

Global overview of scientific production on immediate transfusion reactions: a bibliometric analysis

Panorama global da produção científica sobre reações transfusionais imediatas:
análise bibliométrica

*Panorama global de la producción científica sobre reacciones transfusionales inmediatas:
un análisis bibliométrico*

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Abstract

Objetivo: mapear la producción científica sobre reacciones transfusionales inmediatas en pacientes sometidos a transfusión sanguínea en instituciones sanitarias. **Método:** estudio bibliométrico descriptivo y cuantitativo. La búsqueda se realizó en octubre de 2025 en las bases de datos Web of Science, Scopus y PubMed, sin restricciones de idioma ni de período. Los registros se exportaron, integraron, estandarizaron y analizaron utilizando el software R[®] 4.5.2 a través de RStudio, con los paquetes Bibliometrix y Biblioshiny. Se aplicaron las leyes de Lotka, Bradford y Zipf. **Resultados:** se incluyeron 3.996 documentos, predominantemente artículos originales en inglés. Se observó un crecimiento significativo en la producción desde el siglo XXI en adelante, concentrado en países de altos ingresos, especialmente Estados Unidos, China, Canadá y el Reino Unido. La productividad de los autores y la distribución de las revistas se ajustaron a las leyes bibliométricas, mientras que los descriptores mostraron estandarización terminológica y un enfoque clínico. **Conclusión:** el campo muestra madurez, con centros de autores, institucionales y editoriales bien definidos, pero persisten las desigualdades geográficas, lo que indica la necesidad de fortalecer la investigación local.

Descriptors: Bibliometrics; Transfusion Reaction; Patient Safety; Blood Safety; Blood Transfusion

Resumo

Objetivo: mapear a produção científica sobre reações transfusionais imediatas em pacientes submetidos à transfusão sanguínea em instituições de saúde. **Método:** estudo bibliométrico, descritivo, quantitativo. A busca ocorreu em outubro de 2025, nas bases *Web of Science*, *Scopus* e *PubMed*, sem restrição de idioma ou período. Os registros foram exportados, integrados,

padronizados e analisados no *software* R® 4.5.2, via RStudio, com os pacotes *Bibliometrix* e *Biblioshiny*. Aplicaram-se as leis de Lotka, Bradford e Zipf. **Resultados:** incluíram-se 3.996 documentos, predominando artigos originais em inglês. Observou-se crescimento expressivo da produção a partir do século XXI, concentrada em países de alta renda, especialmente Estados Unidos, China, Canadá e Reino Unido. A produtividade autoral e distribuição dos periódicos aderiram às leis bibliométricas, enquanto os descritores mostraram padronização terminológica e foco clínico. **Conclusão:** o campo mostra maturidade, com núcleos autorais, institucionais e editoriais definidos, porém persistem desigualdades geográficas, indicando a necessidade de fortalecer pesquisa local.

Descritores: Bibliometria; Reação Transfusional; Segurança do Paciente; Segurança Transfusional; Transfusão de Sangue

Descritores: Perspectiva de Gênero; Ensino; Estudantes de Enfermagem; Universidades; Sexismo

Resumen

Objetivo: analizar las prácticas de cuidado materno en las actividades cotidianas de niños con cardiopatías congénitas en el hogar. **Método:** estudio descriptivo, con enfoque cualitativo, realizado en la ciudad de Río de Janeiro, Brasil. Participaron 13 madres de niños con cardiopatías congénitas. Las entrevistas tuvieron lugar entre marzo y junio de 2016, las cuales fueron grabadas en audio, transcritas en su totalidad y sometidas a Bardin Content Analysis.

Resultados: las actividades diarias de los niños con cardiopatías se consideraron restringidas y no restringidas. Las madres compararon a sus hijos con niños normales, durante el juego utilizan estrategias para reducir el esfuerzo físico y entienden que el ambiente escolar y la guardería favorecen un buen crecimiento y desarrollo. **Conclusión:** los juegos pasivos son mejor tolerados por las madres ya que no requieren esfuerzo físico. Así, previenen la descompensación cardíaca y el empeoramiento de la enfermedad en sus hijos.

Descriptores: Bibliometría; Reacción a la Transfusión; Seguridad del Paciente; Seguridad de la Sangre; Transfusión Sanguínea

Introduction

Blood transfusion is a therapeutic practice widely used in contemporary medicine, particularly in critical clinical contexts, such as severe anemia, trauma, and major surgical procedures. Millions of transfusions are estimated to be performed annually worldwide, highlighting their importance in healthcare. However, despite its vital role, it is an intervention associated with risks, with transfusion reactions standing out as a major patient safety concern.¹

Transfusion reactions are classified as immediate or delayed according to the time interval between transfusion and the onset of signs and symptoms. Immediate reactions occur during or within 24 hours after the procedure and encompass a broad spectrum of severity, ranging from mild manifestations, such as fever and urticaria, to potentially fatal events, including acute hemolysis, anaphylactic shock, and respiratory

failure.²⁻³ These events are associated with both immunological and non-immunological factors, such as ABO incompatibility, bacterial contamination, and the recipient's immune response to blood component antigens.²

In addition to the risks inherent to the procedure, the literature identifies the underreporting of immediate transfusion reactions as a persistent challenge for hemovigilance systems, compromising knowledge of the actual frequency and severity of these events.⁴ In this context, transfusion quality depends directly on the standardization of screening, storage, transportation, and administration processes for blood components, as well as on the ongoing training of healthcare professionals and strict compliance with institutional protocols.⁵

Hemovigilance is a strategic tool for identifying, assessing, and preventing adverse events related to transfusion.⁶ The Brazilian National Hemovigilance System, coordinated by the Brazilian Health Regulatory Agency, has consolidated epidemiological data since 2001 and supports actions aimed at patient safety.⁷

Recent data reinforce the relevance of the topic: in the first half of 2024 alone, 9,097 notifications of adverse events related to hemovigilance were recorded, of which 8,673 (95.3%) corresponded to transfusion reactions. Among these, 64.1% were classified as mild, 15.5% as moderate, 8.7% as severe, and 11.7% resulted in death, demonstrating the clinical and healthcare impact of these events.⁸

Although the literature on immediate transfusion reactions consists predominantly of clinical, epidemiological, and hemovigilance-related studies, no specific bibliometric studies focused on analyzing the scientific production on this topic were identified during the literature search conducted for this investigation. In this context, bibliometric analysis constitutes a tool for mapping the structure and evolution of this scientific field, providing support for directing future investigations and strengthening transfusion safety.

Given this scenario, immediate transfusion reactions remain a topic of considerable relevance to clinical practice and scientific research, particularly because of the need to strengthen notification, monitoring, and transfusion quality assessment systems. Therefore, this study aims to map the scientific production on immediate transfusion reactions in patients undergoing blood transfusion in healthcare institutions.

Method

This was a descriptive, quantitative bibliometric study. Bibliometric research makes it possible to identify publication patterns, scientific impact, authors, journals, collaborations, and thematic trends over time, contributing to an understanding of the structure and evolution of the field under investigation.⁹⁻¹¹

The reporting of the methodological procedures of this bibliometric review was conducted in accordance with Preliminary Guideline for Reporting Bibliometric Reviews of the Biomedical Literature (BIBLIO) recommendations, ensuring greater transparency, reproducibility, and standardization in the description of the search strategy and the selection and analysis of the studies.¹² Bibliometric analysis was conducted according to methodological frameworks previously described in the literature for scientific mapping studies, encompassing classical indicators of scientific performance and knowledge structure.¹¹

The research question was structured based on the PICo strategy, in which P (Population) corresponded to patients undergoing blood transfusion; I (Interest) referred to immediate transfusion reactions; and Co (Context) comprised healthcare institutions, including hospitals and outpatient services. Based on this strategy, the following guiding question was formulated: What is the landscape of national and international scientific production on immediate transfusion reactions in patients undergoing transfusion in healthcare institutions?

The literature search was conducted in the Web of Science, Scopus, and PubMed databases, accessed through the Coordination for the Improvement of Higher Education Personnel Journal Portal. These databases were selected because of their broad multidisciplinary coverage, international relevance, and recognition for indexing scientific literature in the healthcare field.

The search strategy was developed using keywords, Health Sciences Descriptors, and Medical Subject Headings, combined using the Boolean operators OR and AND.

The general search strategy adopted was: ("*Transusão de Sangue*" OR "Blood Transfusion" OR "*Transfusión Sanguínea*" OR "*Transfusão Sanguínea*" OR "*Transfusión de Sangre*" OR "*Pacientes*" OR "Patients") AND ("*Reação Transfusional*" OR "Transfusion

Reaction" OR "*Reacción a la Transfusión*" OR "*Reação Transfusional Hemolítica Aguda*" OR "Acute Hemolytic Transfusion Reaction" OR "*Reacción Transfusional Hemolítica Aguda*" OR "*Reações Transfusionais*" OR "Transfusion Reaction" OR "*Reacciones Transfusionales*" OR "*Reações Transfusionais Hemolíticas*" OR "Hemolytic Transfusion Reaction" OR "*Reacciones Transfusionales Hemolíticas*" OR "Acute Hemolytic Transfusion Reaction") AND ("*Hospitais*" OR "Hospitals" OR "*Hospitales*" OR "*Instituições de Assistência Ambulatorial*" OR "Ambulatory Care Facilities" OR "*Instituciones de Atención Ambulatoria*" OR "*Ambulatório Hospitalar*" OR "Outpatient Clinics" OR "Hospital" OR "*Servicio Ambulatorio em Hospital*").

In all three databases, the "All fields" option was used, allowing the retrieval of descriptors across all available fields. No restrictions regarding language or publication period were applied to encompass the largest possible number of relevant studies. The search and extraction of documents were conducted in October 2025.

Original research and review articles addressing immediate transfusion reactions in patients undergoing blood transfusion, conducted in healthcare settings and published in scientific journals indexed in the selected databases, were included. Studies available in full text were considered eligible, regardless of language or year of publication.

Editorials, letters to the editor, conference proceeding abstracts, book chapters, dissertations, theses, regulatory documents, and technical reports were excluded, as were studies that addressed exclusively delayed transfusion reactions or had no direct relationship with the healthcare setting.

The consolidation, standardization, and selection of documents were performed in the R[®] software environment version 4.5.2 through the RStudio interface, using the Bibliometrix package. Records retrieved from the databases were exported in BibTeX (Web of Science and Scopus) and TXT (PubMed) formats and integrated into a single database using the "mergeDbSources" function, with the "remove.duplicated = TRUE" parameter, which is responsible for the automatic identification and removal of duplicate records during the consolidation of metadata from the different databases.

Initially, the document types of retrieved records were standardized based on the "Document Type" field of bibliographic records, retaining only original research and review articles. Editorials, letters, works published in conference proceedings, books,

and other ineligible document types were excluded. Subsequently, textual filters were applied to the title, abstract, author keywords, and indexed keywords fields to identify and exclude studies that addressed exclusively delayed transfusion reactions.

Studies conducted in healthcare settings were identified through complementary textual filtering using the terms related to hospital and outpatient settings employed in the search strategy in the title, abstract, and keyword fields of bibliographic records. After database refinement, the eligible records were organized in an Excel 2013 (.xlsx) spreadsheet, constituting the final corpus for the bibliometric analysis.

Descriptive and exploratory bibliometric analysis was performed using the Bibliometrix and Biblioshiny tools and included indicators of scientific productivity, impact, and collaboration. The aspects analyzed included document type; language and year of publication; authors' country of affiliation and productivity; institutional affiliations; scientific journals; and descriptor frequency. The visual representations made it possible to examine the temporal evolution of scientific production, the main actors involved, the most relevant journals, and thematic trends related to immediate transfusion reactions.

To assess the temporal behavior of scientific production, linear and exponential regression models were fitted using the Python programming language and the Pandas, NumPy, Matplotlib, and Seaborn libraries. Linear regression was used to assess the trend of constant growth in publications, whereas exponential regression made it possible to investigate potential accelerated growth over the period analyzed. Model performance was compared based on the coefficient of determination (R^2), adopted as a measure of goodness of fit. Graphical representations of the fitted models were generated using the Matplotlib and Seaborn libraries.

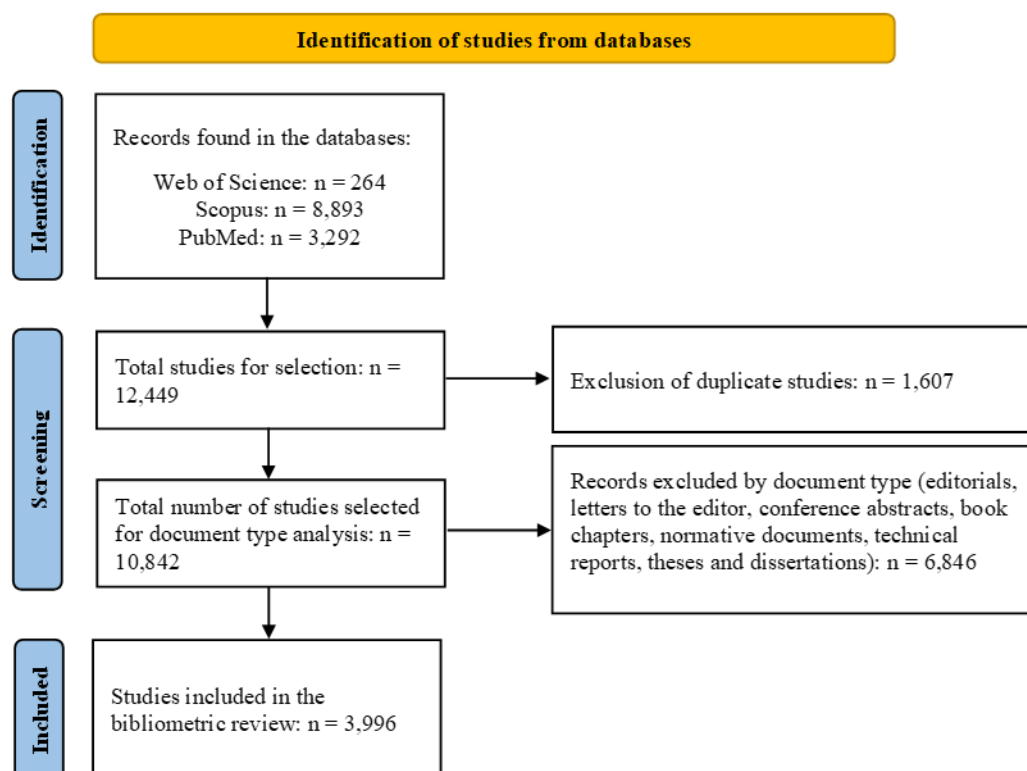
Additionally, the analysis followed the principles of the three classical laws of bibliometrics: Lotka's Law, applied to assess author productivity; Bradford's Law, used to identify the dispersion of publications among journals; and Zipf's Law, employed to examine the frequency of terms occurring in the keywords and titles of the studies.¹³

Since this was a bibliometric study based on secondary data in the public domain, submission to the Research Ethics Committee was waived, in accordance with Resolution 510/2016 of the Brazilian National Health Council.

Results

The process of identifying, standardizing, and selecting the documents included in the bibliometric review is presented in Figure 1.

Figure 1 - Flowchart of the identification, screening, and inclusion of studies in the bibliometric review, Belém, 2025

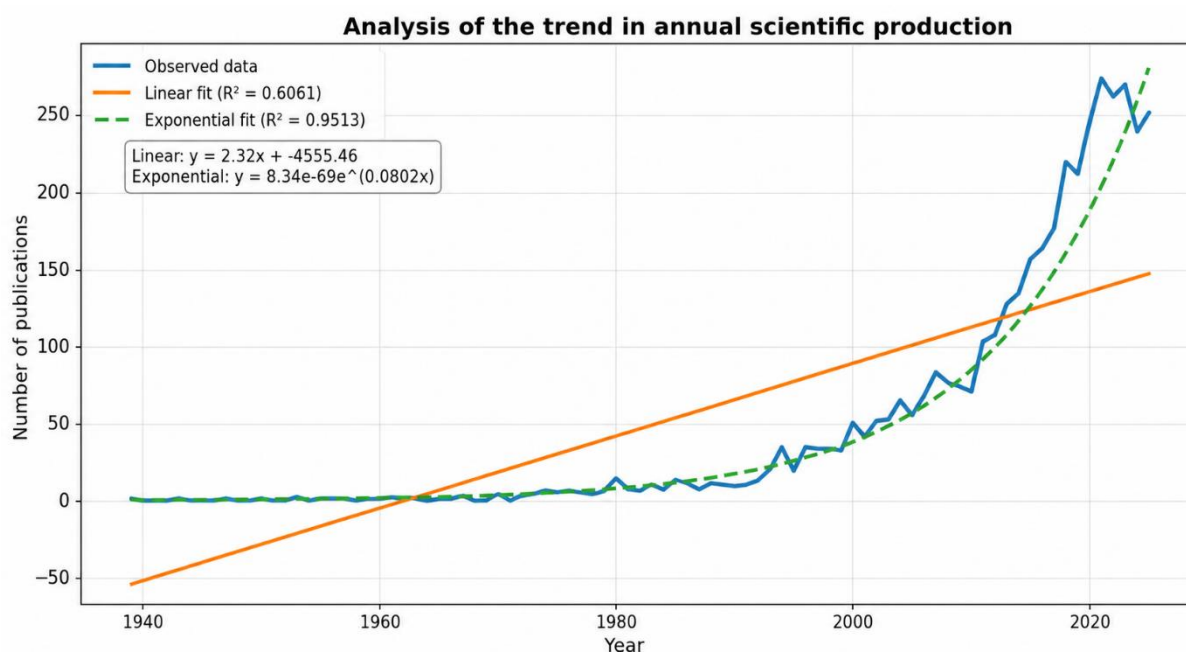


Of the 3,996 documents included in the analysis, 3,238 (81.0%) were original articles, whereas 758 (19.0%) were classified as review articles, demonstrating the predominance of primary studies in the scientific production of the field.

Concerning the language of publication, English predominated, with 3,654 documents (91.4%), followed by Mandarin with 144 (3.6%), French with 50 (1.3%), Spanish with 29 (0.7%), and German with 25 (0.6%). The remaining languages had a residual share, all with frequencies below 1%, reinforcing the centrality of English as the main language for scientific dissemination in the field of transfusion medicine.

Figure 2 presents the annual evolution of scientific production on immediate transfusion reactions between 1939 and 2025, demonstrating the temporal behavior of publications throughout the period analyzed.

Figure 2 - Trend in annual scientific production on immediate transfusion reactions (1939-2025), Belém, 2025



Temporal evolution analysis of scientific production showed an increasing trend in the annual number of publications throughout the period analyzed. The linear regression model yielded the equation $y = 2.32x - 4555.46$, with a coefficient of determination of $R^2 = 0.6061$, indicating that 60.6% of the variability in the number of publications was explained by temporal progression.

Additionally, an exponential regression model was fitted, represented by the equation $y = 8.34 \times 10^{-69} \times e^{(0.0802x)}$, with a coefficient of determination of $R^2 = 0.9513$. Comparatively, the exponential model provided a better fit to the data than the linear model ($R^2 = 0.9513$ versus $R^2 = 0.6061$), demonstrating that the growth in scientific production was better described by an exponential model throughout the period analyzed.

The better performance of the exponential model, as evidenced by its higher coefficient of determination, indicates that this model described the temporal behavior of publications more accurately during the period analyzed.

The analysis of scientific production by country showed that the United States had the highest number of publications (1,418 documents), followed by China (459), Canada (295), and the United Kingdom (290). Countries such as India, France, the Netherlands, Germany, and Japan also showed substantial scientific production, whereas Brazil accounted for 126 publications, making it the Latin American country with the highest number of documents identified.

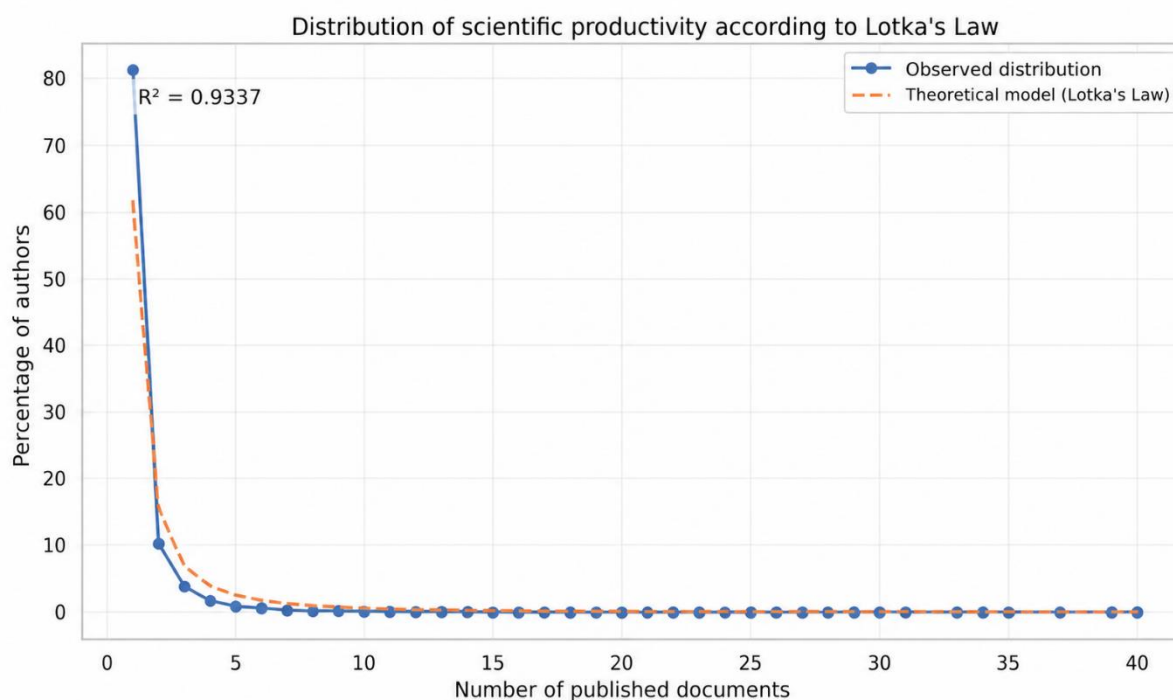
In relation to author productivity, Calo J. had 40 publications, followed by Stanworth S. and Triulzi D., with 39 documents each. Murphy M. (37), Estcourt L. and Yazer M. (35 each), as well as Fergusson D. and Ness P. (34 each), completed the group of authors with the highest numbers of publications.

Author scientific productivity was analyzed based on Lotka's Law, which describes the distribution of scientific production among authors within a given field of knowledge. Figure 3 presents the relationship between the number of documents published per author and the proportion of authors, comparing the observed distribution with the theoretical pattern proposed by the model.

It was observed that most authors published only one document, corresponding to approximately 81.3% of the total. Authors with two publications accounted for 10.3%, whereas progressively smaller proportions were observed for three or more studies. This pattern demonstrates a typical distribution of scientific productivity, characterized by the concentration of publications among a restricted group of researchers.

The observed distribution showed behavior similar to the theoretical pattern described by Lotka's Law, demonstrating a predominance of authors with a single publication and a progressive reduction in the frequency of authors as the number of published documents increased.

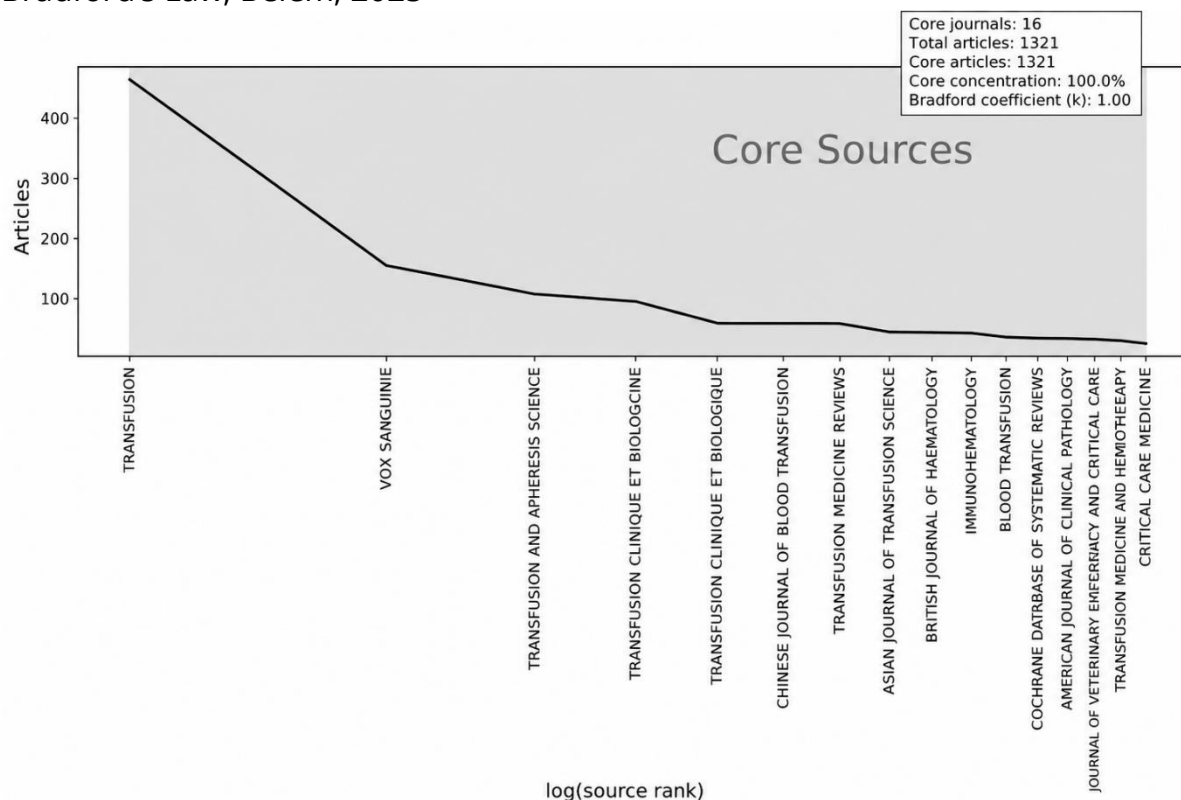
Figure 3 - Distribution of author productivity according to the number of documents published based on Lotka's Law, Belém, 2025



The analysis of institutional affiliations revealed a predominance of international universities and academic centers. The University of Toronto Faculty of Medicine had the highest number of associated publications (97), followed by the Johns Hopkins University School of Medicine (92) and McMaster University (89). The University of California (75), Mayo Clinic (72), *Leids Universitair Medisch Centrum* (71), University of Pittsburgh School of Medicine (68), University of Toronto (66), University of Oxford Medical Sciences Division (65), and Harvard Medical School (64) also stood out.

The dispersion of publications among journals was analyzed based on Bradford's Law, which describes the pattern of concentration and dispersion of scientific production within a given field of knowledge. Figure 4 presents the distribution of articles according to journal productivity rankings, demonstrating the formation of productivity zones.

Figure 4 - Distribution of journals according to productivity ranking based on Bradford's Law, Belém, 2025



The analysis identified a core consisting of 16 journals responsible for 1,321 publications, constituting the zone with the highest concentration of scientific production. The second zone comprised 221 journals, totaling 1,797 articles, whereas the third zone included 1,054 journals responsible for 878 publications.

The distribution of journals showed behavior consistent with the pattern described by Bradford's Law, characterized by the concentration of publications in a limited number of journals, followed by the dispersion of the remaining articles across a larger set of sources. Among the journals with the highest numbers of publications were Transfusion, Vox Sanguinis, Transfusion and Apheresis Science, and Transfusion Medicine.

The analysis of descriptor frequency demonstrated a distribution consistent with Zipf's Law (Figure 5), characterized by the high frequency of a limited number of terms and a progressive decrease in the occurrence of the remaining descriptors. The most frequent terms were human (n = 3,170), article (n = 2,405), and humans (n = 2,311), corresponding predominantly to indexing terms used by the databases.

Temporal analysis revealed progressive growth in scientific production over the decades, with a marked intensification from the 21st century onward and the highest volumes of publications concentrated in recent years.¹⁶ This pattern suggests that immediate transfusion reactions remain a current and relevant issue, driven by factors such as the increasing complexity of clinical and surgical procedures, the expanded use of blood components in vulnerable populations, and the strengthening of hemovigilance policies. In addition, the greater volume of recent studies may reflect improvements in reporting systems, the standardization of transfusion protocols, and the growing recognition of patient safety as a central component of healthcare quality.¹⁷

Temporal trend analysis using linear and exponential regression models reinforces this pattern of growth in scientific production. The positive relationship observed between time and publication volume indicates that scientific production expanded throughout the period analyzed.

The better fit of the exponential model suggests that the literature grew at an accelerated rate throughout the period analyzed. This pattern has been observed in areas related to patient safety and transfusion medicine and may reflect increased scientific production, the indexing of specialized journals, and growing interest in studies aimed at preventing adverse events associated with blood transfusion.

The marked predominance of English as the language of publication confirms its central role in the dissemination of scientific knowledge in healthcare, including in the field of immediate transfusion reactions. This pattern facilitates the international circulation of evidence and conceptual standardization but may also limit the visibility of studies produced in non-English-speaking countries.¹⁸ Furthermore, this predominance may influence access to evidence among professionals and researchers in countries whose scientific production occurs predominantly in local languages, making it more difficult to disseminate knowledge produced in regional contexts. The residual participation of other languages suggests that some knowledge produced in local contexts may remain underrepresented in major international scientific repositories, reinforcing the importance of research internationalization strategies, particularly in low- and middle-income countries.¹⁹

The distribution of scientific production by country was strongly concentrated in high-income nations, with the United States taking a prominent lead, followed by China, Canada, and the United Kingdom. This pattern is consistent with the greater availability of technological infrastructure, research funding, and well-established hemovigilance systems in these countries.²⁰ Brazil's prominence in the Latin American context indicates regional progress in scientific production on immediate transfusion reactions, although the lower participation of countries in Africa, Latin America, and the Middle East reveals persistent inequalities in the generation and dissemination of knowledge, possibly related to structural limitations, underreporting of events, and lower investment in research.²¹

This geographic distribution may influence the representativeness of available evidence, since different healthcare systems have distinct epidemiological, structural, and organizational characteristics that are not always represented in the literature originating from countries with greater scientific production capacity.

The analysis of author productivity, based on Lotka's Law, revealed a classic pattern of concentration in which most researchers contributed only one study, whereas a restricted group demonstrated high productivity. This behavior is consistent with the pattern described by Lotka's Law and has been observed in different bibliometric studies, in which a small number of researchers account for a larger volume of publications while most contribute a limited number of studies.²²⁻²³

This distribution demonstrates the existence of highly productive authors in the field under investigation. The coexistence of highly productive authors with a large contingent of occasional authors suggests that the topic is cross-cutting and of recurring interest, being addressed in different healthcare and institutional contexts. The concentration of scientific production among a limited number of authors may be related to the sustained work of research groups specialized in the field, favoring the development of lines of investigation on immediate transfusion reactions.

Concerning institutional affiliations, there was a predominance of universities and academic centers of recognized international relevance, particularly those associated with medical schools and university hospitals. This finding reinforces that scientific production on immediate transfusion reactions is strongly associated with

environments that integrate clinical care, professional education, and research, favoring the generation of evidence applicable to practice and the development of protocols for the prevention, early identification, and management of these adverse events.²⁴

This scenario demonstrates the importance of integrating research, education, and healthcare in promoting transfusion safety, contributing to the improvement of clinical practices and the reduction of adverse events associated with blood transfusion. However, the concentration of publications in leading institutions also highlights the need to expand the participation of research centers located in regions with less established scientific traditions, promoting the production of evidence that is more representative of different healthcare contexts and healthcare systems.

The application of Bradford's Law demonstrated the existence of a limited core of journals responsible for a substantial proportion of scientific production, followed by the broad dispersion of articles across a large number of journals with lower individual productivity. This pattern confirms that, although specialized journals concentrate the scientific debate on blood transfusion, the topic of immediate transfusion reactions also extends across different fields of knowledge, such as hematology, intensive care, surgery, nursing, and public health. It also demonstrates that immediate transfusion reactions are addressed across different medical specialties and healthcare fields, reflecting their multidisciplinary nature and relevance to different healthcare contexts.²⁵⁻²⁶

The analysis of descriptors, based on Zipf's Law, revealed a strong concentration of central terms related to blood transfusion, transfusion reactions, and clinical studies involving human beings. The recurrence of these terms reflects the conceptual standardization of the field and the predominant focus on healthcare-related investigations directed toward clinical practice and patient safety. The presence of terms related to different types of blood components and adverse reactions reinforces the centrality of these events as objects of study and highlights the importance of continuous surveillance in the transfusion context.^{11,27}

Similar distributions have been observed in bibliometric studies related to patient safety and healthcare, in which a small number of descriptors occur with high frequency,

whereas numerous terms have low individual frequencies, consistent with the pattern described by Zipf's Law.²⁵⁻²⁶

This study has limitations inherent to bibliometric analyses, particularly regarding its dependence on the databases used and the search strategy adopted, which may have limited the retrieval of publications indexed in other sources or in the gray literature. In addition, possible inconsistencies in the indexing of descriptors and metadata may partially influence the results of bibliometric analyses.

Taken together, the results of this bibliometric analysis demonstrate that scientific production on immediate transfusion reactions has shown continuous growth, a concentrated distribution among specific authors, institutions, and journals, and a predominance of descriptors directly related to the object under investigation. These findings broaden the understanding of the organization of scientific literature in the field of transfusion medicine and may support future investigations aimed at identifying knowledge gaps and strengthening research on hemovigilance and transfusion safety.

Conclusion

This bibliometric review made it possible to map national and international scientific production on immediate transfusion reactions, demonstrating a field characterized by continuous growth in publications and a well-defined bibliometric structure. The predominance of original articles, the concentration of publications in high-income countries and leading academic centers, as well as the predominance of English, characterize the distribution of scientific literature in the field of transfusion medicine.

The patterns observed regarding author productivity, journal dispersion, and descriptor frequency were consistent with Lotka's, Bradford's, and Zipf's Laws, demonstrating scientific production concentrated among specific authors and journals and a predominance of descriptors related to the object under investigation.

Despite the growth in scientific production, inequalities persist in the geographic distribution of publications, with lower representation of low- and middle-income countries, indicating the need to expand the participation of these contexts in the production and dissemination of scientific knowledge. By integrating classical bibliometric indicators with the temporal analysis of scientific production, this study provides a better understanding of the

organization of knowledge in hemovigilance. It also offers an updated synthesis that may guide future research, transfusion safety policies, and research priorities in the field, contributing to the identification of trends, gaps, and patterns in the literature on immediate transfusion reactions and supporting researchers, professionals, and managers in improving quality of care.

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