43) surpassed "middle aged" (24), reflecting sharper elderly focus. "Risk factors" (19) and "age factors" (27) gained prominence as analytical categories. Retrospective approaches (28) solidified as the dominant research method. Exponential growth observed during 2016-2025 and these years can be termed as specialization and expansion. All terms showed dramatic increases, with "humans" growing from 87 to 221 occurrences. "Treatment outcome" (137) and "retrospective studies" (107) became near-ubiquitous. The octogenarian focus ("aged, 80 and over" 120) intensified relative to younger elderly. Gender reporting reached near-parity ("female" 148 vs "male" 144). Risk analysis ("risk factors" 95) emerged as a major research theme.

The findings demonstrate that the field has maintained remarkable consistency in its core terminology since inception. Retrospective designs have grown proportionally faster than other methodologies. Focus has progressively shifted toward older age cohorts within the elderly population. Gender-balanced reporting has become standard practice. Outcome measurement and risk assessment have become increasingly sophisticated.

The network analysis reveals six distinct thematic clusters in vascular intervention research for frail elderly patients, with key nodes demonstrating varying levels of influence across the scientific literature: Core Clinical Focus (Cluster 6 - Highest Centrality). Dominated by fundamental demographic terms: "humans" (PageRank 0.082), "aged" (0.072), "female/male" (0.065 each). Key outcome measures include "treatment outcome" (0.06), "aged, 80 and over" (0.054). Methodology mainly focus on "retrospective studies" (0.049) far outweighs "prospective studies" (0.013). Risk Assessment & Temporal Factors (Cluster 4 - High Betweenness). Central nodes include "risk factors" (Betweenness 37.06), "age factors" (10.14). Important secondary themes are "risk assessment" (6.09), "time factors" (7.63). Practical considerations include "length of stay" (1.98), "comorbidity" (0.153). Frailty & Geriatric Evaluation (Cluster 1 - Emerging Importance). Core concept include "frail elderly" (Betweenness 10.68). Assessment tools include "geriatric assessment" (2.45). Procedure-specific outcomes are multiple endovascular and surgical adverse effect terms. Endovascular Focus (Cluster 2 - Technical Specialization). Procedure-centric include "endovascular procedures/adverse effects" (0.291). Device-specific: "stents" (0.218). Outcome measures are "prognosis" (0.185), "follow-up studies" (0.145). Statistical Methodology (Cluster 5 - Analytical Foundation) which was dominated by analytical approaches: "multivariate analysis" (0.435), "odds ratio" (0.402). Modeling techniques

include "logistic models" (0.141), "chi-square distribution" (0.136). Surgical Approaches (Cluster 3 - Niche Focus) include alternative interventions, such as "vascular surgical procedures" (0.078). Emerging concept: "frailty" (0.002) shows potential for future development.

Key network insights indicate "Risk factors" and "age factors" serve as crucial bridges between clusters (high betweenness). Demographic terms form the dense core of the network (high PageRank). Frailty concepts are gaining traction but remain less central than traditional risk factors. Endovascular techniques have developed their own specialized subnetwork. Statistical methods maintain consistent but peripheral importance.

This longitudinal analysis reveals distinct generational shifts in research focus over the past two decades, organized by term emergence and peak activity periods. Early Technical Focus (2004-2012) focus on Pioneering Techniques, such as Balloon angioplasty (2005), stents (2005-2012), and prosthesis implantation (2007-2015) dominated early research. Outcome Measures include survival rates (2004-2020) and severity indices (2005-2016) were primary endpoints. Imaging Advances include X-ray computed tomography emerged as key diagnostic tool (2009-2016). Demographic awakening (2013-2018) indicates population focus, such as gender-specific analysis (female/male terms peaking 2013-2018) and age factors (2012-2019) gained prominence. Methodological shift includes retrospective designs (2015-2023) became dominant over prospective studies. Core terminology includes "Humans" and "aged" reached median usage by 2018, reflecting field maturation. Risk & frailty era (2019-Present) indicate contemporary priorities, including risk assessment (2021-2023), frailty concepts (2021-2024), and geriatric methods (2020-2025) represent current frontiers. Procedure-specific outcomes, such as Endovascular adverse effects (2020-2023) and thrombectomy (2021-2023) reflect technical refinements.

This thematic map reveals a highly interconnected research landscape centered around human clinical studies, with several notable patterns in term centrality and clustering: Core Research Themes (High PageRank Centrality). Fundamental descriptors dominate: "humans" (0.063), "aged" (0.054), "female/male" (0.048-0.049). Outcome measures include "treatment outcome" (0.043), "aged, 80 and over" (0.04). Methodology include "retrospective studies" (0.036) remains primary research approach. Key bridging concepts (High Betweenness Centrality) indicate "Retrospective studies" (1,190.56) serves as the most important connector. Demographic terms such as "female" (640.42), "male" (388.04), "middle aged" (1,645.68). Procedure-related terms include "stents" (661.42), "endovascular procedures" (361.80). Emerging subthemes include frailty concepts show potential but low centrality: "frailty" (44.17), "frailty/complications" (60.79). Specialized procedures include "thrombectomy" (86.32), "angioplasty" (150.27). Advanced analytics include "propensity score" (130.08), "Kaplan-Meier" (122.93).

All terms cluster under "humans" label, indicating tight thematic cohesion. High betweenness scores suggest many terms serve as bridges between subthemes. Procedure-specific terms generally show lower centrality than demographic/outcome terms.

The country collaboration network analysis on Vascular Interventions for Frail Elderly research reveals several unexpected patterns in international research partnerships, with particularly striking findings. The strongest collaborations indicate Australia-New Zealand shows remarkably intense collaboration (171.48), reflecting their close academic ties and shared healthcare systems. Saudi Arabia-Egypt (29.86) and Germany-Cyprus (33.01) demonstrate unexpectedly strong regional partnerships. Norway-Denmark (10.03) maintains expected Nordic research cooperation.

China-USA displays a strongly negative collaboration score (-112.46), suggesting either geopolitical tensions or competitive research environments. Multiple countries show negative ties with France (-2.76), potentially indicating methodological or thematic incompatibilities. Australia-Hungary (19.40) reveals an unexpected but growing East-West collaboration. Cyprus-Greece (22.96) demonstrates strong cultural-academic ties. Italy-Finland (26.27) represents a notable North-South European connection.

The bibliometric analysis of key terms in vascular interventions for frail elderly patients reveals a research landscape strongly anchored in demographic descriptors ("humans" 221, "aged" 184) and gender-balanced reporting ("female" 148, "male" 144), with predominant focus on treatment outcomes (137) and octogenarians (120). The field heavily relies on retrospective designs (107), outweighing prospective studies (26) by 4:1, while maintaining robust investigation of risk factors (95) and age-related considerations (57). Notably, despite the titular focus, "frail elderly" appears relatively infrequently (42), ranking below more general age terms, suggesting potential underutilization of comprehensive frailty assessments. Technical procedure terms (e.g., "stents" 24, various endovascular terms 17-25) dominate over geriatric-specific concepts ("geriatric assessment" 29), revealing a possible tension between procedural and holistic patient-centered approaches. The presence of system factors like "length of stay" (21) and emerging frailty subdomains (9) indicates evolving research priorities, while the stark methodological imbalance highlights opportunities for more prospective, geriatrically-informed study designs that better integrate frailty metrics with established outcome measures in this vulnerable population.

Discussion.

This bibliometric analysis is the first to systematically evaluate the global research landscape on vascular interventions in frail elderly patients, covering trends, contributors, and thematic evolution over the past two decades. Our findings highlight an accelerating growth in publications since 2016, with a peak in 2025, reflecting both the aging population worldwide and the increasing recognition of frailty as a determinant of surgical outcomes [7].

Rising Research Attention: The surge in publications after 2016 aligns with global awareness of frailty as a core predictor of postoperative complications. For example, Rockwood's frailty index and the Clinical Frailty Scale gained wide adoption during this period, driving more structured research into vulnerable surgical populations [8]. In vascular surgery specifically, large-scale cohort studies have shown that frailty independently

predicts higher rates of morbidity, mortality, and institutional discharge following interventions such as EVAR and carotid endarterectomy [9,10]. These findings likely contributed to the observed growth in scholarly output.

Journals and Interdisciplinary Scope: Our results show that vascular and endovascular journals, particularly the Journal of Vascular Surgery and Annals of Vascular Surgery, dominate the field. However, notable contributions also come from radiology (AJNR) and gerontology (Advances in Gerontology), reflecting the multidisciplinary nature of managing frail elderly patients. This interdisciplinary spread is consistent with broader bibliometric trends in surgical science, where collaboration between surgeons, anesthesiologists, and geriatricians has become increasingly common [11]. Nonetheless, frailty-specific geriatric assessments were underrepresented in keywords, suggesting that integration of geriatrics into vascular research remains limited.

Authorship and Collaboration Networks: The author analysis revealed a highly skewed productivity distribution: nearly 90% of authors contributed only one paper, while very few demonstrated sustained research output. This exceeds Lotka's expected distribution and implies a "hit-and-run" pattern, where many clinicians publish single studies without long-term engagement. Similar patterns have been reported in bibliometric studies of other surgical specialties [12]. This lack of continuity may hinder cumulative knowledge development, emphasizing the need for stronger, sustained research groups. International collaboration patterns also revealed disparities: while China had the highest output and collaboration strength, the USA showed predominantly domestic research. This mirrors previous observations in global surgery research, where Asian countries have rapidly expanded output through international partnerships, whereas Western countries often remain siloed [13].

Institutional and Geographic Shifts: The dominance of Sichuan University, the University of Utah, and Yale highlights the concentration of research in a few high-output centers. The recent surge in publications from China reflects broader national investments in medical science and an increasing burden of vascular disease in its aging population [14]. Conversely, the relatively low contributions from traditionally strong research systems such as the UK and Canada are noteworthy and may reflect differing funding priorities or focus on other aspects of geriatric care. Similar regional disparities were observed in global bibliometric analyses of cardiovascular interventions and aging-related surgery [15].

Clinical Implications.

The keyword analysis indicated that frailty, despite being central to this patient group, was infrequently used compared to general descriptors like "aged" or "elderly." This suggests that many studies fail to apply standardized frailty measures, relying instead on age as a surrogate for vulnerability. Previous meta-analyses have demonstrated that chronological age alone is a poor predictor of surgical outcomes, whereas frailty indices provide more accurate risk stratification [16,17]. Therefore, future research should integrate validated frailty assessments to enhance clinical applicability.

Strengths and Limitations.

A major strength of this study is its comprehensive inclusion of multiple databases (PubMed, Medline, Embase) and use of established bibliometric tools (Bibliometrix, VOSviewer). However, limitations include possible language and database bias, exclusion of gray literature, and reliance on indexed terms that may underrepresent frailty-specific studies. These are common constraints in bibliometric analyses [18].

Future Directions.

Moving forward, three priorities emerge: (1) improving the consistency of frailty assessment in vascular intervention studies, (2) fostering sustained research groups and cross-border collaborations, and (3) aligning clinical trials with geriatric principles to optimize outcomes for this vulnerable group. Integrating frailty into guidelines for vascular surgery, as has been recommended in cardiology and orthopedics, may also help bridge the gap between research and practice.

Conclusion.

This bibliometric analysis provides the first comprehensive mapping of global research trends on vascular interventions in frail elderly patients from 2000 to 2025. The findings reveal a steady growth in scientific output, with accelerated contributions after 2016 and a clear shift toward leadership from Asian countries, particularly China and Japan. Despite this growth, standardized frailty assessment remains underrepresented in the literature, indicating a persistent gap between vascular intervention research and geriatric best practices.

Strengthening research collaboration, especially between high-output regions, and integrating validated frailty measures into vascular studies are critical next steps. Future investigations should also emphasize prospective designs and multidisciplinary approaches to optimize outcomes for this vulnerable population. By aligning vascular care with geriatric principles, the global research community can help ensure more effective, equitable, and patient-centered management of elderly patients undergoing vascular interventions.

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