



Language and Geographic Representation of Neurosurgical Journals: A Meta-Science Study

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Key words

- Global health
- Global neurosurgery
- Global surgery
- Health disparities
- Health equity
- Neurological surgery
- Research equity

Abbreviations and Acronyms

AFR: African region
AMR: Americas region
APC: Article processing charge
EMR: Eastern Mediterranean region
EUR: European region
FIENS: Foundation for International Education in Neurological Surgery
GDP: Gross domestic product
HICs: High-income countries
IF: Impact factor
JCI: Journal citation indicator
LMICs: Low- and middle-income countries
PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses
SEAR: South-East Asian region
WFNS: World Federation of Neurosurgical Societies
WHO: World Health Organization
WPR: Western Pacific region

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Citation: *World Neurosurg.* (2022) 166:171–183.
<https://doi.org/10.1016/j.wneu.2022.08.006>

Journal homepage: www.journals.elsevier.com/world-neurosurgery

Available online: www.sciencedirect.com

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INTRODUCTION

Global neurosurgery is a rapidly growing subfield at the intersection of neurosurgery and public health focused on

■ **OBJECTIVE:** Medical journals have a role in promoting representation of neurosurgeons who speak primary languages other than English. We sought to characterize the language of publication and geographic origin of neurosurgical journals, delineate associations between impact factor (IF) and language and geographic variables, and describe steps to overcome language barriers to publishing.

■ **METHODS:** Web of Science, Scopus, and Ulrich's Serial Analysis system were searched for neurosurgery journals. The journals were screened for relevance. Language of publication, country and World Health Organization region, World Bank income status and gross domestic product, and citation metrics were extracted.

■ **RESULTS:** Of 867 journals, 74 neurosurgical journals were included. Common publication languages were English (52, 70.3%), Mandarin (5, 6.8%), and Spanish (4, 5.4%). Countries of publication for the greatest number of journals were the United States (23, 31.1%), United Kingdom (8, 10.8%), and China (6, 8.1%). Most journals originated from the Americas region (29, 39.2%), the European region (28, 37.8%), and from high-income countries ($n = 54$, 73.0%). Median IF was 1.55 (interquartile range [IQR] 0.89–2.40). Journals written in English (1.77 [IQR 1.00–2.87], $P = 0.032$) and from high-income countries (1.81 [IQR 1.0–2.70], $P = 0.046$) had highest median IF. When excluding outliers, there was a small but positive correlation between per capita gross domestic product and IF ($\beta = 0.021$, $P = 0.03$, $R^2 = 0.097$).

■ **CONCLUSIONS:** Language concordance represents a substantial barrier to research equity in neurosurgery, limiting dissemination of ideas of merit that currently have inadequate outlets for readership. Initiatives aimed at increasing the accessibility of neurosurgical publishing to underrepresented authors are essential.

increasing access to neurosurgical care worldwide.^{1–4} Organizations such as the World Federation of Neurosurgical Societies (1955) and the Foundation for International Education in Neurological Surgery (1969) have sought to improve neurosurgical education and care in low- and middle-income countries (LMICs).^{5–9} The modern field of global neurosurgery came to the forefront following the publication of the Lancet Commission on Global Surgery report and adoption of the World Health Organization Resolution WHA68.15 in 2015, both of which highlighted the need for access to safe, timely, and affordable surgical

care.^{10,11} Neurosurgeons, neurosurgical trainees, and medical students across the world have mobilized to identify and address the global burden of neurosurgical disease.^{12–19}

A core element of global neurosurgery is research. Research informs the pathway to increase access to neurosurgical care and reduce disparities globally.²⁰ Global neurosurgery-related publications have accelerated over time in the number and scholarly impact.^{21–23} Publications from LMICs have increased over time. At least 31 African countries were represented in neurosurgical journals between 1999 and 2018.²⁴ However, a major gap persists, such

Table 1. Search Methodology

Database	Search Parameter	Search String	Number of Journals
Web of Science	Category	WC=(“Clinical Neurology” OR “Neuroimaging” OR “Neurosciences”) AND WC=(“Surgery”)	167
	Research Area	SU=(“Neurosciences & Neurology” AND “Surgery”)	167
Scopus	Subject areas	SUBJTERMS(2728 OR 2800 OR 2801 OR 2802 OR 2804 OR 2805 OR 2806 OR 2807 OR 2808 OR 2728) AND SUBJTERMS(2746)	83
Ulrich’s	Subject area	Subject (Exact): Surgery (Medical Sciences) Subject (Exact): Psychiatry and Neurology (Medical Sciences)	148
	Subject area and keywords	Subject (Exact): Surgery (Medical Sciences) Keyword: “neuroscience” OR “neurology” OR “neuro”	302

that the majority of neurosurgical literature arises from North America or Europe.²⁴⁻²⁶ This is particularly worrisome when the subject under investigation occurs with greater frequency in LMICs than high-income countries (HICs). For example, Southeast Asian and Western Pacific regions experience the greatest burden of traumatic brain injury.²⁷ Within global neurosurgery in particular, most literature is published by researchers and institutions in HICs, while most LMIC research groups publish in collaboration with HIC institutions.²⁸ Language concordance and the related issue of geographic origin represent common challenges. While English is a “lingua franca” in academia and serves as the primary language for many journals, most LMICs are non-Anglophone and access to English language training may be scarce.²⁹ The concept of research equity, defined as the representation of authors across the globe through mitigation of socioeconomic factors that impact their ability to publish their work, has become increasingly discussed.

Existing studies have shown that articles published in English tend to be published in higher impact factor (IF) journals and have a greater number of citations than articles published in other languages when journal, year of publication, and paper length were controlled.²⁹⁻³² While investigators in other surgical specialties have performed studies related to language and geographic representation in relevant journals, no such data exists for neurosurgery.^{33,34} Accordingly, we performed a meta-science study to examine the language and geographic representation in neurosurgical journals.

We aimed to 1) characterize the language of publication and World Health Organization (WHO) region of peer-reviewed neurosurgical journals, 2) delineate associations between impact factor and language, geographic, and economic variables, and 3) describe steps to overcome language barriers to publishing in neurosurgery. This study will serve as a useful foundation for initiatives to promote research equity in neurosurgery and create a forum in which all concepts of merit to neurosurgery may be examined.

MATERIALS AND METHODS

Search

We carried out a meta-science study. A meta-science study is a hybrid study design that combines elements of multiple commonly utilized study designs.³⁵ The purpose of meta-science is to study the scientific process. This study included elements of a systematic review and cross-sectional examination. Since no reporting guideline exists for this study design, the Preferred Reporting Items for Systematic Reviews and Meta-Analyses 2020 guidelines were followed.^{36,37} Web of Science (Elsevier), Scopus (Elsevier), and Ulrich’s Serial Analysis System (ProQuest) were searched in September 2020. Two searches were conducted on Web of Science as follows: 1) categories of Clinical Neurology, Neuroimaging, Neurosciences, and Surgery, 2) research areas of Neurosciences & Neurology, Surgery. Scopus was searched for subject areas of Neurology (clinical), General Neuroscience, Neuroscience

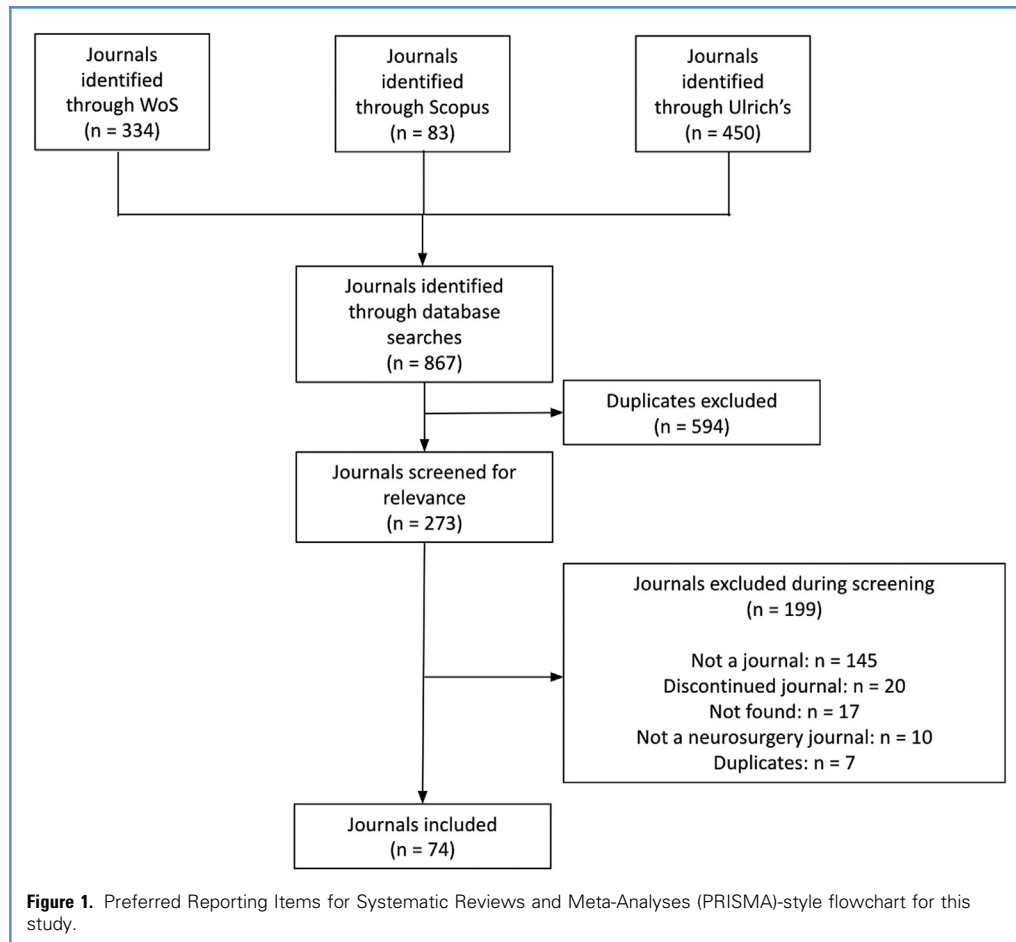
(miscellaneous), Behavioral Neuroscience, Cellular and Molecular Neuroscience, Cognitive Neuroscience, Developmental Neuroscience, Endocrine and Autonomic Systems, Neurology, Neurology (clinical), and Surgery. Two searches were conducted on Ulrich’s Serial Analysis System as follows: 1) subject alone, 2) subject and keywords. Full search methodology is displayed in **Table 1**. All database searches were conducted by librarians with specific training in database syntax and searches.

Screening

Following the search, journals were automatically reduplicated by one reviewer. Remaining journals were screened for relevance by 2 reviewers. Inclusion criteria were as follows: journals currently in publication, journals that are peer-reviewed journals focused on neurosurgery or sponsored by a neurosurgical society. The peer-review status was verified by examining the websites of the retrieved journals. Exclusion criteria were duplicates, other publication types (including textbooks, conference proceedings), discontinued journals, journals not focused on neurosurgery, and journals unable to be accessed for review due to the lack of a website or because their titles were listed in non-Anglophone characters on search engines. No journals were excluded on the basis of country. A third reviewer verified the screening decisions of the other reviewers.

Data Extraction

After the final set of included journals was finalized, the language of publication and country of origin as defined by the location



of the publisher of the journal were extracted from the journal website. Journals with translation options were categorized based on the stated language of publication on the website, rather than via the potential languages it may be translated into. The 2020 journal IF and journal citation indicator (JCI) were extracted from Journal Citation Reports (Clarivate Analytics). IF reflects the annual mean number of citations of articles published in a journal in the preceding 2 years.³⁸ The JCI is the average Category Normalized Citation Impact of citable items published by a journal over a recent 3-year period, with 1.0 denoted as the average in a given category. For each journal, the country of origin was classified into a WHO region. Additionally, for each journal, the gross domestic product (GDP) per capita and income status of the country of origin were obtained from the World Bank. Data were extracted by 2 reviewers, and discrepancies were resolved by consensus.

Data Analysis

Stata 14.1 was used for data analysis (Stata Corp, College Station, Texas, USA).

The language of each journal was analyzed using descriptive statistics. Tableau Public (Tableau Software, Inc, Mountain View, California, USA) was used to create a geographic density map of journals by WHO Region. Kruskal–Wallis one-way analysis of variance test was used for comparisons of IF based on language, WHO region and World Bank Income Status. A linear regression was used to assess the relationship between IF and GDP per capita. Statistical significance was defined as $P < 0.05$.

RESULTS

Language and Geographic Journal Distribution

Of 867 resultant journals, 74 neurosurgical journals were included (Figure 1). The most

common publication languages were English (52, 70.3%), Mandarin (5, 6.8%), Spanish (4, 5.4%), German (2, 2.7%) and Japanese (2, 2.7%). Three (4.1%) of the journals were published in multiple languages (1 English/Japanese, 1 Czech/Slovak, 1 Ukrainian/Russian) (Figure 2). Five (6.8%) journals published abstracts in a second language in addition to the primary language of publication. Countries of publication for the greatest number of journals were the United States (23, 31.1%), United Kingdom (8, 10.8%), China (6, 8.1%), Germany (4, 5.4%), and Japan (4, 5.4%). The majority of journals originated from the Americas region (AMR) (29, 39.2%) and the European region (EUR) (28, 37.8%). Meanwhile, 12 (16.2%) of the journals originated from the Western Pacific region (12, 16.2%), 3 (4%) from the Eastern Mediterranean region, and 2 (2.7%) from the South-East Asian region (Figure 3). There were no neurosurgical journals from the African region retrieved

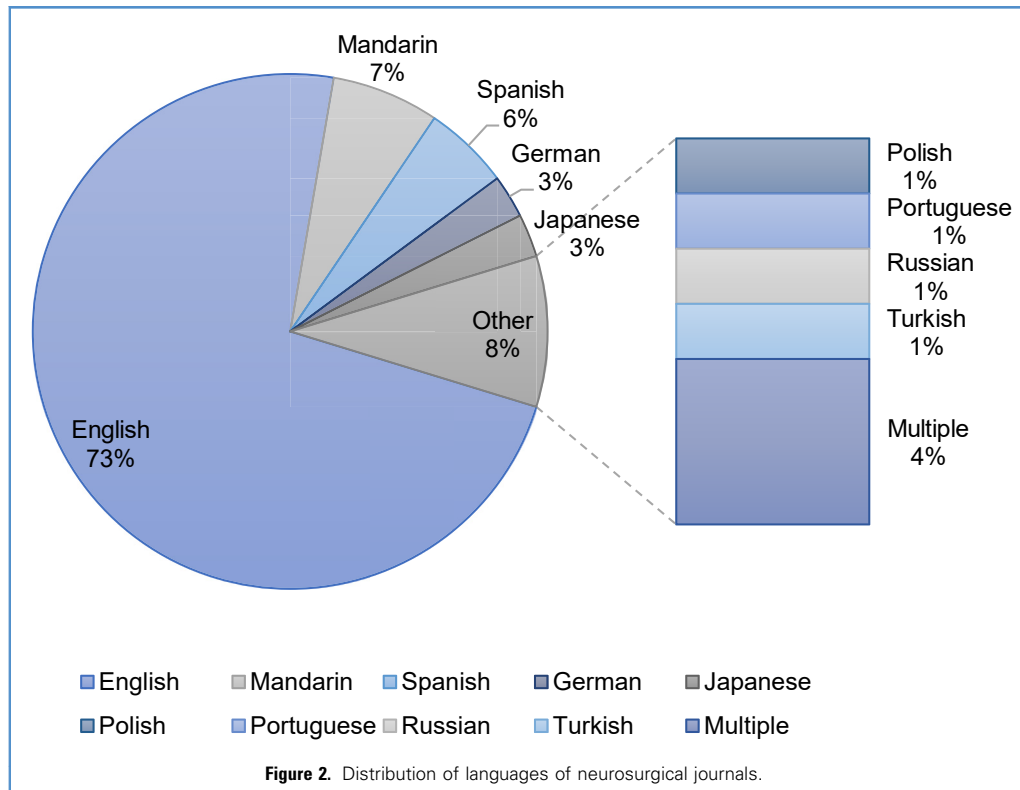


Figure 2. Distribution of languages of neurosurgical journals.

at the time of the search. Most journals originated from high-income countries ($n = 54$, 73.0%), followed by upper middle-income countries ($n = 14$, 18.9%) and finally lower middle-income countries ($n = 6$, 8.1%). **Table 2** provides all included journals.

Associations with Impact Factor

Of the 74 neurosurgical journals included, 51 had a published IF. The median IF was 1.55 (interquartile range [IQR] 0.89–2.40). Journals written in English had the highest median IF (1.77 [IQR 1.00–2.87]). Journals written in Polish, Portuguese, Russian, Turkish and 3 journals published in multiple languages were grouped together under the “other” category and had a median IF of 1.27 [IQR 0.38–1.81]. Journals written in Spanish, German and Japanese all had median impact factors less than 1 (IF = 0.55 [IQR 0.55–0.55], 0.10 [IQR 0.05–0.14], and 0.06 [IQR 0.06–0.06], respectively). Although there were 5 journals written in Mandarin, none had a published IF. There was a statistically significant difference in the IF of the journal based on the language of publication ($P = 0.032$) (**Table 3**).

When comparing median IF across WHO regions, there was no statistically significant difference in the IF of the journal based on the WHO region of publication (**Table 3**). Journals published within the AMR had a median IF 2.12 (IQR 0.95–3.64), and journals published within the EUR had a median IF of 1.43 (IQR 1.00–2.18). Journals published within the South-East Asian region, Western Pacific region, and Eastern Mediterranean region all had an IF close to 1 (1.05 [IQR 0.98–1.12], 1.04 [IQR 1.21–1.81], and 0.77 [IQR 0.77–77], respectively). The African region had no published neurosurgical journals.

Journals published by HICs had a higher median IFs (1.81 [IQR 1.0–2.70]), compared to upper middle-income countries (IF: 0.29 [0.21–1.00]), and LMICs (IF: 0.98 [IQR 0.77–1.12]) and this difference was statistically significant ($P = 0.046$) (**Table 3**).

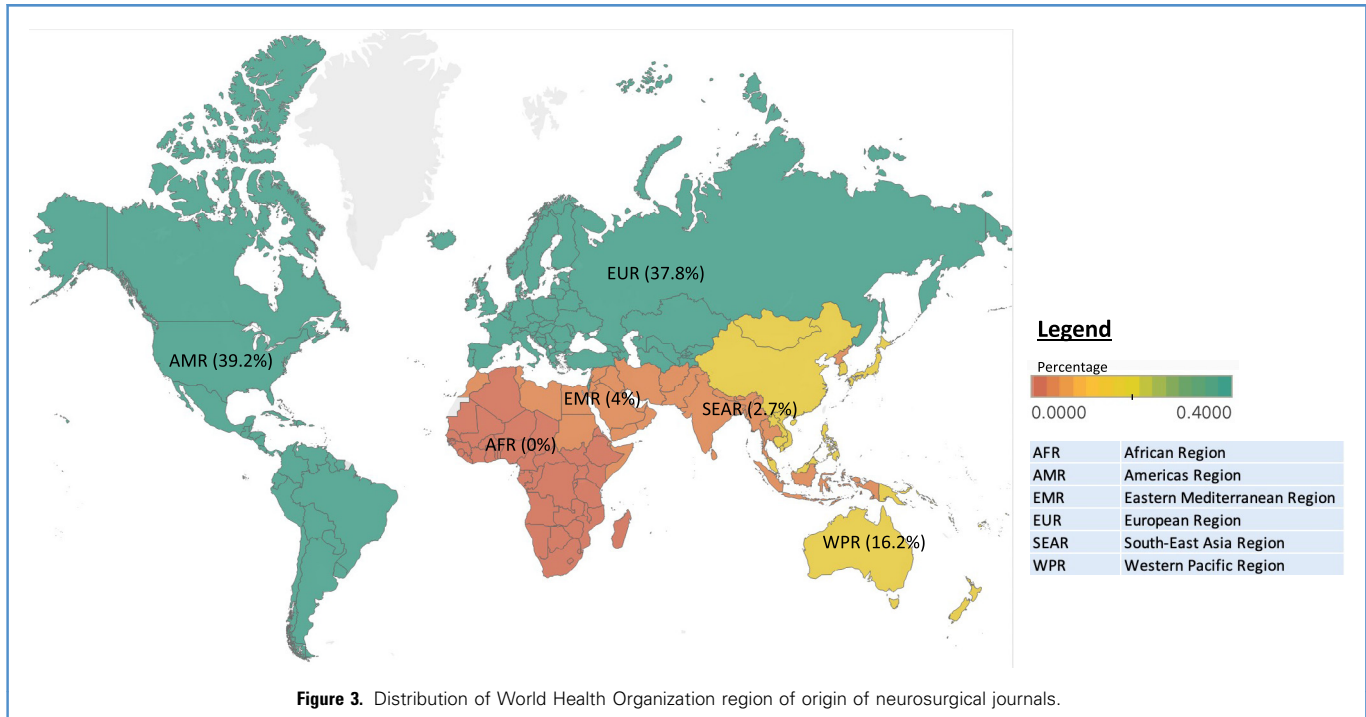
Regression Analysis

A linear regression analysis was performed to study the association between GDP per

capita of a journal’s country of publication and IF. When excluding 2 outliers, there was a small but statistically significant positive correlation between GDP per capita and journal IF ($\beta = 0.021$, $P = 0.03$, $R^2 = 0.097$) (**Figure 4**).

DISCUSSION

Research plays an essential role in global neurosurgery by characterizing the burden of neurosurgical disease and associated disparities, identifying the socioeconomic implications of these factors, and generating strategies to increase access to neurosurgical care.²⁰ Existing studies have focused on representation of authors from LMICs in the neurosurgical literature.²⁵ However, authorship representation depends on both production of high-quality research by investigators and the accessibility of journals. No previous study within neurosurgery has focused on the characteristics of journals for publication. We characterized the language and geographic origin of neurosurgical journals to shed light on disparities in



neurosurgical publishing and inform initiatives to promote research equity in neurosurgery.

Language and Geographic Distribution of Neurosurgical Journals

Our study found that over two-thirds of neurosurgical journals were published in English; an expected finding gave English as the “lingua franca” in biomedical research.³⁹ In fact, the databases examined for this study are dominated by English language journals, although Scopus has greater non-English coverage compared to Web of Science.⁴⁰ Mandarin and Spanish are the second- and third-most commonly represented languages among journals available in Scopus and Web of Science, which was congruent with the findings of this study.⁴⁰ Unsurprisingly, United States and United Kingdom were the countries of origin and AMR and EUR were the WHO regions of origin for the greatest number of neurosurgical journals. However, only 41.9% of journals originated from the United States or United Kingdom, while 77.0% of journals originated from AMR or EUR. The discrepancy suggests that many journals published in English originate from countries where the primary language is not English to adapt to the

predominance of English in biomedical research. Our findings regarding language and geographic origin parallel the results of larger-scale scientometric studies examining Web of Science and Scopus in general.^{40,41} Strikingly, there were no dedicated neurosurgery journals published by countries within the African region. However, it is important to note that surgical journals, such as the East and Central African Journal of Surgery, which may publish neurosurgical articles, were excluded because they did not focus on neurosurgery. Additionally, the search was conducted prior to the establishment of the *Egyptian Journal for Neurosurgery* in the latter half of 2021.⁴² The search was also conducted prior to formalization of the *Journal of Global Neurosurgery*, an online open access journal with no article processing charge (APC) focused on ensuring equitable access to global neurosurgery research and research capacity for all individuals involved in neurosurgery that publishes articles in English.⁴³

Unraveling the Relationship Between Journal-Level and Author-Level Research Equity

Research equity occurs when authors are adequately represented and is, in part,

influenced by the availability of journals to feature their work given language and socioeconomic factors. Undoubtedly, the representation of authors is intrinsically tied to the demographics of the journals to which they submit their manuscripts.²⁴⁻²⁶ However, the relationship is more complex than might be assumed initially. A previous scientometric study has indicated a critical caveat that countries publishing the highest volume of scientific journals may not be the highest volume producers of manuscripts.⁴¹ For example, the Netherlands is the country of origin for 7% of all journals, yet the country publishes only 2% of scientific manuscripts.⁴¹ Meanwhile, although 2% of all journals originate from China, the country publishes 15% of all articles.⁴¹

In conjunction with the results of previous studies, our study validates these findings in the neurosurgical literature.^{25,44} More importantly, our study implies that the language of publication of a journal, rather than its geographic origin, may be key in increasing scholarly impact of publications. Although language of publication and geographic origin both depend on the journals' publisher, journals based in non-Anglophone countries are often published in English. Research equity also

Table 2. Included Journals

Journal Name	Language	Country	WHO Region	World Bank Income Status	GDP (in US Million)	GDP (per Capita, in US \$)	GDP (per Capita, in Thousands US \$)	JIF 2020 (JCR)	JCI	Impact Factor	Comments
Revista Argentina de Neurocirugia (The Argentine Journal of Neurosurgery)	Spanish	Argentina	AMR	UMIC	383,066	8441.90	8.44				
Revista de Neurocirugia (Journal of Neurosurgery)	Spanish	Argentina	AMR	UMIC	383,066	8441.90	8.44				
Acta Neurochirurgica	English	Austria	EUR	HIC	428,965.40	48,105.40	48.11	2.216	0.68	1.834	
Journal Fur Neurologie Neurochirurgie Und Psychiatrie	German	Austria	EUR	HIC	428,965.40	48,105.40	48.11			0.054	
Brazilian Neurosurgery	English	Brazil	AMR	UMIC	1,444,733.26	6796.80	6.80		0.04		abstracts also in Portuguese
Coluna Columna	English	Brazil	AMR	UMIC	1,444,733.26	6796.80	6.80			0.29	abstracts also in Spanish and Portuguese
Seara Medica Neurocirurgica	Portuguese	Brazil	AMR	UMIC	1,444,733.26	6796.80	6.80				
Revista Chilena de Neurocirugia (The Chilean Journal of Neurosurgery)	Spanish	Chile	AMR	HIC	252,940.02	13,231.70	13.23				
Chinese Journal Of Neurosurgery	Mandarin	China	WPR	UMIC	14,722,730.70	10,500.40	10.50				abstracts also in English
Chinese Neurosurgical Journal	English	China	WPR	UMIC	14,722,730.70	10,500.40	10.50			0.21	
Linchuang Shenjing Waike Zazhi	Mandarin	China	WPR	UMIC	14,722,730.70	10,500.40	10.50				
Liti Dingxiang he Gongnengxing Shenjing Waike Zazhi	Mandarin	China	WPR	UMIC	14,722,730.70	10,500.40	10.50				
Zhongguo Wei Qinxu Shenjing Waike Zazhi (Chinese Journal of Minimally Invasive Neurosurgery)	Mandarin	China	WPR	UMIC	14,722,730.70	10,500.40	10.50				
Zhonghua Shenjing Chuangshang Waike Dianzi Zazhi (Chinese Electronic Journal of Neurotraumatic Surgery)	Mandarin	China	WPR	UMIC	14,722,730.70	10,500.40	10.50				
Ceska a Slovenska Neurologie a Neurochirurgie	Czech, Slovak, English	Czech Republic, Slovakia	EUR	HIC	243,530.38	22,762.20	22.76	0.35	0.1	0.377	
The Egyptian Journal of Neurosurgery	English	Egypt	EMR	LMIC	363,069.25	3547.90	3.55				
Neurochirurgie	English	France	EUR	HIC	2,603,004.40	38,625.10	38.63	1.553	0.4	1.553	
Childs Nervous System	English	Germany	EUR	HIC	3,806,060.14	45,723.60	45.72	1.475	0.5	1.298	

European Spine Journal	English	Germany	EUR	HIC	3,806,060.14	45,723.60	45.72	3.134	0.93	3.134	summaries also in French
Journal Of Neurological Surgery Part A Central European Neurosurgery	English	Germany	EUR	HIC	3,806,060.14	45,723.60	45.72	1.268	0.38	1.268	
Neurosurgical Review	English	Germany	EUR	HIC	3,806,060.14	45,723.60	45.72	3.042	0.92	3.042	
Journal Of Craniovertebral Junction And Spine	English	India	SEAR	LMIC	2,622,983.73	1900.70	1.90		0.45	0.98	
Surgical Neurology International	English	India	SEAR	LMIC	2,622,983.73	1900.70	1.90			1.12	
Iranian Journal of Neurosurgery	English	Iran	EMR	LMIC	191,718.27	2282.60	2.28				
Journal Of Neurosurgical Sciences	English	Italy	EUR	HIC	1,886,445.27	31,676.20	31.68	2.279	0.44	1.645	
Japanese Journal Of Neurosurgery	Japanese	Japan	WPR	HIC	5,064,872.88	40,113.10	40.11			0.062	abstracts in Japanese
Neurologia Medico Chirurgica	English & Japanese	Japan	WPR	HIC	5,064,872.88	40,113.10	40.11	1.742	0.52	1.807	
No Shinkei Geka Neurological Surgery	Japanese	Japan	WPR	HIC	5,064,872.88	40,113.10	40.11				
Spine Surgery And Related Research	English	Japan	WPR	HIC	5,064,872.88	40,113.10	40.11		0.26	0.89	
Clinical Neurology And Neurosurgery	English	Netherlands	EUR	HIC	912,242.34	52,304.10	52.30	1.876	0.56	1.876	
Interdisciplinary Neurosurgery	English	Netherlands	EUR	HIC	912,242.34	52,304.10	52.30		0.09	0.36	
Neurologia I Neurochirurgia Polska	Polish	Poland	EUR	HIC	594,164.69	15,656.20	15.66	1.621	0.36	1.27	
Romanian Neurosurgery	English	Romania	EUR	HIC	248,715.55	12,896.10	12.90				
Zhurnal Voprosy Neirokhirurgii im. NN Burdenko	Russian	Russia	EUR	UMIC	1,483,497.78	10,126.70	10.13				
Journal Of Korean Neurosurgical Society	English	South Korea	WPR	HIC	1,630,525.01	31,489.10	31.49	1.729	0.48	1.187	
Neurospine	English	South Korea	WPR	HIC	1,630,525.01	31,489.10	31.49	3.492	0.91	2.364	
Neurocirugia	Spanish	Spain	EUR	HIC	1,281,199.09	27,057.20	27.06	0.553	0.17	0.553	
Radiosurgery (Journal of Radiosurgery and SBRT)	English	Spain	EUR	HIC	1,281,199.09	27,057.20	27.06		0.49	1.05	
Stereotactic And Functional Neurosurgery	English	Switzerland	EUR	HIC	747,968.64	86,601.60	86.60	1.875	0.46	1.875	
Swiss Archives of Neurology, Psychiatry and Psychotherapy	German	Switzerland	EUR	HIC	747,968.64	86,601.60	86.60			0.143	
AMR, American Region; EMR, Eastern Mediterranean Region; EUR, European Region; GDP, gross domestic product; HIC, high-income country; JCI, journal citation index; JIF, journal impact factor; LMIC, lower middle-income country; SEAR, Southeast Asian Region; USA, United States of America; UMIC, upper middle income country; WPR, Western Pacific Region; WHO, World Health Organization.											
Continues											

Table 2. Continued

Journal Name	Language	Country	WHO Region	World Bank Income Status	GDP (in US Million)	GDP (per Capita, in US \$)	GDP (per Capita, in Thousands US \$)	JIF 2020 (JCR)	JCI	Impact Factor	Comments
Türk Norosirurji Dergisi (Turkish Journal of Neurosurgery)	Turkish	Turkey	EUR	UMIC	720,101.21	8538.20	8.54				
Turkish Neurosurgery	English	Turkey	EUR	UMIC	720,101.21	8538.20	8.54	1.003	0.35	1.003	
British Journal Of Neurosurgery	English	UK	EUR	HIC	2,707,743.78	40,284.60	40.28	1.596	0.44	1.29	
Concussion	English	UK	EUR	HIC	2,707,743.78	40,284.60	40.28			1	
Egyptian Journal Of Neurology Psychiatry And Neurosurgery	English	UK	EMR	LMIC	2,707,743.78	40,284.60	40.28		0.15	0.77	
Journal Of Clinical Neuroscience	English	UK	EUR	HIC	2,707,743.78	40,284.60	40.28	1.961	0.42	1.961	
Journal Of Neurointerventional Surgery	English	UK	EUR	HIC	2,707,743.78	40,284.60	40.28			5.836	
Journal Of Neurology Neurosurgery And Psychiatry	English	UK	EUR	HIC	2,707,743.78	40,284.60	40.28	10.154	2.59	10.154	
Neuro Oncology	English	UK	EUR	HIC	2,707,743.78	40,284.60	40.28	12.3	2.5	12.3	
Neurological Research	English	UK	EUR	HIC	2,707,743.78	40,284.60	40.28	2.448	0.69	2.401	
Ukrains'kyi Neirokhirurhichnyi Zhurnal (Ukrainian Journal of Neurosurgery)	Ukrainian, Russian, English	Ukraine	EUR	LMIC	155,582.01	3726.90	3.73				
Clinical Spine Surgery	English	USA	AMR	HIC	20,936,600.00	63,543.60	63.54	1.876	0.58	1.72	
Contemporary Neurosurgery	English	USA	AMR	HIC	20,936,600.00	63,543.60	63.54				
Indian Journal of Neurosurgery	English	USA	AMR	HIC	20,936,600.00	63,543.60	63.54		0.06		
Journal Of Neurological Surgery Part B Skull Base	English	USA	AMR	HIC	20,936,600.00	63,543.60	63.54	1.826	0.44	1.826	
Journal Of Neurological Surgery Reports	English	USA	AMR	HIC	20,936,600.00	63,543.60	63.54		0.16	0.367	
Journal Of Neuroscience Nursing	English	USA	AMR	HIC	20,936,600.00	63,543.60	63.54	1.23	0.55	0.945	
Journal Of Neurosurgery	English	USA	AMR	HIC	20,936,600.00	63,543.60	63.54	5.115	1.77	5.115	
Journal Of Neurosurgery Pediatrics	English	USA	AMR	HIC	20,936,600.00	63,543.60	63.54	2.375	0.88	2.375	
Journal of Neurosurgery Research and Reviews	English	USA	AMR	HIC	20,936,600.00	63,543.60	63.54				
Journal Of Neurosurgery Spine	English	USA	AMR	HIC	20,936,600.00	63,543.60	63.54	3.602	1.13	3.602	
Journal Of Neurosurgical Anesthesiology	English	USA	AMR	HIC	20,936,600.00	63,543.60	63.54	3.956	1.04	3.956	
Journal of Spine & Neurosurgery	English	USA	AMR	HIC	20,936,600.00	63,543.60	63.54			0.22	
Journal Of Stroke And Cerebrovascular Diseases	English	USA	AMR	HIC	20,936,600.00	63,543.60	63.54	2.136	0.48	2.136	

Neurosurgery	English	USA	AMR	HIC	20,936,600.00	63,543.60	63.54	4,654	1.64	4,654
Neurosurgery Cases and Reviews	English	USA	AMR	HIC	20,936,600.00	63,543.60	63.54			
Neurosurgery Clinics Of North America	English	USA	AMR	HIC	20,936,600.00	63,543.60	63.54	2,509	0.86	0.682
Neurosurgery Open	English	USA	AMR	HIC	20,936,600.00	63,543.60	63.54			
Neurosurgical Focus	English	USA	AMR	HIC	20,936,600.00	63,543.60	63.54	4,047	1.21	3.642
Neurosurgical Focus: Video	English	USA	AMR	HIC	20,936,600.00	63,543.60	63.54			
Operative Neurosurgery	English	USA	AMR	HIC	20,936,600.00	63,543.60	63.54	2,703	0.81	2.703
Pediatric Neurosurgery	English	USA	AMR	HIC	20,936,600.00	63,543.60	63.54	1,162	0.37	1.162
Spine Journal	English	USA	AMR	HIC	20,936,600.00	63,543.60	63.54	4,166	1.28	4.166
World Neurosurgery	English	USA	AMR	HIC	20,936,600.00	63,543.60	63.54	2,104	0.63	2.104

AMR, American Region; EMR, Eastern Mediterranean Region; EUR, European Region; GDP, gross domestic product; HIC, high-income country; JCI, journal citation index; JIF, journal impact factor; LMIC, lower middle-income country; SEAR, Southeast Asian Region; USA, United States of America; UMIC, upper middle income country; WPR, Western Pacific Region; WHO, World Health Organization.

extends to scientific impact. In our study, journals published in English and arising from HICs had the highest IF, and GDP was an independent predictor of IF.

Similarly, the role of article open access journals is important to examine. Open access journals are freely accessible to all at the time of publication, mitigating expensive subscription charges for a single download or annual fee, but at a cost to the author through APCs.⁴⁵ The number of open access journals has increased over time.⁴⁶ As many as 94% of APCs are paid to journals owned by the 10 most prominent publishers in HICs.⁴⁷ The APC for a single article may be greater than the average yearly income of an individual in an LMIC.⁴⁸ As many as 70% of all journals provide APCs waivers to authors in LMICs.^{49,50} However, investigators from LMICs are rarely in a position to publish their work if the waivers are partial and often cannot access other grant funding to cover APCs.^{45,51} As a result, APCs may exclude LMIC researchers from publishing their research. Given most open access journals are published in English,⁵² language and financial barriers may interact to promote research inequity. The proliferation of predatory open access journals and their indexing on reputable databases complicate the issue further.⁵³⁻⁵⁶

Our findings point to a particularly detrimental cycle of research inequity. Neurosurgical researchers from non-Anglophone regions/LMICs may be less likely than individuals from Anglophone regions/HICs to publish their work in English language journals, particularly when APCs are involved, reducing the visibility and impact of their work. In turn, this affects the researchers' opportunity to obtain further funding to carry out subsequent studies, decreases the opportunity for academic promotion, and reduces the likelihood of academic collaboration with other institutions.

Overcoming Language Barriers in Neurosurgical Research

A lack of language concordance represents a substantial obstacle to research equity. However, there are potential journal-level strategies to overcome this barrier. One broad strategy is catalyzing the establishment of neurosurgical

Table 3. Median Impact Factor, Stratified by Language, World Health Organization (WHO) Region and World Bank Income Status

Impact Factor (Median [IQR])		P-Value
Language		
English	1.77 [1.00–2.87]	P = 0.032
Mandarin	N/A	
Spanish	0.55 [0.55–0.55]	
German	0.10 [0.05–0.14]	
Japanese	0.06 [0.06–0.06]	
Other	1.27 [0.38–1.81]	
WHO Region		
Africa (AFR)	N/A	P = 0.291
Americas (AMR)	2.12 [0.95–3.64]	
Eastern Mediterranean (EMR)	0.77 [0.77–0.77]	
European (EUR)	1.43 [1.00–2.18]	
South-East Asia (SEAR)	1.05 [0.98–1.12]	
Western Pacific (WPR)	1.04 [1.21–1.81]	
World Bank Income Status		
HIC	1.81 [1.0–2.70]	P = 0.046
UMIC	0.29 [0.21–1.00]	
LMIC	0.98 [0.77–1.12]	
IQR, Interquartile range; WHO,World Health Organization; AMR, American Region; EMR, Eastern Mediterranean Region; EUR, European Region; LMIC, lower middle-income country; SEAR, Southeast Asian Region; UMIC, upper middle income country; WPR,Western Pacific Region.		
N/A: no impact factors available for these journals.		

journals that are language concordant with most researchers who will submit their articles to these journals. Notably, this approach does not address issues of impact. Another broad strategy is to translate articles into other languages following publication, either in written or audio form. A few of the journals included in our study were published in multiple languages, though these journals only provided abstracts in languages other than their primary language. The online open access *Journal of Global Neurosurgery*, which was established following our search and has no APC, publishes abstracts in Spanish, French, and Portuguese as well.⁴³ Similarly, *Neurosurgery* features the Neurosurgery Speaks initiative, in which native speakers translate and provide audio abstracts in as many as 11 languages.⁵⁷ A third broad strategy is to provide mechanisms to assist with English language writing or editing to

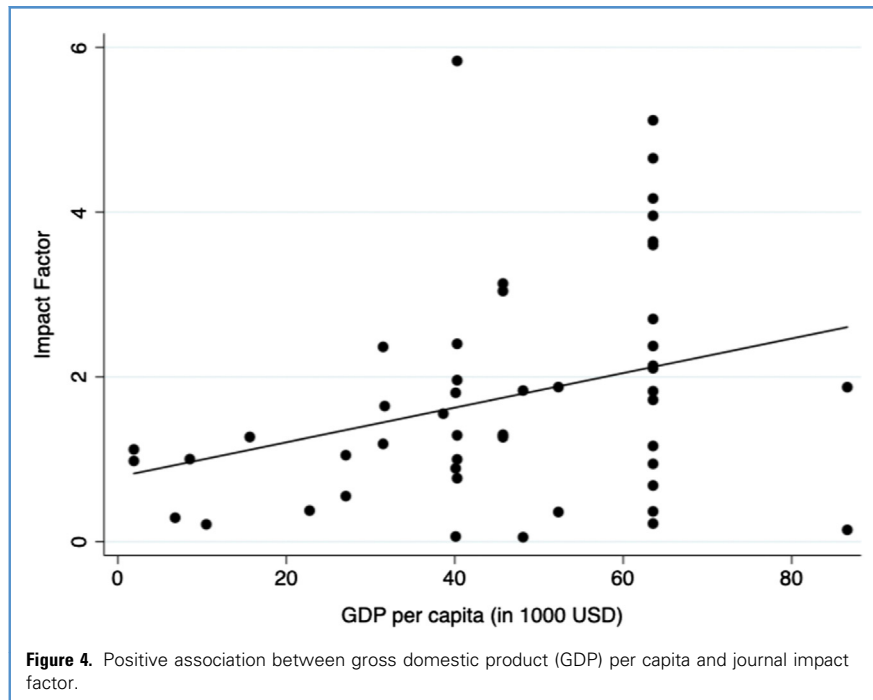
non-Anglophone authors, inherently requiring recognition of English as the “lingua franca” in biomedical research. Some publishers offer translation services, although they tend to be costly and exceed the budgets of researchers from low-resource settings. Of note, *World Neurosurgery* has recently established the Global Champions Program, in which an international board composed of medical students and trainees with senior consultant supervision provide English language editing suggestions for articles with scientific merit that were rejected by primary reviewers based on poor English language. This novel program is under the direction of a board-certified academic neurosurgeon who serves as the section editor. The first-year experience with this pilot program will be described later this year.

Furthermore, it is important to consider the role of translation technologies and artificial intelligence in increasing the

number of publications from non-Anglophone countries. Natural language processing is a collection of computation techniques for automated analysis and representation of language and combines the expertise of linguists, computer scientists, and statisticians.⁵⁸ Natural language understanding, viewed as an extension of natural language processing, requires a deeper understanding of natural language by machines.⁵⁸ Translation technologies seek to mobilize natural language processing and understanding. Generally, literature from other medical specialties indicates that translation technologies are somewhat accurate, albeit only for select languages.^{59,60} However, existing studies have been limited to simple and short dialogues.^{61,62} In total, performance of translation technologies is usually superior for simple, less technical sentences and when English is translated into Western European languages.⁶³ This latter aspect is unsurprising given the concordance between English and Western European languages in alphabet and some aspects of grammar. Additionally, some involve problematic methodologies such as back translations that may distort the nature of errors and obscure their root causes.^{61,64} At present, human correction with preediting and postediting is necessary to ensure accurate translations.⁶³ Although existing artificial intelligence-based translation technologies are not ready for clinical use, they may represent a sustainable option for reducing research disparities based on language in the future. Ideally, these technologies will have the capacity to translate complex sentences from languages with varying alphabets, syntaxes, and grammar.

Limitations

This study has limitations. Some journals could not be accessed for review. It is likely that these journals originated from non-Anglophone countries and/or LMICs, perhaps overestimating the proportion of neurosurgical journals originating from Anglophone countries and/or HICs. Of note, Scopus and Web of Science have been demonstrated to overrepresent English language journals.⁴¹ However, for that reason, we used Ulrich’s database,



which is widely considered the most comprehensive list of journals worldwide.⁴¹ Additionally, some journals had abstracts published in languages different from the primary journal language. Our study did not account for this because only the primary language of the journal was extracted, which may have underestimated the accessibility of neurosurgical research to non-Anglophone researchers. A total of 6.8% of journals included in our study published abstracts in another language in addition to the primary language of publication. However, publication of abstracts in languages other than the primary language is often not sufficient for researchers to utilize articles as references in designing their studies or presenting their findings. Country of origin of the journal may not necessarily represent the distribution of countries represented by authors. Additionally, data on journal IF or JCI was missing for some journals, perhaps reducing the validity of the associations reported. Moreover, the use of IF as a measure for journal quality has been controversial, particularly given IF may be manipulated by journals.^{65,66} However, IF

remains the most commonly utilized indicator of journal quality and is generally viewed as valid among physicians.⁶⁷ Despite these limitations, this meta-science study provides a comprehensive, methodologically rigorous investigation of language and geographic distribution of journals within neurosurgery.

CONCLUSIONS

The majority of neurosurgical journals is published in English and arises from the American and European WHO regions and from high-income countries. Journals published in English and arising from high-income countries have higher impact factors. Given language concordance represents a substantial barrier to research equity in neurosurgery, initiatives aimed at increasing the accessibility of neurosurgical publishing to underrepresented authors is essential. This may improve the free exchange of ideas despite language barriers and highlight novel practices from underrepresented regions. Additionally, the adaptation of the medical community to languages spoken by large segments of

the global population and the growing utility of artificial intelligence must be considered in the continual improvement process of neurosurgical publications.

ACKNOWLEDGMENTS

We thank Laura Abate, MLIS, for her valuable insights in reviewing our manuscript.

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Conflict of interest statement: The authors declare that the article content was composed in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Received 10 May 2022; accepted 1 August 2022

Citation: World Neurosurg. (2022) 166:171-183.
<https://doi.org/10.1016/j.wneu.2022.08.006>

Journal homepage: www.journals.elsevier.com/world-neurosurgery

Available online: www.sciencedirect.com

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