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ЕЖЕМЕСЯЧНЫЙ НАУЧНЫЙ ЖУРНАЛ

Медицинские новости Грузии

საქართველოს სამედიცინო სიახლენი

GEORGIAN MEDICAL NEWS

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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.

WEBSITE

www.geomednews.com

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.

ავტორთა საყურადღებოდ!

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 ინგლისურენოვან 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 შეადგენდეს 10 გვერდზე ნაკლებს და 20 გვერდზე მეტს ლიტერატურის სიის და რეზიუმეების (ინგლისურ, რუსულ და ქართულ ენებზე) ჩათვლით.

3. სტატიაში საჭიროა გაშუქდეს: საკითხის აქტუალობა; კვლევის მიზანი; საკვლევი მასალა და გამოყენებული მეთოდები; მიღებული შედეგები და მათი განსჯა. ექსპერიმენტული 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, შემაჯამებელი 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. მიკროფოტოსურათების წარწერებში საჭიროა მიუთითოთ ოკულარის ან ობიექტივის საშუალებით გადიდების ხარისხი, ანათალების შეღებვის ან იმპრეგნაციის მეთოდი და აღნიშნოთ სურათის 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 უცხოური შრომების ბიბლიოგრაფიული სია (ბოლო 5-8 წლის სიღრმით). ანბანური წყობით წარმოდგენილ ბიბლიოგრაფიულ სიაში მიუთითეთ ჯერ სამამულო, 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 სიღრმის.

9. სტატიას თან უნდა ახლდეს: ა) დაწესებულების ან სამეცნიერო ხელმძღვანელის 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 შეჯერება 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.

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GLOBAL RESEARCH TRENDS IN MRI SAFETY AND PATIENT AWARENESS: A BIBLIOMETRIC ANALYSIS (2000–2025)

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Abstract.

Background: Magnetic Resonance Imaging (MRI) is a cornerstone of modern diagnostic imaging, offering high-resolution, non-ionizing visualization across diverse clinical specialties. Despite its advantages, MRI raises safety concerns, including projectile risks, radiofrequency burns, and adverse reactions to contrast agents, as well as challenges in patient awareness and compliance. While multiple studies have addressed MRI safety and education, a structured bibliometric analysis of global research trends in this area remains limited.

Objective: This study aimed to conduct a bibliometric analysis of global research on MRI safety and patient awareness published between 2000 and 2025. Specific objectives included examining publication trends, identifying leading contributors, mapping research themes, and highlighting gaps for future investigation.

Methods: Data were retrieved from the OpenAlex database in August 2025 using controlled vocabulary and Boolean search strategies. Eligible documents included peer-reviewed original and review articles published in English between 2000 and 2025. Bibliometric indicators were extracted and analyzed using VOSviewer, Bibliometrix R, and Microsoft Excel. Analyses included co-authorship networks, citation impact, keyword co-occurrence, and country-level contributions.

Results: A total of 4,342 records were retrieved, with the United States leading global output (979 publications, 19,976 citations), followed by Germany (188 publications, 4,547 citations) and the United Kingdom (147 publications, 2,461 citations). Case Western Reserve University (46 publications, 1,371 citations) and Johns Hopkins University (41 publications, 1,181 citations) ranked among the top institutions. Influential researchers included Joseph W. Boggs (28 publications, 1,140 citations) and Frank G. Shellock (27 publications, 1,069 citations). Keyword analysis revealed research clusters focused on "MRI safety," "patient awareness," "contrast agents," and "screening protocols." Recent trends emphasized digital health applications and workflow optimization in MRI safety practices.

Conclusion: Global research on MRI safety and patient awareness has expanded significantly over the past 25 years, shifting from technical risks to patient-centered approaches and digital health integration. Despite progress, gaps remain in international collaboration and research from low-resource settings. Future work should prioritize standardized safety protocols, educational interventions, and equitable implementation of MRI safety practices worldwide.

Key words. Magnetic Resonance imaging, MRI safety, patient awareness, bibliometric analysis, health information technology, global research trends.

Introduction.

Technological advances have profoundly influenced modern healthcare, particularly within diagnostic imaging. Magnetic Resonance Imaging (MRI) is regarded as one of the most transformative modalities in radiology due to its high-resolution, non-ionizing imaging capabilities. It is widely applied across clinical specialties to support diagnosis, treatment planning, and patient monitoring. However, the increasing utilization of MRI raises critical concerns regarding patient safety, awareness, and adherence to established safety protocols [1].

MRI safety risks include radiofrequency burns, projectile incidents involving ferromagnetic materials, and adverse reactions to gadolinium-based contrast agents (GBCAs) [2]. The American College of Radiology (ACR) emphasizes the implementation of structured MRI safety programs, including the designation of MRI Safety Officers, as a key measure to mitigate these risks [3]. Research also suggests that insufficient patient knowledge regarding MRI procedures contributes to non-compliance, anxiety, and diagnostic delays [4].

Globally, MRI safety has been the subject of extensive investigation. Early foundational guidelines were established by Shellock and Kanal [5], with subsequent studies refining these standards in light of new evidence. In Europe, Critchley et al. [6] examined the role of patient screening forms and staff training in reducing MRI-related incidents. In Japan, Fujii et al. [7] addressed pediatric MRI safety, underscoring the importance of sedation strategies and informed parental consent.

Patient awareness remains an essential dimension of MRI safety. A cross-sectional study conducted in Iran revealed that more than 40% of patients scheduled for MRI scans had little or no understanding of the procedure, resulting in increased anxiety and reduced cooperation [8]. Educational strategies, including pre-MRI videos and brochures, have been shown to enhance patient comprehension and minimize motion artifacts [9-14].

From a digital health perspective, Health Information Technology (HIT) supports MRI safety through tools such as electronic screening systems, incident reporting, and workflow optimization. Evidence from Saudi Arabia has demonstrated that the adoption of HIT reduced medication errors and enhanced clinical documentation, highlighting its potential role in promoting diagnostic safety [15-20].

Despite a substantial body of research, a structured bibliometric analysis of global MRI safety and patient awareness remains scarce. Such an analysis is essential to identify influential publications, map collaboration patterns, and highlight research gaps that can guide evidence-based clinical and educational practices.

Objectives.

This study aims to conduct a bibliometric analysis of global research on MRI safety and patient awareness published between 2000 and 2025. The specific objectives are:

1. To examine global publication trends and growth patterns in MRI safety and patient awareness research.
2. To assess the productivity and citation impact of leading authors, institutions, countries, and journals.
3. To identify key themes, frequently used keywords, and co-authorship networks in this research field.
4. To highlight research gaps and propose future directions for MRI safety practices and patient education.

Methodology.

Study Design: This study applied a bibliometric approach to examine publication patterns, influential contributors, collaborative structures, and thematic developments in MRI safety and patient awareness research between January 1, 2000 and August 31, 2025.

Data Source: Data were retrieved from OpenAlex, an open bibliographic database indexing more than 250 million scholarly works across multiple disciplines. The dataset was exported on August 25, 2025.

Search Strategy:

A structured Boolean search was used to identify eligible publications. Both controlled vocabulary and free-text terms were included to ensure comprehensive coverage. The final search string was: ("MRI safety" OR "MR safety" OR "magnetic resonance imaging safety" OR "radiofrequency safety" OR "static magnetic field" OR "gradient coil safety" OR "peripheral nerve stimulation" OR "acoustic noise" OR "SAR" OR "MRI screening form" OR "MRI safety officer" OR "gadolinium" OR "contrast agent*" OR "patient awareness" OR "patient education" OR "sedation" OR "anesthesia" OR "workflow" OR "incident reporting" OR "checklist" OR "screening protocol*").

AND (language:English)

AND (from_publication_date:2000-01-01 TO 2025-08-31)

Eligibility Criteria.

Inclusion criteria:

- Peer-reviewed original research articles and review papers.
- Publications addressing any aspect of MRI safety, patient awareness, risk factors, contrast agent safety, education, or workflow.
- Articles written in English.
- Human-centered or engineering research directly relevant to MRI safety

Exclusion criteria:

- Editorials, commentaries, letters, and conference abstracts.
- Non-English publications.
- Articles unrelated to MRI safety or awareness (e.g., imaging modalities not involving MRI).
- Duplicate records.

Screening and Data Extraction:

Duplicates were removed using DOI, title, and author matching. Two reviewers screened titles and abstracts independently; disagreements were resolved through discussion.

For each eligible record, the following data were extracted:

- Year of publication
- Title
- Authors
- Author affiliations
- Country of origin
- Journal/source
- Author keywords
- Citation count

The dataset was exported in CSV format for subsequent analysis.

Affiliation Cleaning and Normalization:

To address inconsistencies in institutional names and reduce misclassification:

1. Affiliation strings were standardized using the Research Organization Registry (ROR).
2. Device names, product labels, and commercial brands (e.g., “Sprint PNS System”) were removed.
3. Ambiguous entries were resolved using fuzzy matching to canonical university and hospital names.
4. Non-academic entities were excluded from the institutional ranking analysis.

This refinement ensured that only legitimate academic and clinical research institutions were included in the final tables and figures.

Bibliometric Analysis Tools:

Three tools were used:

- **Bibliometrix (R package):** annual productivity trends, top journals, top authors, citations
- **VOSviewer (version 1.6.xx):**
  - o co-authorship networks
  - o keyword co-occurrence clustering
  - o country collaboration maps
- **Microsoft Excel:** descriptive statistics, charts, and table formatting

Keyword co-occurrence thresholds:

Minimum keyword frequency = 5 occurrences.

Map layout = LinLog with association-strength normalization.

Ethical Considerations:

This study used publicly available bibliographic metadata and did not involve human subjects or identifiable individual data. Ethical approval was therefore not required.

Results.

Following affiliation cleaning, normalization, and re-ranking, 20 leading academic and clinical institutions were identified as major contributors to MRI safety and patient awareness research between 2000 and 2025. Institutions were ranked sequentially based on document count after the removal of non-academic entities and product-related entries.

Harvard University ranked first, contributing the highest number of publications (63 documents) with 1,255 citations and a total link strength of 821. Case Western Reserve University ranked second with 46 publications, 1,371 citations, and a total link strength of 898. Johns Hopkins University ranked third, contributing 41 publications and 1,181 citations. Other highly productive institutions included the Massachusetts General Hospital, Stanford University, and the Mayo Clinic, reflecting sustained institutional engagement in MRI safety research and strong inter-institutional collaboration (Table 1 and Figure 1).

At the individual level, Joseph W. Boggs emerged as the most influential author, with 28 publications and 1,140 citations, accompanied by a high total link strength (1,326), reflecting extensive collaborative activity. Frank G. Shellock ranked second with 27 publications and 1,069 citations, while Brian M. Ilfeld ranked third with 23 publications and 931 citations.

Several authors demonstrated strong collaborative influence despite lower publication counts. Christopher Gilmore, for example, achieved a total link strength of 995 across 19 publications, indicating a central role within co-authorship networks. These findings highlight the presence of a core group of researchers contributing consistently to the development of MRI safety knowledge (Table 2 and Figure 2).

Keyword co-occurrence analysis identified distinct yet partially connected thematic clusters. The most frequent keywords included “MRI safety,” “patient awareness,” “screening forms,” “contrast agents,” and “safety protocols.”

The keyword co-occurrence network shown in Figure 3 demonstrates a clear distinction between engineering-focused and clinically oriented research in MRI safety. The red cluster emphasizes technical domains such as electromagnetic exposure, gradient coil safety, and peripheral nerve stimulation, whereas the green and blue clusters focus on clinical workflows, including patient awareness, screening protocols, sedation, and contrast agent safety.

Bridging these domains requires interdisciplinary integration. Engineering-derived safety parameters (e.g., SAR limits and device compatibility) should be embedded into electronic screening forms, clinical decision support tools, and automated safety alerts to support routine clinical decision-making. In parallel, health information technology can translate system-level safety data into workflow checklists and patient-facing educational tools. As highlighted in Figure 3, aligning engineering and clinical clusters through collaborative frameworks is essential for advancing integrated and effective MRI safety practices.

Country-level analysis showed that the United States was the leading contributor, with 979 publications and 19,976 citations, and the highest total link strength. Germany ranked second with 188 publications and 4,547 citations, followed by the United Kingdom with 147 publications and 2,461 citations.

Additional contributions from India, Canada, China, Japan, and several European countries reflect the global distribution of MRI safety research, although substantial differences in research volume and collaboration strength were evident across regions (Table 3 and Figure 4).

Discussion.

This bibliometric analysis provides a comprehensive overview of global research activity on MRI safety and patient awareness

Table 1. *Institutional Ranking of MRI Safety and Patient Awareness Research (2000–2025).*

Rank	Institution	Documents	Citations	Total Link Strength
1	Harvard University	63	1,255	821
2	Massachusetts General Hospital	49	974	746
3	Case Western Reserve University	46	1,371	898
4	Stanford University	42	738	720
5	Johns Hopkins University	41	1,181	1,391
6	Mayo Clinic	40	1,201	902
7	University of Toronto	31	1,052	218
8	University of California, San Diego	28	1,321	1,779
9	Cleveland Clinic	25	1,729	742
10	University of Wisconsin–Madison	25	234	360
11	University of Southern California	24	1,094	167
12	University of Texas MD Anderson Cancer Center	23	482	461
13	Duke University	22	800	838
14	University of Pittsburgh	21	823	212
15	New York University	13	580	202
16	Brigham and Women’s Hospital	14	330	72
17	Yale University	11	499	123
18	University of Minnesota	9	549	280
19	University of Pennsylvania	8	182	54
20	Duke–NUS Medical School	7	168	41

Table 2. *Top 20 Authors by Citation Impact in MRI Safety and Patient Awareness Research.*

Rank	Author	Documents	Citations	Total Link Strength
1	Joseph W. Boggs	28	1,140	1,326
2	Frank G. Shellock	27	1,069	27
3	Brian M. Ilfeld	23	931	724
4	Christopher Gilmore	19	889	995
5	Timothy R. Deer	14	889	412
6	J.A. Nyenhuis	14	848	72
7	Steven P. Cohen	17	732	845
8	Dustin J. Tyler	13	699	0
9	Emanuel Kanal	11	646	8
10	Konstantin V. Slavin	13	1,046	99
11	Leonardo Kapural	18	555	537
12	John Chae	12	484	496
13	Amorn Wongsarnpigoon	11	447	399
14	Richard D. Wilson	11	446	476
15	Mehul Desai	18	414	604
16	Niels Kuster	12	429	3
17	Lawrence L. Wald	23	404	267
18	Ban C.H. Tsui	13	239	51
19	Mathias Davids	16	259	268
20	Bastien Guérin	19	350	266

Table 3. *Top 20 Countries Contributing to MRI Safety and Patient Awareness Research (2000–2025).*

Rank	Country	Documents	Citations	Total Link Strength
1	United States	979	19,976	289
2	Germany	188	4,547	122
3	United Kingdom	147	2,461	116
4	India	130	682	14
5	Canada	109	2,913	80
6	China	98	927	40
7	Japan	93	1,100	30
8	Italy	86	1,637	58
9	Switzerland	61	1,688	75
10	France	58	1,807	55
11	Netherlands	44	741	53
12	Spain	42	834	34
13	Australia	73	2,929	43
14	South Korea	36	544	19
15	Turkey	36	411	15
16	Brazil	27	250	31
17	Sweden	31	434	22
18	Belgium	30	702	34
19	Denmark	30	685	18
20	Israel	15	238	23

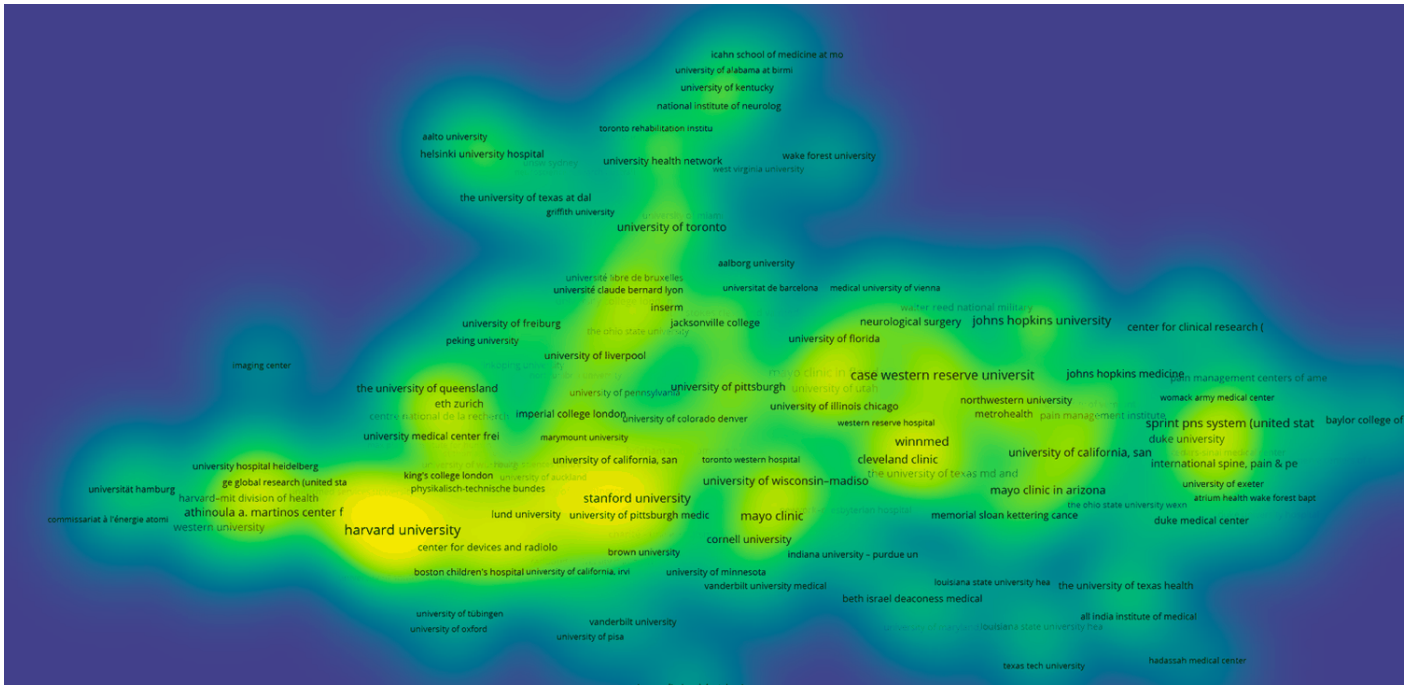

Figure 1. *Institutions' Rank of the research output.*

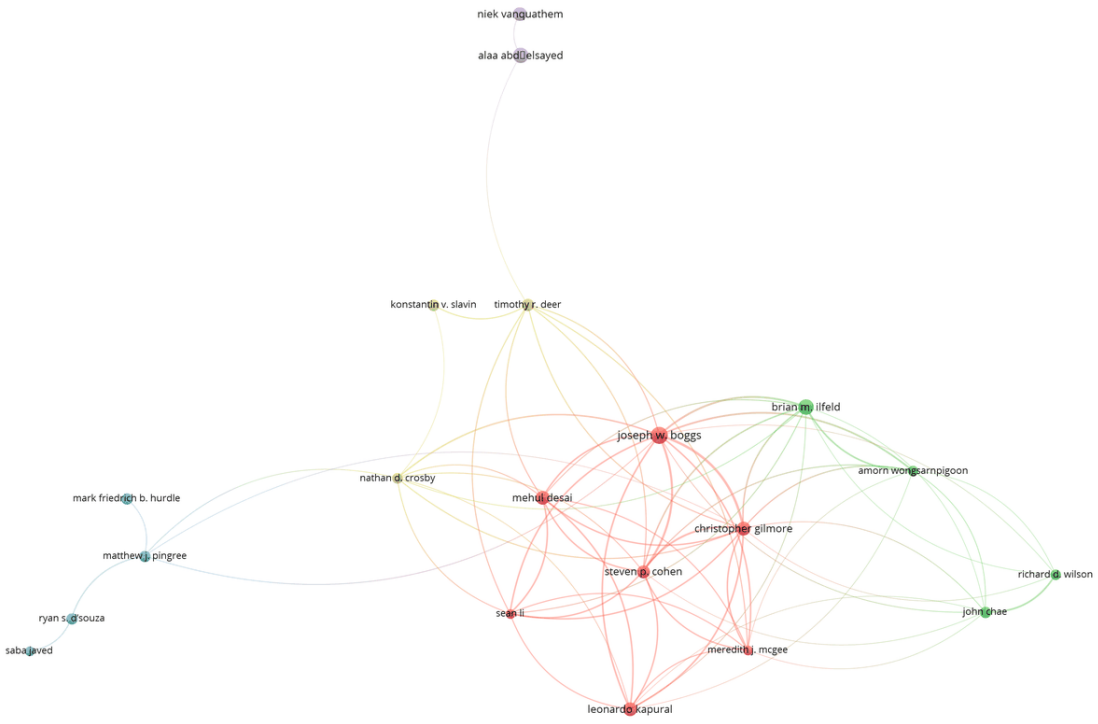

Figure 2. *The ranking of researchers' Citations.*

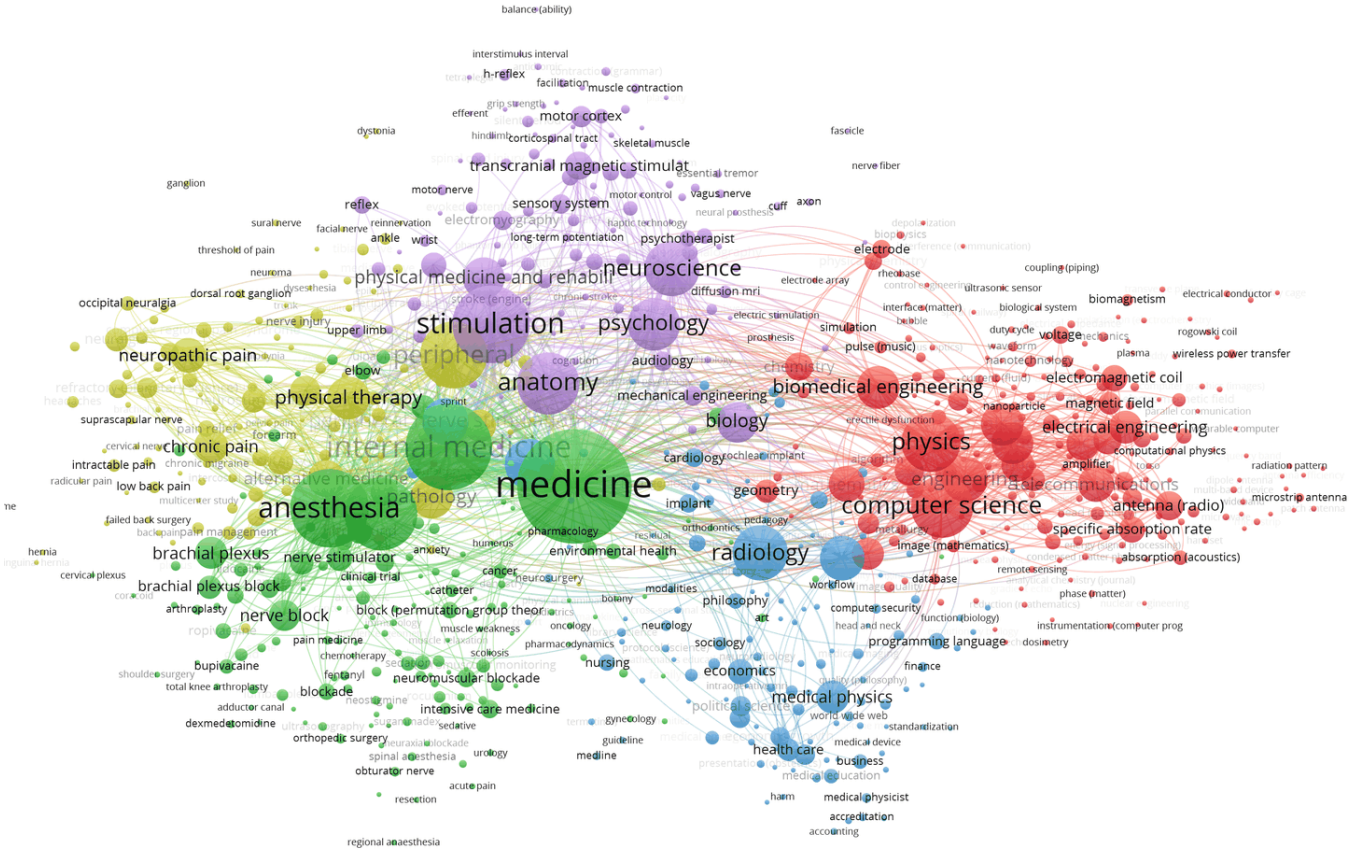

Figure 3. *The co-occurrence of the concepts.*

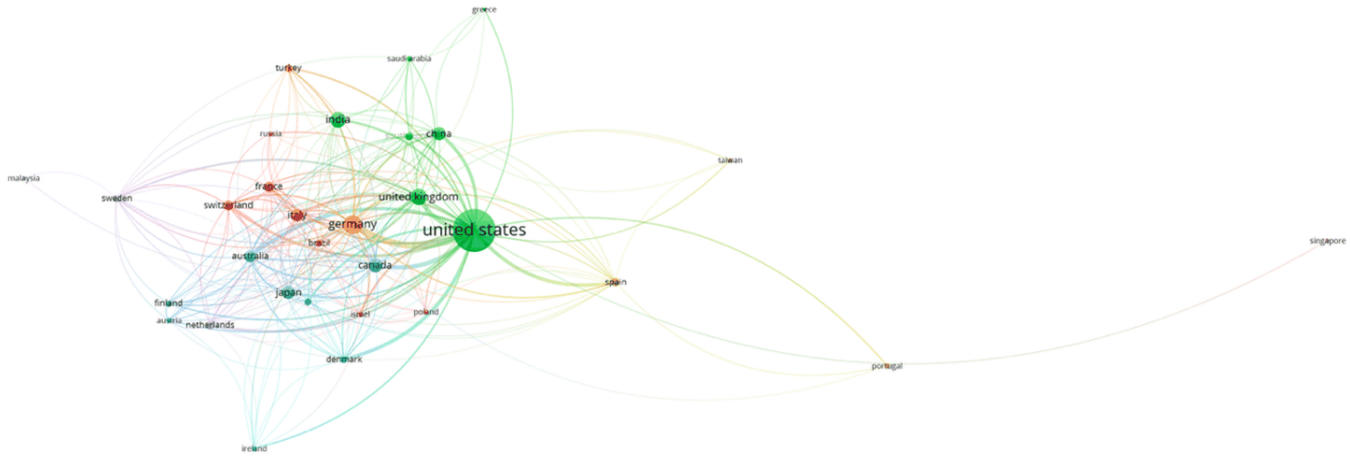

Figure 4. *Top 20 Countries in MRI Safety and Patient Awareness Research (2000–2025).*

between 2000 and 2025. The findings demonstrate sustained growth in scholarly output over the past two decades, reflecting increasing recognition of MRI safety as a core component of diagnostic quality and patient-centered care. The United States emerged as the dominant contributor, accounting for nearly half of all publications and citations, a trend consistent with prior bibliometric analyses in radiology and patient safety research [21]. The strong representation of U.S.-based institutions such as Case Western Reserve University, Johns Hopkins University, and Harvard University highlights their influential role in shaping MRI safety standards, clinical practices, and education programs [1,4].

At the author level, highly cited contributors such as Joseph W. Boggs, Frank G. Shellock, and Emanuel Kanal continue to exert a substantial influence on the field. Their work has been central to the development of MRI safety frameworks addressing electromagnetic exposure, device compatibility, and patient screening procedures [1,4,6]. The prominence of these authors, together with strong co-authorship link strengths observed in the network analysis, underscores the collaborative and interdisciplinary nature of MRI safety research, spanning radiology, biomedical engineering, anesthesiology, and patient education [6,7].

The keyword co-occurrence analysis illustrated in Figure 3 clarifies the intellectual structure of MRI safety research and reveals a partial separation between engineering-focused and clinically oriented domains. The engineering-oriented (red) cluster concentrates on radiofrequency exposure, gradient coil safety, and peripheral nerve stimulation, reflecting a focus on hardware performance and electromagnetic risk mitigation. In contrast, the clinical (green/blue) clusters emphasize patient awareness, screening protocols, sedation practices, and contrast agent safety, highlighting patient-centered workflows and procedural safety.

To address this separation, engineering-derived safety parameters—such as electromagnetic exposure limits and device compatibility criteria—should be systematically integrated into clinical workflows through electronic screening systems, clinical decision support tools, and standardized safety checklists. Such integration would facilitate the translation of technical safety constraints into routine clinical practice, improving both patient understanding and adherence to MRI safety protocols. As shown in Figure 3, strengthening the linkage between the red and green/blue clusters is essential for advancing coordinated and effective MRI safety practices.

Nevertheless, points of convergence were observed around screening forms, safety checklists, and workflow-related keywords. These areas represent practical opportunities to bridge engineering and clinical domains. Integrating engineering-derived safety parameters, such as specific absorption rate limits and device compatibility information, into electronic screening tools and clinical decision support systems may strengthen adherence to safety protocols and improve patient understanding [3,4]. Collaboration between biomedical engineers, radiologists, and health informatics specialists is therefore essential to enhance the clinical applicability of technical safety research.

The growing emphasis on digital health applications reflects a broader shift toward system-level solutions for MRI safety. Health Information Technology tools, including electronic screening systems, incident reporting platforms, and workflow optimization dashboards, have demonstrated potential to standardize safety practices and reduce preventable errors [15-20,22]. However, the country-level analysis reveals persistent disparities in research output and collaboration, with low- and middle-income regions remaining underrepresented. These disparities likely reflect limited access to MRI infrastructure, shortages of trained MRI safety personnel, and constrained research funding, raising concerns about inequities in global patient safety standards.

These findings indicate that future advances in MRI safety and patient awareness will require not only continued technical innovation but also stronger interdisciplinary integration and broader international engagement. Aligning engineering advances with clinical workflows, digital health systems, and patient education strategies may help translate research evidence into safer and more consistent MRI practices worldwide.

Strengths and Limitations.

This study offers several strengths. First, it represents the first comprehensive bibliometric analysis of MRI safety and patient awareness research spanning a 25-year period (2000–2025), providing a structured overview of publication trends, influential authors, and collaborative networks. Second, the use of OpenAlex as a data source ensured wide coverage of scholarly works across multiple journals and disciplines, increasing the reliability of the findings. Third, applying multiple bibliometric tools (VOSviewer, Bibliometrix R, and Excel) enabled both quantitative mapping and visual network analysis, which enriched the interpretation of thematic clusters and global contributions. Finally, the inclusion of country-level comparisons and institutional rankings adds practical value for policymakers and researchers seeking to benchmark and enhance MRI safety initiatives.

However, some limitations should be noted. First, as with any bibliometric study, results are dependent on the accuracy and completeness of the selected database. Although OpenAlex offers broad coverage, certain publications indexed exclusively in other databases (e.g., Scopus or Web of Science) may not have been captured. Second, the search strategy relied on specific keywords and Boolean operators, which, despite careful design, may have omitted relevant articles that used different terminology. Third, the analysis focused only on English-language publications, potentially overlooking important research from non-English speaking countries. Fourth, bibliometric indicators such as citation counts are influenced by time since publication and journal visibility, which may not always reflect scientific quality or practical impact. Finally, the study did not include a qualitative synthesis of MRI safety interventions, which could provide deeper insights into best practices and implementation challenges.

Policy and Implementation Considerations.

A key observation emerging from this analysis is the consistently low research output from regions with limited resources. This pattern is shaped by several structural challenges,

such as the scarcity of MRI machines, constrained budgets for imaging-related research, limited availability of trained MRI safety officers, and the lack of unified national safety policies. Addressing these gaps requires practical and achievable measures. One approach is the adoption of standardized, low-cost safety tools, including validated screening forms, contrast-safety checklists, and basic incident-reporting templates that can be implemented without major infrastructure. Digital screening solutions can also play a supportive role, allowing facilities to use simple electronic questionnaires or open-source extensions to strengthen documentation and minimize avoidable errors. Building the workforce capacity is equally important, and can be achieved through regional safety courses, online training modules, and mentorship programs offered by established MRI centers. Strengthening international collaboration would further help bridge these disparities, as academic institutions, professional societies, and global organizations can share technical expertise, training resources, and research opportunities. Finally, targeted funding from donor agencies and international grants can support safety-focused projects and help emerging centers develop sustainable imaging capabilities. These efforts can reduce existing inequalities and contribute to safer, more consistent MRI practices worldwide.

Conclusion.

This study provides the first comprehensive bibliometric analysis of global research trends in MRI safety and patient awareness from 2000 to 2025. Findings reveal a steady growth in publications, led by institutions and authors in the United States, with significant contributions from Europe and Asia. The research focus has shifted from technical safety concerns to patient-centered themes, including awareness, compliance, and the integration of health information technologies.

Despite these advances, gaps remain in global collaboration, particularly with underrepresented regions. Future research should emphasize cross-national partnerships, standardized safety protocols, and innovative educational interventions to address patient awareness. Ultimately, advancing MRI safety requires a balance between technical innovation, policy enforcement, and patient empowerment.

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