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ORIGINAL RESEARCH

# Global Trends and Evidence Gaps in Medical Errors Research: A Mixed-Methods Scientometrics Study

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**Background:** Medical errors represent a critical challenge to global healthcare systems, ranking among the leading causes of preventable morbidity and mortality. The aim of this study was to explore the evolution, characteristics, and correlation of research on medical errors and global health and research indicators.

**Methods:** A mixed-methods scientometrics study was conducted to analyse publications from 1865 to 2024 on medical errors from five databases. Correlational analyses were performed, focusing on publication trends, geographic and economic disparities, journal metrics, and thematic evolution. Multiple regression assessed relationships between bibliometric metrics and global indicators.

**Results:** Five thousand seven hundred thirty-two publications related to medical errors were analysed. An annual growth rate of 1.49% was documented, with high-income countries contributing 83.32% of publications. The Americas accounted for the highest regional output, while Africa and Southeast Asia showed marginal contributions. Most studies were published in high-impact journals (46% in Q1), but only 22.98% were open access. Thematic analysis revealed a transition from error reporting to mitigation strategies. Correlations showed strong associations between intellectual property fees and publication volume ($r^2$=0.75; p<0.001), while official development assistance negatively correlated with publication output ($r^2$=−0.33; p<0.01). Disability-adjusted life years showed weak correlations with publication volume ($r^2$=0.32; p<0.01) and journal impact ($r^2$=0.14; p<0.001).

**Conclusion:** This study highlights significant inequities in global research on medical errors, with high-income countries dominating production. While thematic shifts suggest advancements in the field, the lack of representation from low- and middle-income countries and limited access to open-access publications pose barriers to global applicability.

**Keywords:** medical errors, health services, health care quality indicators, global health, bibliometrics, meta-research

## Introduction

Medical errors pose a critical challenge to healthcare systems, ranking among the leading causes of preventable morbidity and mortality worldwide.[1] Studies conducted in the United States estimate that approximately half a million hospitalized patients experience some form of avoidable harm of medical origin,[2] and about 200,000 die as a result of such errors.[2] Consequently, this issue impacts not only patient safety but also healthcare quality indicators, public trust in health services, and the economic burden of medical care. According to experts, these costs may reach as high as $20 billion annually.[3] The most common medical errors include medication errors, unsafe surgical procedures, health care-associated infections, diagnostic errors, patient falls, pressure ulcers, and patient misidentification.[2] Strengthening

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research on system and organizational factors, technological factors, human factors and behavior, patient-related factors, and high-risk populations (such as older adults) could contribute to reducing the incidence of preventable medical errors.[2] Despite its significance, research in this area remains inconsistent, with substantial gaps in knowledge regarding its epidemiology, impact, and effective mitigation strategies.

Identifying knowledge gaps is essential to inform evidence-based decision-making and prioritize research lines that enhance health outcomes.[4] Previous bibliometric studies have primarily focused on characterizing scientific publications and macro research themes.[5–7] However, it remains unclear whether scientific production on medical errors has evolved consistently with global clinical and policy needs. Furthermore, few studies have examined the methodological quality and scientific pluralism in this area,[8] limiting the effective application of their findings.

The unexplored geographic inequality in scientific production, the neglect of specific areas of practical implementation, and the marked inconsistency in meeting health service quality indicators[9,10] severely hinder the extrapolation of findings and obstruct the coherent and effective adoption of strategies across diverse international contexts in addressing medical errors. In this scenario, mixed scientometrics methods have emerged as disruptive tools, capable of mapping invisible patterns, exposing critical gaps, and redefining research priorities. These methods empower researchers, healthcare institutions, and health systems to design and implement evidence-based quality management policies.[11,12]

Given the current knowledge gap and the need to provide evidence demonstrating alignment between scientific production and global health indicators related to human safety, this study aimed to explore, in a novel manner, the evolution, characteristics, and correlation of global research on medical errors and health research and development indicators, and global health metrics.

This study was reported following the recommendations of the BIBLIO guideline (Guideline for Reporting Bibliometric Reviews of the Biomedical Literature), which provides standards for reporting scientometrics/bibliometric studies.[13]

# Methods

## Study Design

Mixed-methods longitudinal study. This study integrates scientometrics methods based on global indicators with bibliometric methods that analyze the evolution of scientific activity in a specific field over time, using scientific publications as the unit of analysis.

## Data Sources

A systematic literature search was conducted using the Scopus, PubMed/MEDLINE, Web of Science Core Collection, SciELO Citation Index, and KCI-Korean Journal Database search engines and databases. These databases and indexes were selected due to their global scope and the extensive volume of documental and citation content in the fields of medical and health sciences. Additionally, they are recognized for the rigorous standards applied in the inclusion of peer-reviewed journals, positioning them as superior options compared to other available sources. The use of these resources has been previously demonstrated to be valid and reproducible in studies of this nature.[14–17]

## Search Strategy

A search strategy was developed using MeSH terms and their equivalents to identify any documents meeting standard peer-review criteria and focusing on the analysis, discussion, investigation, summarization, or examination of medical errors in the health sciences. The strategy prioritized literature from thematic areas systematically categorized within various bibliographic databases, encompassing disciplines such as medicine, nursing, dentistry, health professions, biochemistry, genetics, molecular biology, immunology, neuroscience, pharmacology, toxicology, and pharmaceutical sciences. In the initial phase, pilot tests were conducted by combining terms and tags across different search engines and databases to optimize the strategy. An example of the final strategy, implemented in the Scopus database and yielding the most precise results, was as follows: SUBJAREA(HEAL) OR SUBJAREA(DENT) OR SUBJAREA(NURS) OR SUBJAREA(MEDI) OR SUBJAREA(BIOC) OR SUBJAREA(IMMU) OR SUBJAREA(NEUR) OR

SUBJAREA(PHAR) AND TITLE("Medical Errors") OR TITLE("Diagnostic Errors") OR TITLE("Medication Errors") This strategy was adapted for use in each of the other databases or search engines.

## Time Period

The search was conducted on July 11, 2024, in English and Spanish. The initial screening of titles and abstracts was performed between July 13, 2024, and September 18, 2024. A second review phase was carried out between September 19, 2024, and November 12, 2024, to complete the data collection for core scientometrics domains and specific health metrics.

## Eligibility Criteria

Studies meeting the following criteria were included in the synthesis and analysis: 1) Scientific documents subjected to the standard peer-review process and published in scientific journals with regular serial publications; 2) Documents with full-text availability; and 3) Documents with a general and explicit objective related to analyzing, discussing, investigating, summarizing, or examining medical errors in the health sciences.

Documents meeting at least one of the following criteria were excluded: 1) Conference proceedings, book chapters, books, errata, and retracted documents; 2) Documents lacking basic bibliographic information (eg, author details, journal name, correspondence information); and 3) Publications in press.

Documents not originally published in English or Spanish but including an abstract in one of these languages were included, provided they met all inclusion criteria and none of the exclusion criteria. Given that this was a historical analysis, no lower time limit was applied regarding the year of publication.

## Data Standardization

The results from the various databases were exported in.CSV format, including all available metadata such as document titles, authors and their affiliations, keywords, year of publication, accumulated citations, publication type, and more. Initially, two researchers conducted an independent manual review to remove duplicates and evaluate titles and abstracts to ensure compliance with the inclusion and exclusion criteria. This process was performed using Microsoft Office Excel 2016.

Subsequently, a second independent review was conducted by two researchers, focusing on completing information related to scientometrics domains, healthcare quality indicators, and global health metrics. In cases of disagreement, a third evaluator intervened to resolve discrepancies. Additionally, efforts were made to standardize as many variables as possible to ensure greater homogeneity in the dataset. For instance, all articles categorized as reviews—regardless of their design (narrative, systematic with or without meta-analysis)—were grouped under the category "reviews". For the variable "country", the country of the corresponding author was used.

Although different databases record varying metadata, this analysis utilized the metadata common to all databases.

## Data Synthesis and Analysis

To analyze the scientometrics domain, information was collected on the quartile and h-index of each publication, adjusted to the reference year. These data were retrieved from the historical databases of Scimago Journal & Country Rank (records available since 1999) and Journal Citation Report (records available since 1997), selecting the most favorable metric for the journal in which the document was published.

Additionally, countries were grouped by geographic region into the following categories: The Americas, Europe, Western Pacific, Eastern Mediterranean, South-East Asia, and Africa. Countries were also classified by economic income levels into four groups: low-income, lower-middle-income, upper-middle-income, and high-income, according to the official World Bank classification based on the most recent data available for 2024.[18]

To address domains related to healthcare quality indicators and global health metrics, quantitative variables directly linked to health expenditure, disease burden, and research and development activities were used. The data were recorded in their original units of measurement and classified by country or geographic region, as appropriate. This information was obtained from open-access databases, including those of the World Bank,[19] the World Health Organization's Global

Health Observatory,[20] and the Global Observatory on Health Research and Development.[21] All indicators were analyzed in their original forms and values. These bases were consulted on August 16, 2024.

To evaluate trends, collaborations, and research patterns over time, thematic, collaboration, and term co-occurrence networks were developed. To enhance the clarity of visual analysis, a thesaurus was created to integrate names and terminological variations, enabling the normalization of relevant terms and the exclusion of general concepts. This scientometrics analysis was conducted using tools such as the Bibliometrix package in R (version 4.3.1), Matplotlib in Python (version 3.9), and VosViewer (version 1.6.18).

To examine the fundamental characteristics of scientific production, an exhaustive descriptive analysis was performed. The normality of quantitative variables was assessed using the Kolmogorov–Smirnov test. Quantitative data were presented as mean ± standard deviation or median and interquartile range, depending on the distribution of the variables. Qualitative variables were summarized using absolute frequencies and percentages.

For comparative analysis, Pearson's chi-square test or Student's *t*-test was used for quantitative variables, depending on the nature of the data. Additionally, multiple regression and correlation analyses were performed using Spearman or Pearson coefficients to identify correlations between quantitative variables. A p-value of $<0.05$ was considered statistically significant. All statistical analyses were conducted using R software (version 4.3.1) (https://www.r-project.org/).

## Ethical Statements

This study was approved by the Scientific Committee of Universidad de la Costa (code GRA.2021–07-002-19). However, no humans, animals, or medical records were used as units of analysis.

# Results

Five thousand seven hundred thirty-two publications related to medical errors (from 1865 to 2024) were analyzed following the inclusion and exclusion criteria (Figure 1). An annual growth rate of 1.49% was documented, with a marked increase in publications observed from 1999 onward (Figure 2A). Research articles constituted the majority of publications (68.53%), followed by review articles (11.37%). International collaboration was noted in only 5.5% of the articles. The Americas accounted for the highest production share, contributing 48.6% (n=1285/2644), followed by Europe with 29.8% (Figure 2B). High-income countries produced 83.32% (n=2203/2644) of the total output, whereas low-income countries contributed merely 0.42%. The average number of citations per document was 19.7. Most studies were published in high-impact journals (n=1075/2337), with 46% appearing in Q1-ranked journals. The average number of co-authors per document was three (Table 1). Application of Lotka's Law revealed that 86.4% of authors had authored only one article, while 9% had published two documents.

The Americas demonstrated the highest production across all quartiles, with a notable contribution to Q1 (27.43%). In contrast, the Western Pacific and Eastern Mediterranean regions showed significant representation in Q2 and Q3, while Africa and Southeast Asia reported marginal outputs across all quartiles. High-income countries dominated production in all quartiles, particularly in Q1 (42.19%) (Table 2). Middle-income countries exhibited a more balanced representation, especially in Q2 and Q3, though their contribution remained limited compared to high-income countries. Regarding open access, the proportion of documents published under this model was significantly lower in the lower quartiles (Q3 and Q4), with 19.38% represented in Q1, compared to 6.46% in Q3 and only 2.27% in Q4 (Table 2).

Figure 3A–B illustrate the scientific journals most frequently chosen for publishing research on medical errors and the impact achieved, measured using various metrics. Annual growth in publications has been driven primarily by the United States, the United Kingdom, and Australia (Figure 3C). At the institutional level, prestigious and highly prolific affiliations from the United States, including Johns Hopkins University and Harvard Medical School, demonstrated the greatest growth over time (Figure 3D).

Thematic and network analysis identified the most frequently used keywords, including "patient safety", "medication errors", and "misdiagnosis". These terms highlight a predominant focus on the direct clinical consequences and underlying mechanisms of errors in medical practice (Figure 4A). International collaboration

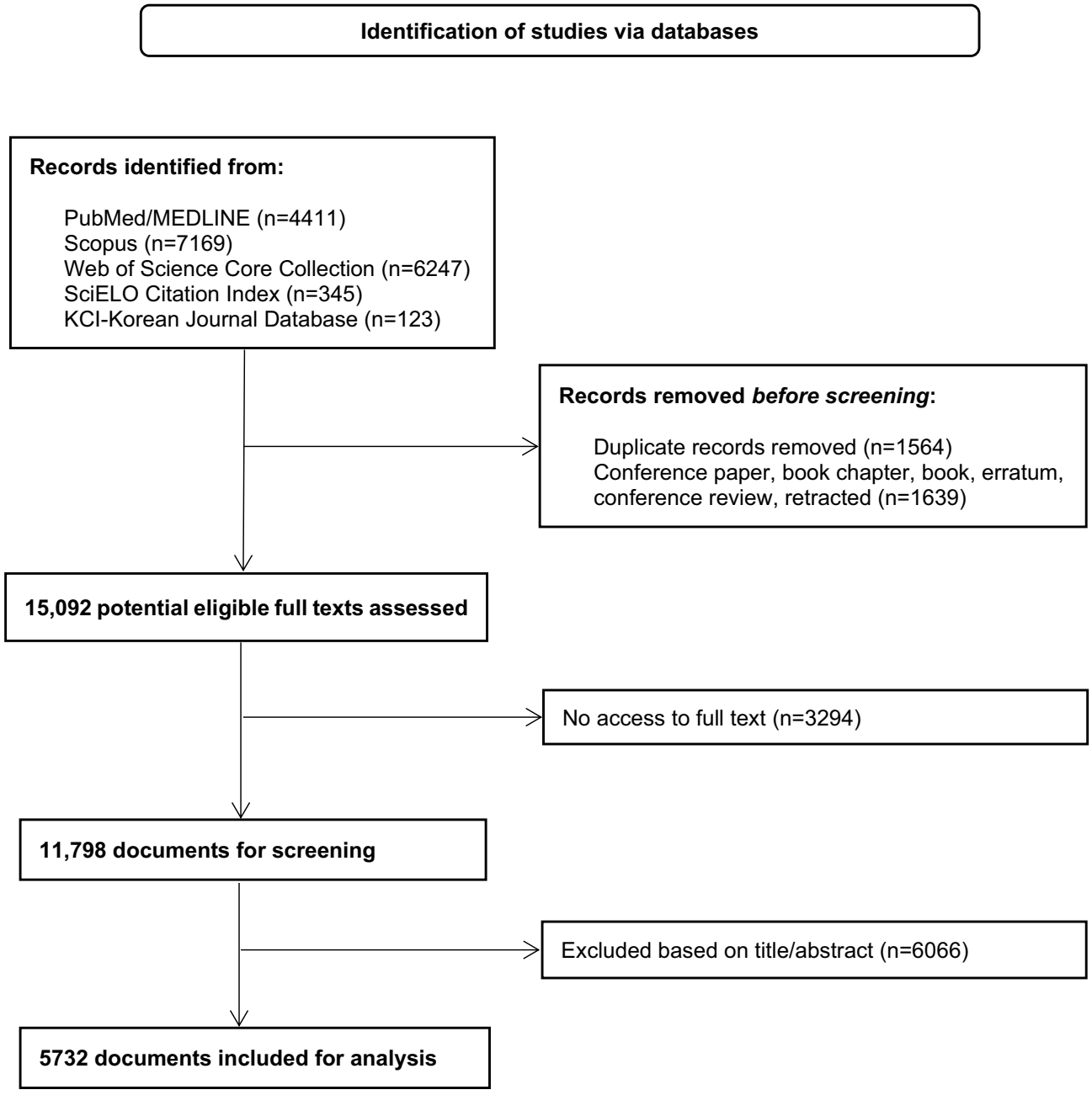


**Figure 1** Documents selection flow diagram.

networks were limited and predominantly led by high-income countries. The strongest connections were observed among the United States, the United Kingdom, and Australia, whereas regions such as Africa and Southeast Asia displayed minimal participation in these networks (Figure 4B). Co-occurrence analysis revealed a gradual shift in research focus, transitioning from topics related to error reporting to strategies for mitigation and learning systems. This progression reflects advances in understanding the issue and developing solutions (Figure 4C).

Correlational analysis yielded important findings regarding the relationships among global health indicators, research and development investments, and bibliometric variables (Figure 5). A strong positive correlation was identified between intellectual property usage fees and publication volume ($r^2$=0.75; $p<0.001$), while a moderate correlation was observed with current health expenditure ($r^2$=0.446; $p<0.0001$). Investment in research and

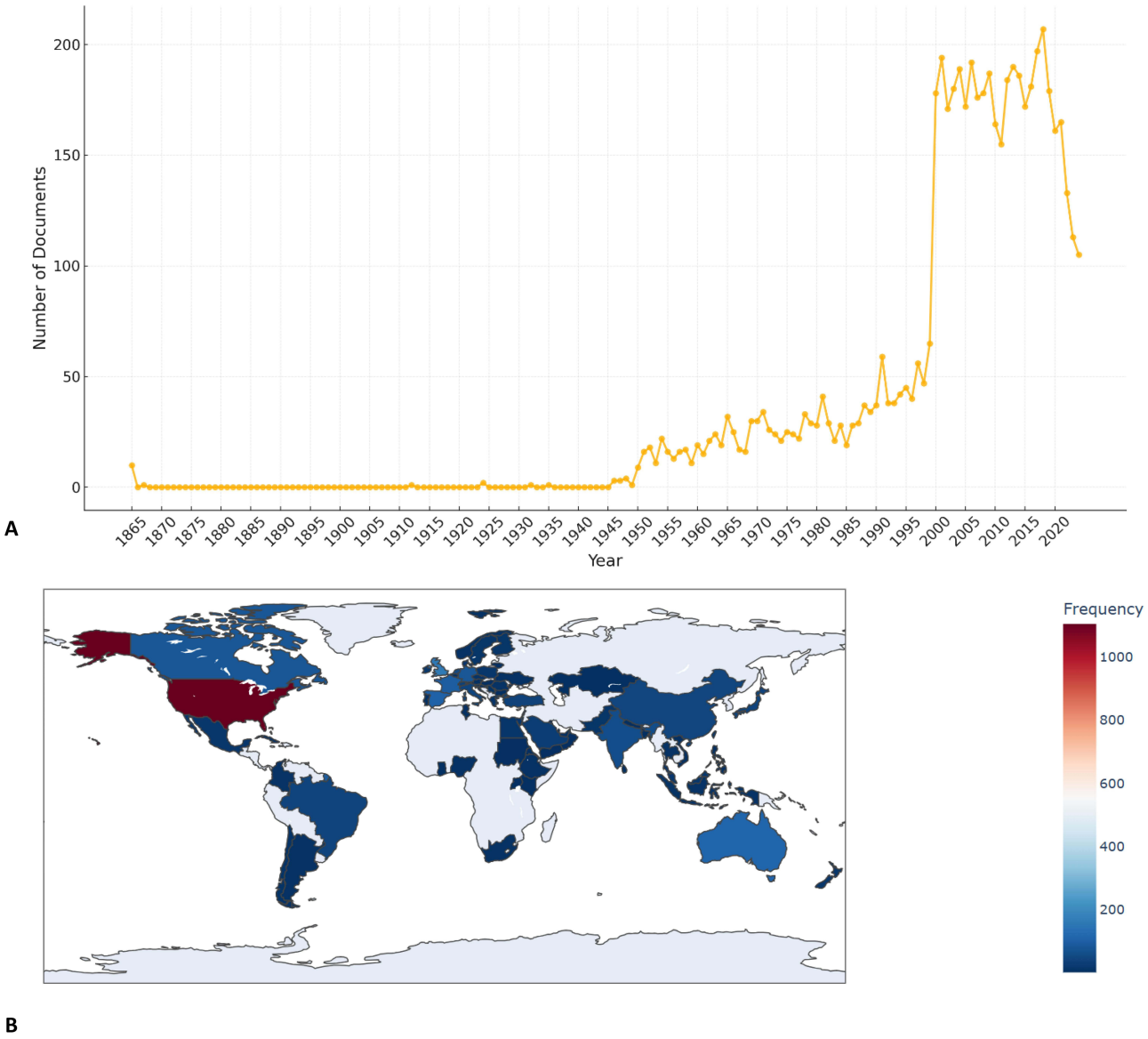


**Figure 2** Global scientific growth of research on medical errors. (**A**) Annual production volume over time. (**B**) Distribution of publication frequency by country.

development showed significant positive correlations with both publication volume ($r^2$=0.476; p<0.0001) and journal h-index ($r^2$=0.19; p<0.0001). Interestingly, a negative correlation emerged between official development assistance and publication volume at both regional ($r^2$=−0.27; p<0.05) and country income-group levels ($r^2$=−0.33;

**Table 1** General Characteristics of Global Publications on Medical Errors Research (N=5732)

| | n | % |
|---|---|---|
| **Document Type** | | |
| Article | 3928 | 68.53 |
| Review | 652 | 11.37 |
| Note | 368 | 6.42 |
| Letter | 323 | 5.64 |
| Editorial | 231 | 4.03 |
| Short survey | 230 | 4.01 |

(*Continued*)

**Table 1** (Continued).

| | n | % |
|---|---|---|
| **Publication language** | | |
| English | 4346 | 75.82 |
| German | 356 | 6.21 |
| Russian | 280 | 4.88 |
| Spanish | 170 | 2.97 |
| Other languages | 580 | 10.12 |
| **Country by región*,†** | | |
| The Americas | 1285/2644 | 48.6 |
| Europe | 788/2644 | 29.8 |
| Western Pacific | 269/2644 | 10.17 |
| Eastern Mediterranean | 199/2644 | 7.53 |
| South-East Asia | 80/2644 | 3.03 |
| Africa | 23/2644 | 0.87 |
| **Country by income*,†** | | |
| High-income | 2203/2644 | 83.32 |
| Upper-middle income | 295/2644 | 11.16 |
| Lower-middle income | 135/2644 | 5.11 |
| Low-income | 11/2644 | 0.42 |
| **Journal quartile‡** | | |
| Q1 | 1075/2337 | 46 |
| Q2 | 582/2337 | 24.9 |
| Q3 | 395/2337 | 16.9 |
| Q4 | 285/2337 | 12.2 |
| **H-index journal‡, mean (SD)** | 63 | 94 |
| **Open access** | | |
| Yes | 1317 | 22.98 |
| No | 4415 | 77.02 |

**Notes**: *Corresponding author's country. †Category according to most recent World Health Organization classification (2024). ‡Year-adjusted value of the journal metrics.
**Abbreviation**: SD, Standard Deviation.

**Table 2** Scientometrics Characteristics of Publications on Medical Errors by Journal Quartile (N=2337)

| | Q1 | Q2 | Q3 | Q4 |
|---|---|---|---|---|
| | n (%) | | | |
| **Top five most prolific countries** | | | | |
| United States | 582 (24.9) | 242 (10.36) | 114 (4.88) | 49 (2.1) |
| United Kingdom | 90 (3.85) | 24 (1.03) | 13 (0.56) | 10 (0.43) |
| Australia | 61 (2.61) | 37 (1.58) | 7 (0.3) | 1 (0.04) |
| Spain | 19 (0.81) | 24 (1.03) | 44 (1.88) | 11 (0.47) |
| Iran | 12 (0.51) | 30 (1.28) | 20 (0.86) | 17 (0.73) |
| **Country by región*,†** | | | | |
| The Americas | 641 (27.43) | 288 (12.32) | 144 (6.16) | 72 (3.08) |
| Europe | 259 (11.08) | 151 (6.46) | 126 (5.39) | 153 (6.55) |
| Western Pacific | 124 (5.31) | 70 (3) | 41 (1.75) | 16 (0.68) |
| Eastern Mediterranean | 38 (1.63) | 47 (2.01) | 58 (2.48) | 27 (1.16) |
| South-East Asia | 8 (0.34) | 20 (0.86) | 18 (0.77) | 15 (0.64) |
| Africa | 5 (0.21) | 6 (0.26) | 8 (0.34) | 2 (0.09) |

(*Continued*)


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**Table 2** (Continued).

| | Q1 | Q2 | Q3 | Q4 |
|---|---|---|---|---|
| | n (%) | | | |
| **Country by income*,‡** | | | | |
| High-income | 986 (42.19) | 479 (20.50) | 288 (12.32) | 203 (8.69) |
| Upper-middle income | 64 (2.74) | 73 (3.12) | 63 (2.70) | 61 (2.61) |
| Lower-middle income | 22 (0.94) | 26 (1.11) | 41 (1.75) | 21 (0.9) |
| Low-income | 3 (0.13) | 4 (0.17) | 3 (0.13) | 0 |
| **Open access** | | | | |
| Yes | 453 (19.38) | 207 (8.86) | 151 (6.46) | 53 (2.27) |
| No | 622 (26.62) | 375 (16.05) | 244 (10.44) | 232 (9.93) |

**Notes**: *Corresponding author's country. ‡Category according to most recent World Health Organization classification (2024).

p<0.01). Although weak, correlations were also observed between disability-adjusted life years and publication volume ($r^2$=0.32; p<0.01) as well as journal h-index ($r^2$=0.14; p<0.001), but not with citation counts ($r^2$=0.1) (Figure 5).

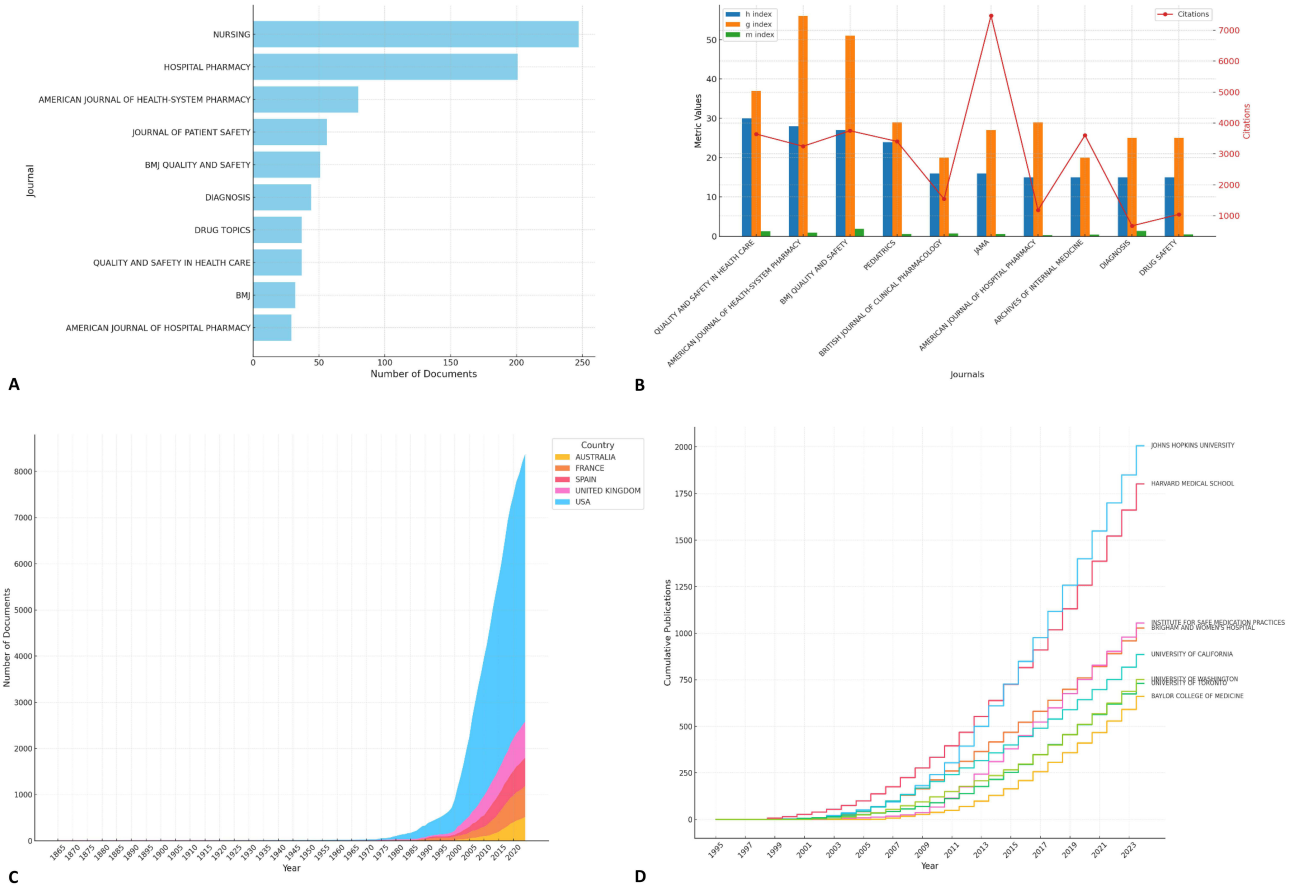


**Figure 3** Most popular scientific sources and scientific growth of the most prolific countries and affiliations in medical error research. (**A**) Top 10 journals with the highest volume of publications on medical errors. (**B**) Metrics of the 10 journals with the greatest impact. (**C**) Growth over time of the five most prolific countries. (**D**) Growth over time of the five most prolific affiliations.

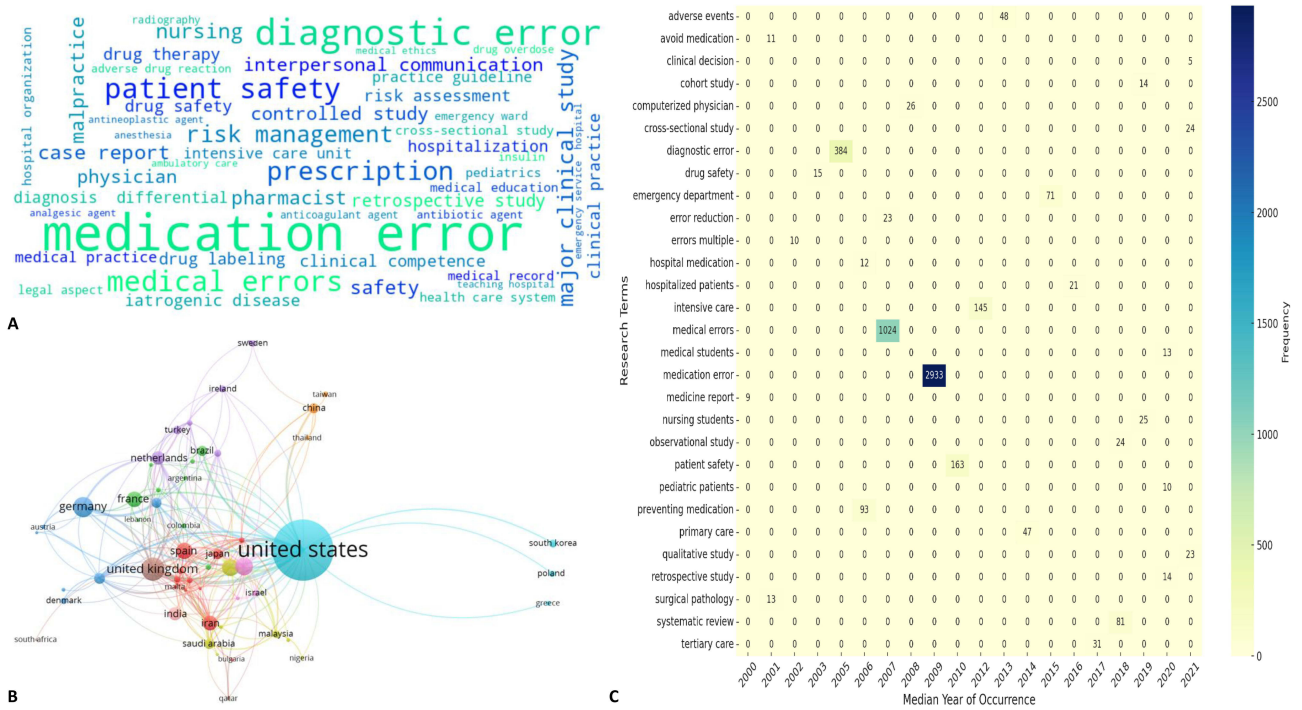


**Figure 4** Research areas, scientific collaboration, and evolution of topics over time in medical error research. (**A**) Word cloud of the most frequently used keywords. (**B**) International collaboration between countries. (**C**) Most frequently used research terms over time.

## Discussion

A detailed analysis of global research on medical errors is presented, revealing critical insights into the field's evolution, geographic disparities, and underlying factors influencing research output. A notable finding is the overwhelming dominance of high-income countries, which accounted for 83.32% of all publications. This imbalance underscores significant inequities in global research capacity, which likely stem from disparities in research funding, infrastructure, and workforce expertise.[22] For example, countries like the United States, the United Kingdom, and Australia demonstrate sustained growth and prominence, driven by their robust health systems, academic networks, and policy frameworks that prioritize patient safety.[23] In contrast, low-income countries contributed less than 0.5% of the global output. This gap reflects systemic barriers, including limited access to funding, inadequate infrastructure, and challenges in disseminating research findings.[22,23] It is imperative to address these inequities, as they hinder the development and implementation of localized strategies for reducing medical errors in resource-limited settings.

The thematic evolution observed in this study highlights a gradual shift from descriptive studies focusing on error prevalence to analytical works exploring mitigation strategies and learning systems. This progression signifies an increasing maturity of the field, driven by advancements in patient safety frameworks, technology, and health systems research.[24] However, the persistent underrepresentation of studies addressing systemic interventions and policy-level solutions suggests a critical gap in the literature.[25]

Despite the recognized importance of international collaboration in advancing health research, limited cross-border partnerships are revealed, with high-income countries predominantly collaborating among themselves. This lack of inclusivity further marginalizes low- and middle-income countries, limiting their ability to contribute to and benefit from global knowledge-sharing networks.[26] Enhanced global partnerships could help address this gap by fostering capacity building, knowledge transfer, and collaborative funding mechanisms.[27]

Several hypotheses emerge to explain these findings. First, the positive correlation between research output and metrics like intellectual property usage fees and current health expenditure highlights the influence of economic factors on research capacity. Second, the strong association between high research and development investment and publication

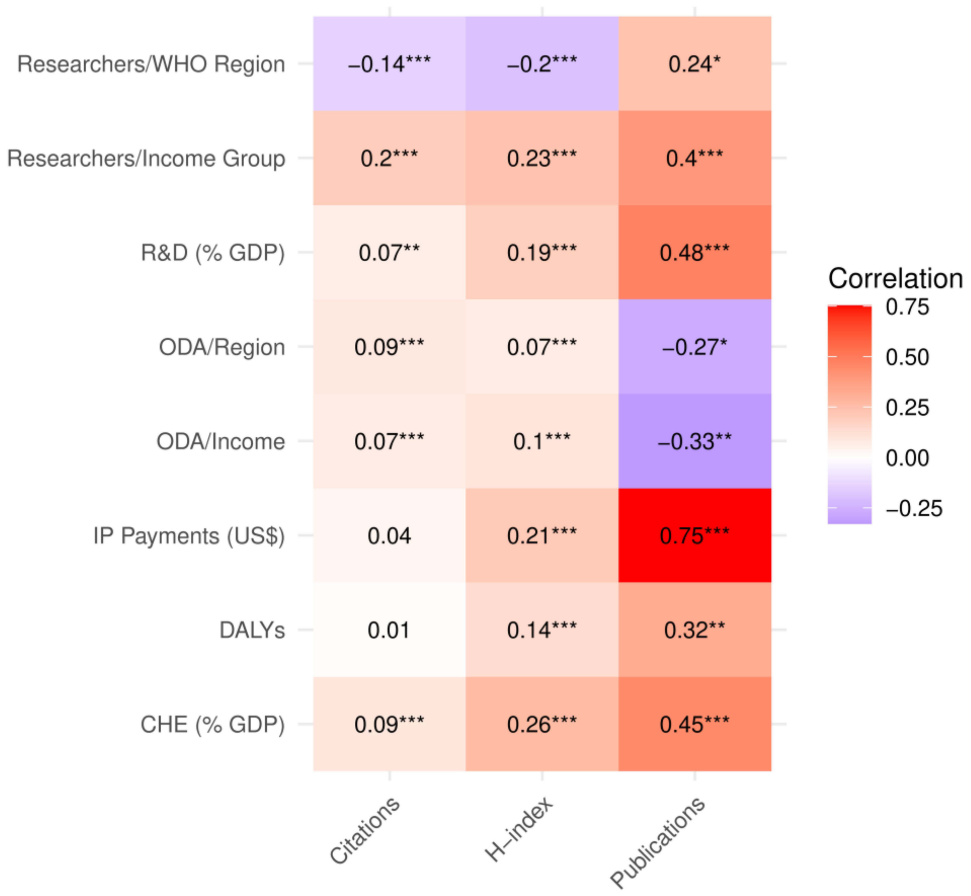


**Figure 5** Spearman correlation coefficients for pairwise relationships between global health, research and development, and bibliometric indicators. The colour gradient represents the strength and direction of correlations. Only rows with complete data for each pair of variables were included in the analysis. (*p < 0.05; **p < 0.01; ***p < 0.001).
**Abbreviations**: CHE, Current Health Expenditure; R&D, Research and Development Expenditure; IP, Intellectual Property; DALYs, Disability-Adjusted Life Years; ODA, Official Development Assistance.

volume reinforces the role of sustained funding in driving scientific productivity. Conversely, the negative correlation between official development assistance and research output suggests that donor priorities may not align with local research needs, particularly in low- and middle-income countries.

The findings carry significant implications for practice and policy. From a theoretical perspective, the need for inclusive frameworks that bridge global inequities in research production is highlighted.[22] Practical implications include the urgent need to strengthen research capacity in low- and middle-income countries through targeted investments, policy support, and technical assistance.[28] Moreover, findings from medical errors research should be integrated into health system reforms and policy-making to enhance patient safety, reduce preventable harm, and improve overall healthcare quality.

Future research should focus on evaluating the impact of interventions aimed at reducing medical errors in diverse settings, particularly in low- and middle-income countries. Additionally, studies exploring the role of cultural, organizational, and systemic factors in shaping patient safety outcomes could provide valuable insights.[29] Greater inclusivity in international collaborations and equity in research funding should be prioritized to address global disparities in medical error research.[28] Finally, these findings underscore the importance of establishing robust health research policies tailored to local missions and needs, ensuring that national and international investments are directed toward addressing issues with a tangible societal impact.[30] Medical errors, along with their specific characteristics, must be prioritized as they represent preventable events with significant associated costs.

The limitations of this analysis include its cross-sectional design, which did not allow for the continuous exploration of changes in global indicators and metrics over time. Similarly, the indicators used were not adjusted by year; instead, the most recent data available in the databases were utilized. However, this limitation remains beyond the researchers' control, as it depends on the quality of information provided by open-access databases.

## Conclusions

This study provides a detailed analysis of global research on medical errors, uncovering significant inequities in geographic and thematic representation. High-income countries dominate the field, while low- and middle-income countries remain underrepresented, reflecting systemic barriers that hinder equitable knowledge production and application. The study highlights a thematic shift toward mitigation strategies and systemic interventions, yet significant evidence gaps persist, particularly in addressing low- and middle-income-specific challenges. These findings underscore the urgent need for inclusive global frameworks to bridge research disparities, enhance international collaboration, and integrate medical error research into evidence-based policy-making. Addressing these gaps requires targeted investments in research capacity building, alignment of donor priorities with local needs, and the adoption of innovative technologies to advance the field.

## Data Sharing Statement

The dataset generated and analyzed is available and provided on request.

## Ethics Approval and Consent to Participate

This study was approved by the Scientific Committee of Universidad de la Costa (code GRA.2021-07-002-19).

## Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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## Disclosure

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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