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Bibliometric Characteristics of the 1000 Most-Cited English-Language Publications per Decade in Anesthesiology, Surgery, and Medicine, 1980–2019: A Comparative Analysis †

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Abstract

Background: Bibliometric comparisons can describe highly cited literature but do not represent the full output of a discipline. The NIH-supported Relative Citation Ratio (RCR) field- and time-normalizes citation rates, while the Altmetric Attention Score (AAS) summarizes online attention. This study compared article-level metrics and bibliometric features among the 1000 most-cited English-language publications per decade in the Web of Science (WoS) categories Anesthesia, Surgery, and Medicine during 1980–2019. Methods: The 1000 most-cited English-language records per decade in the WoS categories Anesthesia, Surgery, and Medicine were retrieved for four decades, 1980–2019, in September 2024. Mean RCRs were obtained from iCite. AAS values were obtained through Dimensions AI and treated as cross-sectional scores measured at the extraction date because historical attention-source coverage was not equivalent. Bibliometric features were summarized for this selected sample. Data linkage and analytic denominators: The 12 category-by-decade datasets each began with 1000 selected records, for 12,000 selections in total. The supplied analysis materials did not include a record-level flow table showing successful linkage to PMID/iCite, DOI/AAS, affiliations, or keyword fields for each field and decade. These counts were not imputed or reconstructed and are reported as a limitation. Results: Within this selected sample, MED had higher RCR values across the study period, whereas ANE and SUR did not show the same increase in RCR from their 1980s values. AAS values were summarized descriptively and were not interpreted as equivalent longitudinal growth because historical coverage and post-publication observation time differed. Funding rankings differed by measure: ANE had the highest NIH-funded proportion in 2010–2019, whereas MED had the highest non-NIH funding proportion. Semantic concentration measures varied by field and metric. Conclusions: Within this selected sample, ANE and SUR did not show the same increase in RCR observed for MED. Semantic measures showed field- and metric-specific changes. These descriptive findings do not establish that topic diversity, collaboration, or journal concentration caused differences in influence, and they should not be generalized to all anesthesiology, surgery, or medicine publications.

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Keywords: Relative Citation Ratio (RCR); Altmetric Attention Score (AAS); anesthesiology; bibliometrics; highly cited publications; Web of Science categories; semantic diversity

1. Introduction

In recent years, bibliometric comparisons have raised questions about how highly cited anesthesiology publications compare with those in other medical specialties [1]. Several studies have highlighted differences in research output and academic capacity. For instance, bibliometric data have reported that a substantial proportion of anesthesiology publications are secondary analyses, including observational studies, database reviews, surveys, and meta-analyses, rather than primary clinical or laboratory research [2,3]. Funding patterns have also raised concern: one study reported a decrease in median NIH funding for anesthesiology departments between 2008 and 2017, with more than half of NIH funding concentrated in 10 U.S. departments [4]. These findings provide context for studying highly cited anesthesiology publications, but they do not establish that the specialty produces less original or high-impact research overall.

To explore field-wide shifts, publication metrics are vital tools that allow scholars to identify areas of rapid development and highlight domains that may benefit from further investigation. These are common elements assessed in bibliometric analyses, as well as authorship trends, journal impact metrics, study design, citation frequency, article visibility, and funding sources [5].

For cross-disciplinary comparisons, field-normalized article-level metrics such as the Relative Citation Ratio (RCR) and Altmetric Attention Score (AAS) can help describe different dimensions of influence. Developed by the National Institutes of Health, RCR compares an article's observed citation rate with an expected citation rate derived from peer articles in its co-citation network and publication year [6]. In this study, RCR is therefore defined as the observed citation rate divided by the expected citation rate; a value of 1 represents the benchmark. Validation studies reported that RCR is transparent, field- and time-normalized, scalable from individual articles to portfolios, and correlated with expert assessments of influence. They also reported substantial stability of RCR values for older NIH-funded articles over time. These findings support RCR as an article-level influence measure, not a direct measure of productivity, novelty, clinical importance, or researcher quality [7,8]. Complementing this, AAS retrieved through Dimensions AI captures online attention from news outlets, social media, blog posts, and policy documents [9,10]. AAS is an attention indicator, not a measure of scientific quality or clinical importance.

The primary endpoint of this study was to compare RCR values among the selected highly cited publications in the WoS categories Anesthesia, Medicine, and Surgery during 1980–2019. AAS values were examined as cross-sectional scores measured at the September 2024 extraction date rather than as a historically equivalent time series. Secondary endpoints were to describe funding patterns, journal distribution, keyword content, and markers of collaboration. We sought to characterize differences in mean RCR and AAS values between the top-cited publications in ANE and MED. Recent studies have examined field-wide anesthesia output and the 100 most-cited anesthesiology articles using different sampling frames [11–13]. The present study extends that work by comparing fixed top-1000 samples across four decades and combining RCR, AAS, funding, collaboration, journal distribution, and semantic measures.

2. Materials and Methods

A search of the Web of Science (WoS) Core Collection was conducted in September 2024 to identify the 1000 most-cited English-language records per decade within the selected journal-level categories "Anesthesiology," "Surgery," and "Medicine." WoS categories are assigned at the journal level, not directly to individual articles, and a journal may carry more than one category. The current category description covers resources focused on administration of anesthetics, pain, and life-support systems, including cardiovascular, pediatric, and neurosurgical anesthesia. In this manuscript, MED denotes the WoS journal-level category Medicine; it is not synonymous with all clinical medicine or the entire biomedical literature. The category is therefore not equivalent to all research conducted by investigators in anesthesia departments, and it may include pain and cross-disciplinary research. The four-decade search covered 1980–2019 and yielded 12 datasets, with 1000 selected records per field and decade, or 12,000 selections before linkage. Metadata included title, authors, document type, Keywords Plus, affiliations, funding sources, PMID, DOI, WoS subject category, and WoS research area. Record-level overlap between datasets could not be re-quantified from the retained analysis materials and is reported as a limitation.

The mean RCR for each article was calculated using the NIH-supported iCite platform (https://icite.od.nih.gov/analysis (accessed on 6 August 2025)) [9]. AAS values were obtained through the Dimensions AI API (version 2.10) by matching articles to their DOIs. AAS was measured at the September 2024 extraction date and treated as a cross-sectional value. We did not impose a standardized post-publication observation window, and source coverage was not assumed to be equivalent for publications from different decades [10]. Accordingly, AAS comparisons across publication decades and any annual slopes are exploratory and are not interpreted as evidence of secular growth [14,15]. All data compilation and processing were carried out using JupyterLab (version 4.2.510) with Python (version 3.12.7).

Generative AI-assisted technologies: During manuscript preparation, the authors used Grammarly (Grammarly, Inc.; web-based application; version information was not recorded) solely for language and grammar editing. The tool was not used to generate study data, figures, study design, data collection procedures, statistical analyses, interpretations, or references. The authors reviewed and edited the output and take full responsibility for the content of this publication.

Key article characteristics analyzed included publisher location, total number of affiliations, journal distribution, author count, NIH funding status, and keyword composition. Funding was classified according to the information reported in the records. Non-NIH funding was not used as a proxy for international funding; it may include U.S. universities, foundations, professional societies, industry, other federal agencies, and domestic or foreign sources. Keywords were extracted from the "Keywords Plus" field for studies published between 1990–1999 and 2010–2019; data for 1980–1989 were excluded because the Keywords Plus column was unreported for more than 99% of publications in that period. These keywords were categorized using MetaMap [16] according to the UMLS Semantic Network subject headings [17]. The analysis documentation did not record the MetaMap version, configuration, preprocessing steps, or rules for resolving ambiguous or multiple mappings. Where percentage changes are reported, the denominator is the category proportion in the 1990–1999 dataset. These limitations make the semantic analysis exploratory. The distribution of keyword categories was then summarized with entropy metrics.

Shannon Entropy provides a measure of the distribution of observations across categories [18]. The Gini coefficient summarizes inequality in that distribution, with 0 representing equal distribution and 1 representing maximal inequality [19]. Top 1% and Top 5% concentration measures describe the share represented by the most frequent categories.

Jensen-Shannon divergence measures the difference between two probability distributions, but does not by itself indicate whether research became broader or narrower [11]. Because these metrics can move in different directions, they are interpreted descriptively and not as a single definitive measure of topic diversification.

3. Statistical Analysis

Missing affiliation data were not imputed; records with missing affiliations were excluded, which constitutes complete-case analysis. Missing values for other fields were coded as unreported rather than interpreted as proof that the feature was absent. Comparisons of mean RCR and mean AAS across fields and decades used ANOVA. Other feature comparisons used chi-square, Mann–Whitney U, or Kruskal–Wallis tests as appropriate to the comparison. Exact model formulas, factors and interactions, analytic sample sizes, diagnostic procedures, post hoc comparisons, effect estimates, confidence intervals, and multiplicity adjustments were not retained in the retained analysis output. The present manuscript therefore treats the inferential findings as exploratory and makes no claim that the analyses controlled the family-wise error rate across the many hypotheses examined. Entropy metrics are reported descriptively; no inferential claim is made for Gini or concentration changes because standard errors or bootstrap confidence intervals were not available in the analysis archive.

4. Results

4.1. Impact Metrics

Within the selected highly cited sample, ANE had lower RCR values than MED across the study period and lower or comparable values to SUR in the primary analysis. Mean RCR increased across decades for MED but did not show the same increase for ANE or SUR relative to their 1980s values. AAS values varied across publication decades, but the single extraction date and changing historical coverage prevent interpretation as equivalent longitudinal growth. The previously reported annual AAS slopes and their associated significance tests have therefore been removed rather than interpreted causally. Article metrics are depicted in Figure 1.

4.2. Authorship/Affiliations/Journals

Across the selected sample, the number of authors and institutions per paper increased over time, reaching medians of three, four, and thirteen institutions and six, eight, and sixteen authors in the 2010–2019 decade for ANE, SUR, and MED, respectively. Single-institution and single-author publications also became less common in the descriptive data. Across fields and decades, the United States accounted for the majority of publications, contributing over 70% of the selected records. These patterns describe the selected citation tail and should not be interpreted as field-wide changes in collaboration.

The number of unique journals represented among the selected records increased for SUR and ANE, reaching 98 and 38, respectively, in the 2010–2019 decade. MED had 18–26 journals in each decade. The New England Journal of Medicine represented more than 50% of the selected MED records, whereas no single ANE or SUR journal represented a comparable majority. In MED, the top 10 journals represented at least 97.5% of the selected records in each decade. In ANE, the top 10 journals represented 89% of the 2010–2019 records, while the corresponding SUR proportion was 49.4%. These are distributions within the selected top-1000 samples, not estimates of the journals' overall publication output.

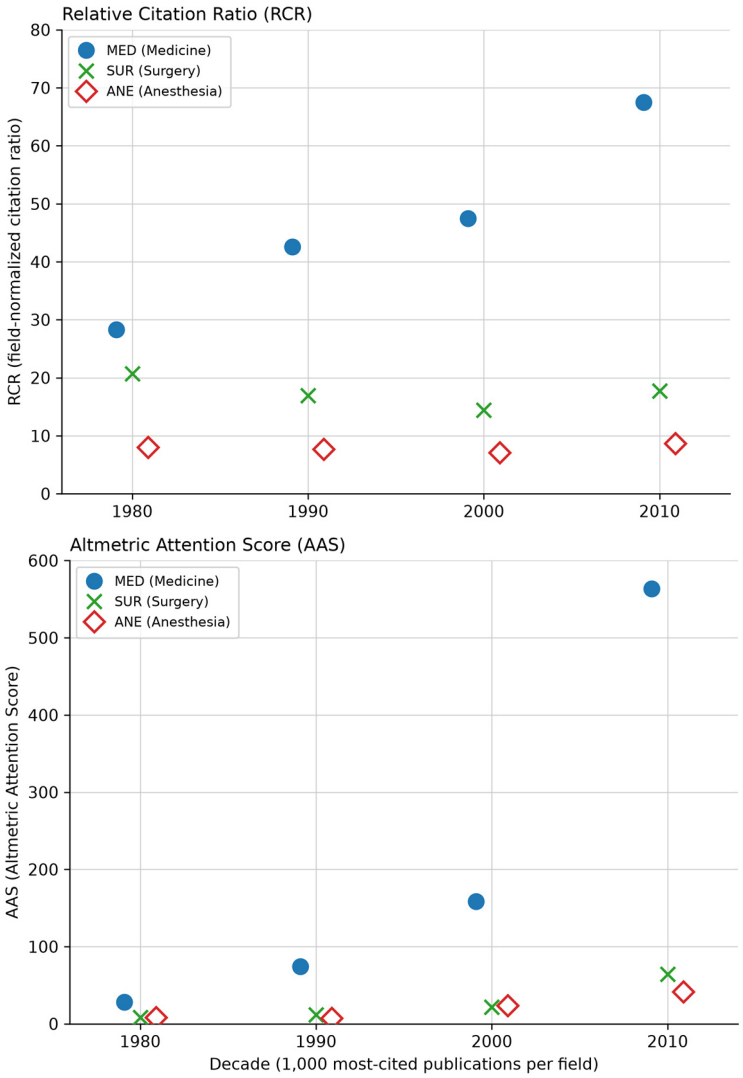


Figure 1. Mean Relative Citation Ratio (RCR) and cross-sectional Altmetric Attention Score (AAS) values among the selected 1000 most-cited publications per decade in Medicine, Surgery, and Anesthesia, 1980–2019. Symbols represent decade-specific cohorts of the 1000 most-cited publications in each field; they do not follow the same articles over time. AAS was measured at the September 2024 extraction date and is treated as a cross-sectional score, so differences across decades reflect both accumulated attention and unequal post-publication observation time.

4.3. Funding

Funding proportions differed by field and funding measure in the selected sample. In 2010–2019, ANE had the highest proportion of NIH-funded records at 27.6%, compared with 20.0% for MED and 17.9% for SUR. NIH funding peaked in 2000–2009 for ANE and in 1990–1999 for MED and SUR. Non-NIH funding was highest for MED at 69.3%, followed by ANE at 44.2% and SUR at 32.0%. Because journal practices differ in how funding is reported, these values describe reported funding fields and should not be treated as standardized measures of total support. The proportion of records without a reported funding source was 28.2% for ANE and 10.7% for MED, while more than half of SUR records lacked a reported source in 2010–2019. A breakdown of reported funding categories is shown in Figure 2.

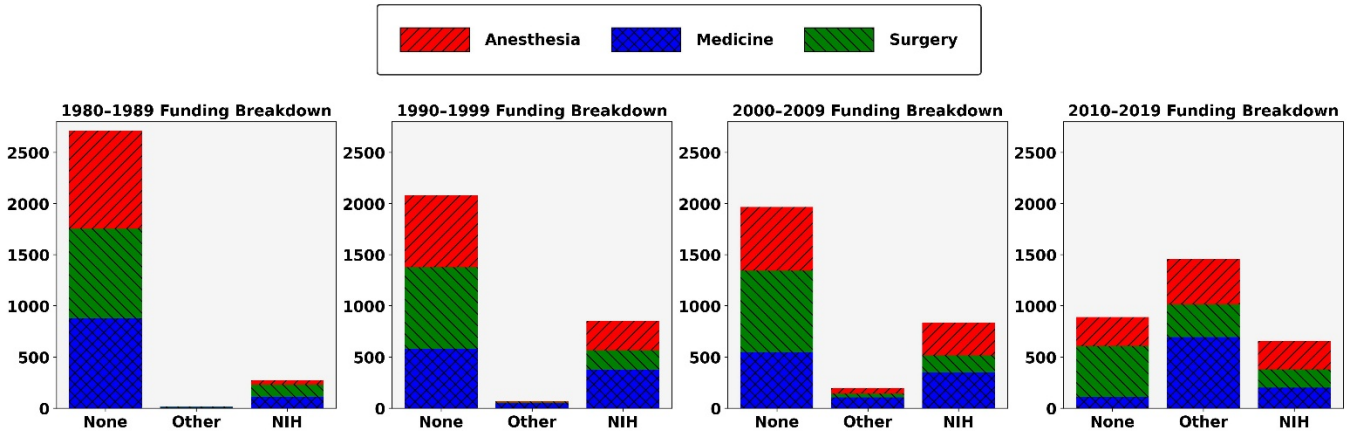


Figure 2. Reported funding distribution for each field and decade. "Non-NIH" includes all reported non-NIH sources; it is not a geographic classification.

4.4. Keywords/Categories

Following exploratory MetaMap classification of article keywords, ANE publications had similar representation among the top 10 categories between 1990–1999 and 2010–2019, although the rank order changed. MED's category profile remained broadly similar between the two periods, with Disease or Syndrome, Pharmacological Substance, Therapeutic Procedure, and Gene or Genome among the most frequent categories. In SUR, Therapeutic/Preventative Procedure, Finding, and Functional Concept were frequent in both periods. Neoplastic Process moved out of the SUR top 10 and into the MED top 10 by 2010–2019, while Gene or Genome showed the opposite pattern.

Within ANE, the largest descriptive changes between 1990–1999 and 2010–2019 included increases in Occupational Activity and Population Group of more than 100%, an increase in Gene or Genome of just under 90%, and an increase in Patient or Disabled Group of more than 93%. Pharmacological Substance, Organic Chemical, Physiologic Function, and Receptor each decreased by more than 40%. In MED, the largest changes were observed in Social Behavior (+101.0%), Occupational Activity (+85.2%), and Hormone (−49.7%). In SUR, the largest shifts occurred in Population Group (+190.7%), Gene or Genome (+73.1%), Patient or Disabled Group (+45.6%), Organ/Tissue Function (−57.5%), and Neoplastic Process (−36.2%).

These percentages are descriptive changes in category proportions within the selected keyword datasets.

The semantic metrics showed no uniform direction across fields. In ANE, the Gini coefficient rose from 0.696 to 0.702, while Top 1% and Top 5% concentration decreased by 13.5% and 0.6%, respectively. In SUR, the Gini coefficient rose from 0.657 to 0.675, the Top 1% concentration increased by 3.1%, and the Top 5% concentration rose from 31.6% to 34.0%. In MED, the Gini coefficient declined from 0.651 to 0.647, the Top 1% concentration increased by 2.7%, and the Top 5% concentration declined from 35.4% to 30.6%. These descriptive measures do not support a single conclusion about topic diversification, and no inferential significance is claimed for these changes. The metrics are displayed in Table 1.

Table 1. Descriptive subject-distribution metric changes between 1990–1999 and 2010–2019. No inferential significance is assigned because uncertainty estimates were not available in the analysis archive. Percent change calculated using unrounded original values not displayed in table.

Metric	Anesthesiology (1990–1999 and 2010–2019)	Surgery (1990–1999 and 2010–2019)	Medicine (1990–1999 and 2010–2019)
Shannon Entropy	5.310 → 5.293 (−0.3%)	5.473 → 5.390 (−1.5%)	5.496 → 5.511 (+0.3%)
Gini Coefficient	0.696 → 0.702 (+0.9%)	0.657 → 0.675 (+2.8%)	0.651 → 0.647 (−0.7%)
Top 1% Concentration	10% → 8.6% (−13.5%)	9.1% → 9.4% (+3.1%)	7.0% → 7.1% (+2.7%)
Top 5% Concentration	35.3% → 35.1% (−0.6%)	31.6% → 34.0% (+7.6%)	35.4% → 30.6% (−13.6%)
Jensen-Shannon Divergence	0.0245	0.0147	0.012

5. Discussion

Among the selected highly cited publications, ANE and SUR did not show the same increase in RCR across decades that was observed for MED. AAS differences are descriptive because scores were extracted at one time point and attention-source coverage varied by publication age. The data support comparisons within this selected sample, but they do not support claims about field-wide progress or historically comparable growth in online attention.

The increases in authorship and affiliations are descriptive features of the selected sample. They may be compatible with changes in team science or research organization, but this study did not measure internet adoption, protected research time, training culture, or other causal mechanisms. Funding patterns also differed by measure. Non-NIH funding cannot be interpreted as international funding, and journal-level reporting practices may affect the observed proportions. The decline from peak NIH funding values should therefore be read as a pattern in reported grant information, not as evidence of a change in total research support.

The selected MED records were concentrated in a small group of journals, including NEJM, whereas ANE and SUR records were distributed across more journals. This pattern is compatible with differences in journal structure, but the analysis does not establish that journal concentration caused greater visibility or higher RCR. Nor does it support a recommendation to concentrate ANE publications in a small group of flagship journals. Prior bibliometric work found that anesthesiology research can be represented differently when defined by journal subject categories versus author department affiliations, particularly for pain-related journals [12]. The present study extends that literature by comparing fixed top-1000 samples across four decades and by combining RCR, AAS, funding, collaboration, journal distribution, and semantic measures. Related field-wide and top-100 bibliometric studies provide context but use different sampling frames and cannot be directly compared with these results [13,20].

The semantic measures should be interpreted together and cautiously. ANE and SUR showed increases in some inequality or concentration measures, while MED showed a decline in the Gini coefficient but not a uniform decline in every concentration measure. The category-level changes identify shifts in the selected keyword distributions, but they do not establish a loss of foundational research, a change in drug discovery, or a causal relationship with visibility or influence. Prior studies have described publication patterns and academic capacity in anesthesiology, but those studies used different datasets and cannot establish the mechanisms behind the present observations [2,3,21].

The lower ANE metrics may reflect differences in specialty structure, training environments, and the physician-scientist pipeline, but these mechanisms were not tested. Recent anesthesiology-specific work found that anesthesiology ranked relatively low among specialties in the proportion of entering residents classified as research-oriented and identified

protected time, mentoring, funding, and research culture as relevant pipeline issues [22]. These findings provide context, not proof that workforce composition caused the RCR or AAS patterns observed here. Anesthesia is also a highly clinical, hospital-based specialty, while medicine includes a broader range of inpatient, outpatient, laboratory, and academic activities. Differences in access to patients, study design, and opportunities to conduct randomized trials are plausible hypotheses, but the present dataset cannot evaluate them. The perceived difficulty of publishing in anesthesiology journals was not measured and is not inferred from these data.

6. Limitations

This study has several limitations. First, the fixed top-1000-per-decade design samples the extreme citation tail and does not represent the average publication, total output, or full topic distribution of anesthesiology, surgery, or medicine. Because total WoS publication volume by field and decade was not retained, the proportion of each field's output represented by 1000 records could not be quantified. The title, abstract, Results, Discussion, and Conclusion have therefore been limited to the selected highly cited sample. Second, the WoS categories are journal-level assignments; journals may carry multiple categories, and journal-category searches do not capture all work by investigators in anesthesia departments. In particular, the full denominator needed to calculate the fraction of scientific articles in the ANE journals, after excluding letters and other non-article content, was unavailable. Chen et al. showed that subject-field and department-based datasets can produce different representations of anesthesiology, especially for pain-related research. Record-level overlap across datasets could not be re-quantified from the retained analysis materials [12]. Third, AAS was extracted at one date. Altmetric source coverage, weighting, and platform availability have changed over time, and older publications had different opportunities for attention to accumulate. AAS therefore should be interpreted as a cross-sectional attention indicator, not as a comparable four-decade growth measure. F [9,10] ourth, RCR and AAS have important limits: RCR measures citation influence relative to an expected rate and does not directly measure novelty, clinical importance, or research quality; AAS measures online attention, which can be affected by media interest, platform use, article type, language, open access, and changing scoring rules. Fifth, missing affiliations were handled by complete-case exclusion, and linkage denominators for PMID/iCite, DOI/AAS, affiliations, and keywords were not retained by field and decade. A study-flow table with these counts, as well as sensitivity analyses excluding reviews and testing alternative citation thresholds, could not be reconstructed from the analysis archive. Sixth, MetaMap version/configuration, preprocessing, ambiguous mapping rules, exact WoS search syntax, export logs, detailed model specifications, exact p-values, effect estimates, confidence intervals, diagnostics, and multiplicity adjustments were not retained. The entropy findings are therefore descriptive and exploratory. No causal interpretation should be drawn from the observed associations.

RCR reflects citation influence relative to an expected rate; it does not establish scientific novelty, clinical importance, or emerging findings. The present results describe differences within a selected highly cited sample and do not show that one discipline produces more important or meaningful research. Mechanisms involving topic diversity, collaboration, funding, journal visibility, training, or publication practices remain hypotheses for future studies.

7. Conclusions

In this selected sample of the 1000 most-cited English-language publications per decade from 1980–2019, MED showed higher RCR values across the study period, while

ANE and SUR did not show the same increase from their 1980s values. AAS differences are exploratory because scores were extracted at one date under historically changing coverage conditions. Funding, collaboration, journal distribution, and semantic measures varied across fields, but the observational design does not establish causal mechanisms or support recommendations to broaden topics or concentrate publications in particular journals. These findings should not be generalized to the full research output of any discipline. Future studies should use field-representative samples, retain complete linkage and analytic denominators, pre-specify models and multiplicity control, perform sensitivity analyses across document types and citation thresholds, and use standardized observation windows for online-attention measures.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/surgeries7040119/s1.

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Conflicts of Interest: The authors declare no conflicts of interest.

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