An analysis of cross-continental scholarship requirements during neurosurgical training and national research productivity

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OBJECTIVE Engagement in research and scholarship is considered a hallmark of neurosurgical training. However, the participation of neurosurgical trainees in this experience has only recently been analyzed and described in the United States, with little, if any, data available regarding the research environment in neurosurgical training programs across the globe. Here, the authors set out to identify requirements for research involvement and to quantify publication rates in leading neurosurgical journals throughout various nations across the globe.

METHODS The first aim was to identify the research requirements set by relevant program-accrediting and/or board-certifying agencies via query of the literature and published guidelines. For the second part of the study, the authors attempted to determine each country's neurosurgical research productivity by quantifying publications in the various large international neurosurgical journals—*World Neurosurgery*, *Journal of Neurosurgery*, and *Neurosurgery*—via a structured search of PubMed.

RESULTS Data on neurosurgical training requirements addressing research were available for 54 (28.1%) of 192 countries. Specific research requirements were identified for 39 countries, partial requirements for 8, and no requirements for 7. Surprisingly, the authors observed a trend of increased average research productivity with the absence of designated research requirements, although this finding is not unprecedented in the literature.

CONCLUSIONS A variety of countries of various sizes and neurosurgical workforce densities across the globe have instituted research requirements during training and/or prior to board certification in neurosurgery. These requirements range in intensity from 1 publication or presentation to the completion of a thesis or dissertation and occur at various time points throughout training. While these requirements do not correlate directly to national research productivity, they may provide a foundation for developing countries to establish a culture of excellence in research.

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KEYWORDS neurosurgical trainee research; global neurosurgery; neurosurgery education

ENGAGEMENT in research and scholarship is considered a hallmark of neurosurgical training. This academic pursuit is fundamental to the advancement of the field. However, the participation of neurosurgical trainees in this experience has only recently been analyzed and described in the United States,^{18,19} with little, if any, data available regarding the research environment in neurosurgical training programs across the globe.

Throughout the United States, participation in research during neurosurgical training is nearly universal, despite a lack of explicit requirements set by residency-accrediting

organizations and board-certifying agencies.^{1,3,19} A recent analysis of 1506 residents in 117 distinct neurosurgical training programs identified the average productivity of individual residents as 5 publications in total, with 3 published during residency.¹⁹ Moreover, one's involvement in neurosurgical research typically begins early, with 1st-year residents averaging at least 1 publication prior to the start of residency.¹⁸ This is likely attributable to both the academic nature of neurosurgery as a specialty and the high value placed on applicant involvement in research by residency program directors. Indeed, according to data

ABBREVIATIONS COSECSA = College of Surgeons of East, Central and Southern Africa; JRAAC = Joint Residency Advisory and Accreditation Committee; WFNS = World Federation of Neurosurgical Societies.

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presented by the National Resident Match Program, neurological surgery ranked as the highest in mean number of abstracts, presentations, and publications among allopathic seniors who matched into the specialty in 2018.²⁴ One of the most significant factors in determining the productivity of these trainees is the extent of support offered by their institutions. Institutions can foster supporting educational environments via the provision of protected research time, funding, medical editorial assistance, and travel stipends.¹⁹ In fact, the lack of protected time and institutional resources, including training in research design and conduct, has been identified as one of the greatest barriers to research involvement among physicians in various specialties.^{9,21} Notably, however, a program's designation of a "research requirement" was not shown to have a significant impact on departmental productivity in the large neurosurgery resident cohort mentioned above. Authors of that study reasoned that research is engrained in the culture of many of the highly productive programs and does not require formal designation, while programs with an explicit requirement may be in the early stages of such a culture change.¹⁹

The translation of these findings to the global arena of neurosurgery is unclear and likely influenced by various country- or region-specific factors including socioeconomic status, density of neurosurgeons, and research infrastructure and support. At present, there is limited literature on identifying and evaluating research requirements during neurosurgical training in nations outside of North America. In an important study focused on identifying requirements for neurosurgery certification across the globe, Gasco et al. reported that 3.8% of responding international societies require involvement in a research project, with publication, prior to oral examination eligibility.¹⁵ However, this analysis was limited to member societies of the World Federation of Neurosurgical Societies (WFNS) and did not explore in depth the impact of the requirement, nor other factors on research productivity in the responding countries. In appreciation of the great value of participation in the pursuit of knowledge via research and/or scholarship, our group has set out to identify research requirements established by relevant accrediting and/or certifying bodies across the globe. Additionally, we seek to understand how these requirements correspond to productivity.

Methods

Data Extraction

A list of countries was compiled from the WFNS Global Neurosurgical Workforce Map (<https://www.wfns.org/menu/61/global-neurosurgical-workforce-map>). Our first aim was to identify research requirements set by relevant program-accrediting and/or board-certifying agencies within each country. This search was conducted using a general query of Google and the PubMed database to obtain the above described information from agency/society guidelines and previously reported literature. Search terms for these queries included various combinations of the country name AND "neurosurgery" AND "residency" OR "training" OR "education" AND "research."

These queries returned results including websites of national/regional neurosurgical certification organizations and previously published scholarly literature, which facilitated our determination of research requirements during training. Required research was defined as any compulsory research activity during residency, such as mandatory publications, presentations, thesis/dissertation, or research time. Explicit requirements including number of publications and/or presentations, when listed, were recorded for analysis. Undefined scholarly requirements were excluded from our analysis.

For the second part of the study, we aimed to determine each country's neurosurgical research productivity, which was assessed by quantifying a given country's publications in the various large international neurosurgical journals: *World Neurosurgery*, *Journal of Neurosurgery*, and *Neurosurgery*. These data were collected by performing a query of the PubMed database using the name of each country as the term in the "affiliation" search field in combination with the title of each journal in the "journal" search field. Our final PubMed query was as follows: "<journal>[Journal] AND "<country>[Affiliation]" with no restriction on time.

Data Analysis

We performed a descriptive analysis of the research requirements and productivity across the countries for which data were available. These countries were grouped into 3 categories based on the nature of their requirements: 1) no stated requirement; 2) partial requirement, defined as a guideline lacking explicit details and/or only requiring education on research methodology; and 3) specific requirement, defined as a guideline with details on the type of research required and/or number of publications/presentations. The number of publications for countries within each group was averaged, with descriptive statistics reported as the mean and range.

Results

We identified a total of 192 countries from the WFNS Global Neurosurgery Workforce Map. A complete list of countries and research output is included in Table 1, which displays each country along with information regarding that country's continent and geographic region as well as its number of publications in the aforementioned journals. Data regarding neurosurgical training requirements for research were available for 54 (28.1%) of the 192 countries. Specific research requirements, as defined above, were identified for 39 countries, partial requirements for 8, and no requirements for 7 (Table 2). The most frequently occurring reporting body was the College of Surgeons of East, Central and Southern Africa (COSECSA), which oversees surgical training in 14 African countries. In Europe, such data were primarily reported by the Joint Residency Advisory and Accreditation Committee (JRAAC), which is an agency that accredits residency programs throughout the various countries in the European Union. Finally, requirements in several nations were set by board-certifying agencies, such as the Japan Neurosurgical Society, making research obligatory in order to be board certified, although

TABLE 1. Summary of countries, with information regarding their geographic location and research output in three neurosurgical journals

Country	Continent	Region	No. of Publications		
			<i>World Neurosurg</i>	<i>Neurosurg</i>	<i>J Neurosurg</i>
Afghanistan	Asia	South Asia	0	0	0
Albania	Europe	Balkan Peninsula	4	0	3
Algeria	Africa	North Africa	3	0	1
Angola	Africa	South-Central Africa	1	0	0
Antigua & Barbuda	North America	Caribbean	0	0	0
Argentina	South America	Southern South America	37	19	21
Armenia	Eurasia	Caucasia	1	0	0
Australia	Oceania		140	140	117
Austria	Europe	Central Europe	75	65	81
Azerbaijan	Eurasia	Caucasia	1	0	0
Bahamas	North America	Caribbean	0	0	0
Bahrain	Asia	Gulf	0	0	0
Bangladesh	Asia	South Asia	5	0	1
Barbados	North America	Caribbean	0	0	0
Belarus	Europe	Eastern Europe	0	0	1
Belgium	Europe	Western Europe	65	100	75
Belize	North America	Central America	0	0	0
Benin	Africa	West Africa	2	0	0
Bhutan	Asia	South Asia	0	0	0
Bosnia & Herzegovina	Europe	Balkan Peninsula	5	0	0
Botswana	Africa	South Africa	0	0	0
Brazil	South America		234	110	103
Brunei Darussalam	Asia	Maritime Southeast Asia	0	0	0
Bulgaria	Europe	Southeast Europe	4	4	0
Burkina Faso	Africa	West Africa	1	0	0
Burundi	Africa	East Africa	0	0	0
Cabo Verde	Africa	West Africa	0	0	0
Cambodia	Asia	Southeast Asia	10	0	0
Cameroon	Africa	Central Africa	0	0	0
Canada	North America		342	570	682
Cayman Islands	North America	Caribbean	0	0	0
Central African Republic	Africa	Central (Middle) Africa	0	0	0
Chad	Africa	North-Central Africa	0	0	0
Chile	South America	Western South America	35	8	0
China	Asia	East Asia	1946	235	336
Colombia	South America	Northern South America	35	14	8
Comoros	Africa	East Africa	0	0	0
Costa Rica	North America	Central America	0	1	0
Côte d'Ivoire	Africa	West Africa	0	0	1
Croatia	Europe	Balkan Peninsula	12	3	8
Cuba	North America	Caribbean	2	1	0
Cyprus	Europe	Mediterranean Basin	4	0	0
Czech Republic	Europe	Central Europe	20	16	33
Democratic People's Republic of Korea	Asia	Korean Peninsula	1	0	0
Democratic Republic of the Congo	Africa	Central Africa	0	0	0
Denmark	Europe	Scandinavia	25	31	36
Dominica	North America	Caribbean	1	0	0

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TABLE 1. Summary of countries, with information regarding their geographic location and research output in three neurosurgical journals

Country	Continent	Region	No. of Publications		
			<i>World Neurosurg</i>	<i>Neurosurg</i>	<i>J Neurosurg</i>
Dominican Republic	North America	Caribbean	2	0	2
Ecuador	South America	Western South America	3	0	0
Egypt	Africa	Northeast Africa	92	19	34
El Salvador	North America	Central America	0	0	0
Equatorial Guinea	Africa	Central (Middle) Africa	0	0	0
Eritrea	Africa	East Africa	0	0	0
Estonia	Europe	Northern Europe	0	1	1
eSwatini	Africa	South Africa	0	0	0
Ethiopia	Africa	East Africa	13	0	0
Federated States of Micronesia	Oceania	Micronesia	0	0	0
Fiji	Oceania	Melanesia	0	0	0
Finland	Europe	Northern Europe	102	106	53
France	Europe	Western Europe	273	365	366
Gabon	Africa	West-Central Africa	0	0	0
Georgia	Eurasia	Caucasia	0	0	0
Germany	Europe	Western Europe	586	754	644
Ghana	Africa	West Africa	4	0	0
Greece	Europe	Balkan Peninsula	71	61	61
Grenada	North America	Caribbean	58	7	5
Guatemala	North America	Central America	1	0	0
Guinea	Africa	West Africa	0	0	0
Guinea-Bissau	Africa	West Africa	0	0	0
Guyana	South America	Northern South America	0	0	0
Haiti	North America	Caribbean	5	0	1
Honduras	North America	Central America	3	0	0
Hungary	Europe	Central Europe	17	14	19
Iceland	Europe	North Atlantic	1	1	0
India	Asia	South Asia	448	121	136
Indonesia	Asia	Maritime Southeast Asia	12	0	4
Iran	Asia	West Asia	122	22	36
Iraq	Asia	West Asia	6	1	0
Ireland	Europe	British Isles	22	19	14
Israel	Asia	West Asia	149	123	124
Italy	Europe	Southern Europe	698	432	303
Jamaica	North America	Caribbean	0	0	0
Japan	Asia	Eastern Asia	1108	1230	1685
Jordan	Asia	Western Asia	7	2	2
Kazakhstan	Asia	Central Asia	3	0	1
Kenya	Africa	East Africa	15	0	0
Kiribati	Oceania	Micronesia	0	0	0
Kosovo	Europe	Balkan Peninsula	0	0	0
Kuwait	Asia	Arabian Peninsula	8	2	2
Kyrgyzstan	Asia	Central Asia	0	0	0
Lao People's Democratic Republic	Asia	Mainland Southeast Asia	0	0	0
Latvia	Europe	Northern Europe	0	0	0
Lebanon	Asia	Western Asia	48	56	47

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TABLE 1. Summary of countries, with information regarding their geographic location and research output in three neurosurgical journals

Country	Continent	Region	No. of Publications		
			<i>World Neurosurg</i>	<i>Neurosurg</i>	<i>J Neurosurg</i>
Lesotho	Africa	South Africa	0	0	0
Liberia	Africa	West Africa	0	0	0
Libya	Africa	North Africa	0	1	0
Lithuania	Europe	Northern Europe	4	2	1
Luxembourg	Europe	Western Europe	2	0	0
Madagascar	Africa	East Africa	0	0	0
Malawi	Africa	Southeast Africa	2	0	0
Malaysia	Asia	Maritime Southeast Asia	10	4	4
Maldives	Asia	South Asia	0	0	0
Mali	Africa	West Africa	0	0	0
Malta	Europe	Mediterranean Basin	0	0	0
Marshall Islands	Oceania	Micronesia	0	0	0
Martinique	North America	Caribbean	0	0	0
Mauritania	Africa	Northwest Africa	0	0	0
Mauritius	Africa	East Africa	0	0	0
Mexico	North America		104	61	58
Mongolia	Asia	East Asia	3	0	1
Montenegro	Europe	Southeast Europe	0	2	1
Morocco	Africa	North Africa	22	6	3
Mozambique	Africa	Southeast Africa	2	0	0
Myanmar	Asia	Mainland Southeast Asia	3	0	0
Namibia	Africa	South Africa	0	0	0
Nauru	Oceania	Micronesia	0	0	0
Nepal	Asia	South Asia	20	0	1
New Zealand	Oceania	Polynesia	18	14	9
Nicaragua	North America	Central America	4	0	0
Niger	Africa	West Africa	0	0	0
Nigeria	Africa	West Africa	24	2	5
North Macedonia	Europe	Balkan Peninsula	0	4	0
Norway	Europe	Scandinavian Peninsula	55	84	61
Oman	Asia	Arabian Peninsula	2	0	1
Pakistan	Asia	South Asia	35	3	2
Palau	Oceania	Micronesia	0	0	0
Panama	North America	Central America	2	0	0
Papua New Guinea	Oceania	Melanesia	1	0	0
Paraguay	South America	Central South America	0	0	0
Peru	South America	Western South America	5	0	1
Philippines	Asia	Maritime Southeast Asia	9	0	7
Plurinational State of Bolivia	South America	Western South America	4	0	1
Poland	Europe	Central Europe	36	9	16
Portugal	Europe	Iberian Peninsula	17	15	7
Puerto Rico	North America	Caribbean	10	7	15
Qatar	Asia	Arabian Peninsula	5	0	2
Republic of Korea	Asia	Korean Peninsula	252	75	100
Republic of Moldova	Europe	Eastern Europe	0	0	0
Republic of the Congo	Africa	Central Africa	0	0	0

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TABLE 1. Summary of countries, with information regarding their geographic location and research output in three neurosurgical journals

Country	Continent	Region	No. of Publications		
			<i>World Neurosurg</i>	<i>Neurosurg</i>	<i>J Neurosurg</i>
Romania	Europe	Balkan Peninsula	18	2	5
Russian Federation	Europe	Eastern Europe	61	5	14
Rwanda	Africa	Central Africa	6	0	0
Saint Kitts & Nevis	North America	Caribbean	0	0	0
Saint Lucia	North America	Caribbean	0	0	0
Samoa	Oceania	Polynesia	0	0	0
São Tomé and Príncipe	Africa	West Africa	0	0	0
Saudi Arabia	Asia	Arabian Peninsula	71	15	22
Senegal	Africa	West Africa	1	0	0
Serbia	Europe	Balkan Peninsula	15	8	3
Seychelles	Africa	East Africa	0	0	0
Sierra Leone	Africa	West Africa	0	0	0
Singapore	Asia	Maritime Southeast Asia	32	26	22
Slovakia	Europe	Central Europe	4	0	3
Slovenia	Europe	Southern Central Europe	0	7	7
Solomon Islands	Oceania	Melanesia	0	0	0
Somalia	Africa	East Africa	0	0	0
South Africa	Africa	South Africa	27	30	21
South Sudan	Africa	East-Central Africa	0	0	0
Spain	Europe	Southwestern Europe	169	110	144
Sri Lanka	Asia	South Asia	0	0	0
State of Palestine	Asia	Western Asia	13	0	0
Sudan	Africa	Northeast Africa	3	0	0
Suriname	South America	Northeastern South America	0	0	0
Sweden	Europe	Scandinavian Peninsula	53	135	149
Switzerland	Europe	Central Europe	190	134	140
Syrian Arab Republic	Asia	West Asia	1	0	0
Tajikistan	Asia	Central Asia	0	0	0
Tanzania	Africa	East Africa	13	1	1
Thailand	Asia	Mainland Southeast Asia	28	8	6
The Gambia	Africa	West Africa	0	0	0
The Netherlands	Europe	Northwest Europe	123	197	192
Timor-Leste	Asia	Maritime Southeast Asia	0	0	0
Togo	Africa	West Africa	0	0	0
Tonga	Oceania	Polynesia	0	0	0
Trinidad & Tobago	South America	Caribbean	0	0	0
Tunisia	Africa	North Africa	15	1	2
Turkey	Europe	Eastern Europe	281	169	158
Turkmenistan	Asia	Central Asia	0	0	0
Tuvalu	Oceania	Polynesia	0	0	0
Uganda	Africa	East Africa	12	3	6
Ukraine	Europe	Eastern Europe	0	0	1
United Arab Emirates	Asia	Arabian Peninsula	8	0	3
United Kingdom	Europe	British Isles	237	127	273
United States	North America		4375	4200	3724
Uruguay	South America	Southeastern South America	3	0	3

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TABLE 1. Summary of countries, with information regarding their geographic location and research output in three neurosurgical journals

Country	Continent	Region	No. of Publications		
			<i>World Neurosurg</i>	<i>Neurosurg</i>	<i>J Neurosurg</i>
Uzbekistan	Asia	Central Asia	1	0	0
Vanuatu	Oceania	Melanesia	0	0	0
Venezuela	South America	Northern South America	1	1	0
Vietnam	Asia	Indochina Peninsula	6	0	3
Yemen	Asia	Arabian Peninsula	0	0	0
Zambia	Africa	South-Central Africa	0	0	0
Zimbabwe	Africa	South Africa	2	0	0

J Neurosurg = *Journal of Neurosurgery*; *Neurosurg* = *Neurosurgery*; *World Neurosurg* = *World Neurosurgery*.

The table is organized alphabetically by country.

it was not required as a component of training. The average number of publications in *World Neurosurgery*, *Journal of Neurosurgery*, and *Neurosurgery* for each category of requirements is summarized in Fig. 1. Surprisingly, we observed a trend of increased average research productivity with the absence of designated research requirements. Similar results have been observed in a previous bibliometric analysis of research productivity among specific neurosurgical residency programs within the United States¹⁹ and will be discussed later. The heterogeneity of our results, especially the variance in research productivity among nations, unfortunately prevented statistical analysis of the relationship between research requirements and national research productivity. In addition, when we averaged publications in each journal among all countries, we found that *World Neurosurgery* had the highest number of publications (69.3, range 0–4375 vs 52.7, range 0–4200 and 53.4, range 0–3724 for *Neurosurgery* and *Journal of Neurosurgery*, respectively). This finding is consistent with the mission of *World Neurosurgery* to provide an “international forum” and “two-way dialogue” for neurosurgeons and those caring for neurosurgical patients.¹⁰ Once again, statistical analysis was not possible because of the high heterogeneity of the data. The breakdown of research productivity in these journals across continents is summarized in Fig. 2. Publication in these journals appears biased toward developed countries in North America, Europe, and Asia. Overall, we have been able to obtain and report interesting descriptive data regarding the types of research mandates imposed during training and/or prior to board certification via a global review of training curricula and requirements.

Discussion

The goal of our study was to identify and describe research requirements during neurosurgical training and/or prior to board certification across the globe. In addition, we sought to quantify research output across various nations via publication in 3 of the most prominent journals in the field: *World Neurosurgery*, *Neurosurgery*, and *Journal of Neurosurgery*. Notably, specific research requirements were identified in countries in Africa, Asia, Europe, and

Oceania. Countries for which requirement information was available in North America and South America identified no mandatory research requirements. We did not find a positive correlation between the presence of a research requirement and research output, as may have been intuited. In fact, our rudimentary analysis suggested that countries lacking research requirements had higher rates of research productivity, although this analysis did not account for other factors such as density of neurosurgeons, size, etc. A similar result was shown in a recent analysis of American residency program research output, in which mandated research did not correlate with improved productivity.¹⁹ Authors of that study postulated that this finding may be attributable to a culture in which research is informally established in many of the high-output institutions, thereby making a requirement unnecessary. However, for programs seeking to establish the culture, such a requirement may be useful.

While some countries detail explicit requirements for research experience during neurosurgical training, such as a minimum number of publications or presentations, others make broad recommendations or requirements, with individual programs then determining their own explicit guidelines. This is characteristic of the United States, in which the American Board of Neurological Surgery encourages resident involvement in research, and individual programs make subsequent decisions about the requirement for, and the timing of, research within the training program.³ We discuss below the research requirements of selected countries across the continents mentioned above, with a focus on the types of requirements and the timing of research involvement during training, as available.

Africa

African countries specifying research requirements spanned the continent in terms of regional representation; however, the majority fell within Eastern, Central, and Southern Africa in territories under the purview of the COSECSA, which has been instrumental in the development and standardization of surgical training curricula in a variety of surgical subspecialties, including neurosurgery, throughout Sub-Saharan Africa. COSECSA currently represents 14 countries,⁷ although according to the most re-

TABLE 2. Summary of research requirements and output for countries

Country	Continent	Region	Requirement Type	Requirement(s) or Comment(s)	Requiring or Reporting Agency	No. of Publications		
						World Neurosurg	Neurosurg	J Neurosurg
Botswana	Africa	South Africa	Specific	Complete dissertation	COSECSA	0	0	0
Burundi	Africa	East Africa	Specific	Complete dissertation	COSECSA	0	0	0
Egypt	Africa	Northeast Africa	Specific	Multiple degrees available to neurosurgeons, 1 pathway requires thesis defense	Egyptian Society of Neurological Surgeons	92	19	34
Ethiopia	Africa	East Africa	Specific	Complete thesis	COSECSA	13	0	0
Ghana	Africa	West Africa	Specific	Complete dissertation	Ghana College of Physicians & Surgeons	4	0	0
Kenya	Africa	East Africa	Specific	Complete dissertation	COSECSA	15	0	0
Malawi	Africa	Southeast Africa	Specific	Complete dissertation	COSECSA	2	0	0
Morocco	Africa	North Africa	Specific	Unspecified no. publications & presentations	WFNS Rabat Reference Center	22	6	3
Mozambique	Africa	Southeast Africa	Specific	Complete dissertation	COSECSA	2	0	0
Namibia	Africa	South Africa	Specific	Complete dissertation	COSECSA	0	0	0
Nigeria	Africa	West Africa	Specific	Complete dissertation	West African College of Surgeon	24	2	5
Rwanda	Africa	Central Africa	Specific	Complete dissertation	COSECSA	6	0	0
South Sudan	Africa	East-Central Africa	Specific	Complete dissertation	COSECSA	0	0	0
Sudan	Africa	Northeast Africa	Specific	Complete dissertation	COSECSA	3	0	0
Tanzania	Africa	East Africa	Specific	Complete dissertation	COSECSA	13	1	1
Uganda	Africa	East Africa	Specific	Complete dissertation	COSECSA	12	3	6
Zambia	Africa	South-Central Africa	Specific	Complete thesis & 1 publication	School of Medicine, University of Zambia; COSECSA	0	0	0
Zimbabwe	Africa	South Africa	Specific	Complete dissertation	COSECSA	2	0	0
Bahrain	Asia	Persian Gulf	Specific	Publish 1 article	ABNPE	0	0	0
China	Asia	East Asia	None	Neurosurgical training standardized nationwide in 2015; will not be fully implemented till 2020; new program does not appear to have specific research requirements or provide dedicated research time	Chinese Congress of Neurological Surgeons	1946	235	336
India	Asia	South Asia	Specific	Complete dissertation	Medical Council of India	448	121	136
Iraq	Asia	West Asia	Specific	Publish 1 article	ABNPE	6	1	0
Japan	Asia	Eastern Asia	Specific	>1 presentation & 1 publication	Japan Neurosurgical Society	1108	1230	1685
Jordan	Asia	Western Asia	Specific	Publish 1 article	ABNPE	7	2	2
Kuwait	Asia	Arabian Peninsula	Specific	Required to take 3 mos dedicated research time	Ministry of Health, Kuwait	8	2	2
Lebanon	Asia	Western Asia	Specific	Publish 1 peer-reviewed article & 1 presentation	ABNPE	48	56	47
Malaysia	Asia	Maritime Southeast Asia	Specific	Complete thesis	Neurosurgical Association of Malaysia	10	4	4

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TABLE 2. Summary of research requirements and output for countries

Country	Continent	Region	Requirement Type	Requirement(s) or Comment(s)	Requiring or Reporting Agency	No. of Publications		
						<i>World Neurosurg</i>	<i>Neurosurg</i>	<i>J Neurosurg</i>
Myanmar	Asia	Mainland Southeast Asia	None	New surgical program in conjunction w/ Switzerland, but no mention of research in curriculum	Swiss Neurosurgeons International	3	0	0
Pakistan	Asia	South Asia	Specific	Complete independent research project	College of Physicians & Surgeons of Pakistan	35	3	2
Qatar	Asia	Arabian Peninsula	Specific	Publish 1 article	ABNPE	5	0	2
Saudi Arabia	Asia	Arabian Peninsula	Specific	Publish 1 article	ABNPE	71	15	22
Singapore	Asia	Maritime Southeast Asia	Partial	Research principles must be taught, but no specific requirements on research projects	Specialists Accreditation Board	32	26	22
Sri Lanka	Asia	South Asia	Specific	Complete dissertation	Postgraduate Institute of Medicine	0	0	0
Syrian Arab Republic	Asia	West Asia	Specific	Publish 1 article	ABNPE	1	0	0
Albania	Europe	Balkan Peninsula	Specific	Present research thesis	School of Neurosurgery	4	0	3
Croatia	Europe	Balkan Peninsula	Partial	NDA on national requirements, but JRAAC accredited 2 neurosurgical programs in Croatia, & per JRAAC, residents must be trained on research methodology, but no specific requirements	JRAAC	12	3	8
Czech Republic	Europe	Central Europe	Partial	NDA on national requirements, but JRAAC accredited 2 neurosurgical programs in Czech Republic, & per JRAAC, residents must be trained on research methodology, but no specific requirements	JRAAC	20	16	33
Denmark	Europe	Scandinavia	Partial	NDA on national requirements, but JRAAC accredited 1 neurosurgical program in Denmark, & per JRAAC, residents must be trained on research methodology, but no specific requirements	JRAAC	25	31	36
Germany	Europe	Western Europe	Partial	NDA on national requirements, but JRAAC accredited 4 major neurosurgical programs in Germany, & per JRAAC, residents must be trained on research methodology, but no specific requirements	JRAAC	586	754	644
Ireland	Europe	British Isles	Specific	Publish 1 peer-reviewed article & 1 presentation	Joint Committee on Surgical Training	22	19	14

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TABLE 2. Summary of research requirements and output for countries

Country	Continent	Region	Requirement Type	Requirement(s) or Comment(s)	Requiring or Reporting Agency	No. of Publications		
						World Neurosurg	Neurosurg	J Neurosurg
Lithuania	Europe	Northern Europe	Partial	NDA on national requirements, but JRAAC accredited 1 neurosurgical program in Lithuania, & per JRAAC, residents must be trained on research methodology, but no specific requirements	JRAAC	4	2	1
Malta	Europe	Mediterranean Basin	Specific	Publish 2 articles & conduct 2 clinical audits	Specialist Accreditation Committee	0	0	0
Poland	Europe	Central Europe	Partial	NDA on national requirements, but JRAAC accredited 1 neurosurgical program in Poland, & per JRAAC, residents must be trained on research methodology, but no specific requirements	JRAAC	36	9	16
Portugal	Europe	Iberian Peninsula	Partial	NDA on national requirements, but JRAAC accredited 1 neurosurgical program in Portugal, & per JRAAC, residents must be trained on research methodology, but no specific requirements	JRAAC	17	15	7
Russian Federation	Europe	Eastern Europe	None	NA	NA	61	5	14
Spain	Europe	Southwestern Europe	Specific	Training on research methodology & involvement in research project resulting in presentation/publication	Comisión Nacional de Neurocirugía	169	110	144
Turkey	Europe	Eastern Europe	Specific	Complete thesis	Turkish Neurosurgical Society	281	169	158
United Kingdom	Europe	British Isles	Specific	Research encouraged but no specific requirements	Joint Committee on Surgical Training	237	127	273
Canada	North America		None	NA	Royal College of Physicians & Surgeons of Canada	342	570	682
Haiti	North America	Caribbean	None	NA	Haitian Ministry of Health, Hospital Bernard-Meys/Project Medishare	5	0	1
United States	North America		None	NA	American Board of Neurological Surgeons	4375	4200	3724
Australia	Oceania		Specific	1 presentation & 1 publication	Neurosurgical Society of Australasia	140	140	117
New Zealand	Oceania	Polynesia	Specific	Publish 1 article & 1 presentation	Neurosurgical Society of Australasia	18	14	9
Colombia	South America	Northern South America	None	NA	No centralized certification system	35	14	8

ABNPE = Arab Board of Neurosurgical Programs and Examinations; COSECSA = College of Surgeons of East, Central and Southern Africa; JRAAC = Joint Residency Advisory and Accreditation Committee; NA = not applicable; NDA = no data available; WFNS Rabat Reference Center = WFNS Rabat Reference Center for Training Young African Neurosurgeons.

FIG. 1. Quantification of publications in *World Neurosurgery*, *Neurosurgery*, and *Journal of Neurosurgery* among countries detailing no research requirements, partial research requirements, or specific research requirements.

cently available data, accredited programs are only present in Kenya, Uganda, Tanzania, Ethiopia, Zambia, Rwanda, and Malawi.^{14,31} In the training guidelines established by COSECSA, trainees who have earned a doctorate in medicine are registered as members of the COS (MCS) after they complete 2 years of training and subsequently complete 4 years of training in neurosurgery, culminating in the Fellow of the COS (FCS) certification.⁶ Participation in research projects during this training period is expected, including completion of a dissertation¹⁴ and prepara-

tion of a presentation for an international surgical conference.⁶ Additionally, 1 non-thesis research paper must be submitted at least 3 months prior to sitting for the oral/clinical FCS examination.⁶ Individual programs within Africa have also implemented research requirements, including the newly developed University of Zambia School of Medicine Neurosurgery Training Program, developed in partnership with the University of Cambridge. This program, spanning 5 years and 3 stages (initial, intermediate, and final), requires registrars to complete a thesis for the

FIG. 2. Quantification of publications in *World Neurosurgery*, *Neurosurgery*, and *Journal of Neurosurgery* across continents.

Master of Medicine degree, with research beginning in the first 2 years and completed in the 3rd or 4th years. Publication of at least 1 peer-reviewed article is required prior to progression to the chief registrar year. During this final year, registrars take on additional scholarly responsibility including delivering student lectures and running morbidity and mortality conferences.³⁰

Asia

Once again, the specification of research requirements traverses regional boundaries across the Asian continent. Within the Middle East and Gulf region, neurosurgical training and certification is overseen by the Arab Board of Neurosurgical Programs and Examinations and includes the countries of Iraq, Jordan, Bahrain, Saudi Arabia, Lebanon, Qatar, and Syria. In the 5th or 6th years of the training program, trainees take the final examination for certification including written, clinical, and oral portions. Prior to this examination, trainees must complete and publish 1 research project, as well as maintain a log of attendance at scientific sessions.^{4,14} Kuwait is one of the few countries whose Ministry of Health mandates the completion of a dedicated research period during neurosurgical training. This dedicated time occurs during the 3rd year of a 5-year program,²⁰ resembling the timing of the research year that is typical of many programs within the United States. Japan is one of the most productive countries in neurosurgical research that utilizes a research requirement. The Japan Neurosurgical Society requires an individual to present at an academic conference more than once and write research papers, at least one of which must be accepted into a peer-reviewed journal to obtain eligibility for the board certification examination. Additionally, recertification is contingent upon continued scholarly work in the form of academic presentations and/or publications.¹⁶ According to our analysis, Japan ranks just second to the United States in research output in the American literature, suggesting that its requirements place an appropriate emphasis on lifelong scholarship, which translates into exceptional productivity. Notably, a similarly industrialized nation, China, bears no research requirement in its newly developed standardized training program, which is set for nationwide adoption by 2020. But a lack of flexibility in the training schedule, limiting the time for research and/or enfolded fellowships, is considered a limitation of this program.³² While China ranks highly at present in terms of research output, the impact of the program's design may perturb this. Finally, in Singapore, while no specific requirements for research involvement exist, programs are required to teach principles of research within the training curriculum. Residents are encouraged to participate in scholarly activity, although this is undefined, and sponsoring institutions are encouraged to provide adequate resources for such involvement.²⁹

Europe

The JRAAC is the central monitoring body for the field of neurosurgery within Europe and is a joint committee between the European Association of Neurosurgical Societies (EANS) and the European Union of Medical Specialists (UEMS). There are currently 16 JRAAC-accred-

ited programs in Turkey, Germany, Czech Republic, Denmark, Lithuania, Poland, Spain, Portugal, and Croatia.¹¹ Guidelines released from the UEMS in 2015 recommend that neurosurgical training programs provide training in research methodology, as well as the opportunity for protected research time during the 6-year training program.¹² However, these recommendations do not represent explicit requirements for compulsory participation in research as a trainee. Despite the lack of requirements by this multinational organization, individual nations within Europe do maintain prerequisites for research participation during training. For example, in the United Kingdom (UK) and Republic of Ireland, where neurosurgical training is overseen by the Joint Committee on Surgical Training, research requirements are quite extensive: trainees must publish 1 peer-reviewed paper covering a laboratory experiment and a case series or systematic audit, as well as deliver 2 verbal presentations at national or international conferences, with attendance at a minimum of 4 conferences in total during training.¹⁷ Furthermore, in Albania, presentation of one's research thesis is, in fact, a component of the final board-certifying examination.²⁷

Oceania

Neurosurgical training in Australia and New Zealand is overseen by the Neurosurgical Society of Australasia, an organization founded in 2014, which currently boasts a membership of 95% of neurosurgeons within the 2 countries.²⁵ The neurosurgical training program guided by the society involves 3 phases: basic, constituting 1–2 years; intermediate, constituting 2–3 years; and advanced, constituting 1–3 years. Research requirements are primarily restricted to the intermediate years including participation in the Critical Literature Evaluation and Research course and completion, presentation, and publication of an approved research project. In fact, prior to 2012, all trainees in neurosurgical training programs were required to complete a compulsory research year during the 4th year of training.²⁶

Barriers to Trainee Research Involvement

Studies identifying barriers to resident/trainee research involvement have been conducted in several countries, identifying results similar to those within the United States: a lack of protected time for both trainees and faculty, a lack of mentorship, and unfamiliarity with research methodologies continue to be reported as the greatest obstacles.^{5,22} But research requirements that are instituted in environments conducive to research and offering the necessary training, resources, and protected time are likely to be more fruitful than similar requirements without the necessary support. International collaboration may provide an important avenue to enhance the research involvement of trainees from institutions without a strong research infrastructure, especially those within low- and middle-income countries. Various models for collaboration exist, often with the primary goal of enhancing clinical productivity within developing countries, although opportunities for involvement in research exist as well. One of the most common models involves integration of a visiting neurosurgeon within the department of a host institution for a short- or long-term fellowship, during which the

visiting fellow trains in clinical and operative care while also participating in clinical research projects.² Trainees can also seek involvement in research collaboratives by partnering their home countries with large international institutions. For example, the UK-based Global Health Research Group on Neurotrauma is conducting a multinational research project to identify optimal strategies for the management of patients with traumatic brain injury via partnership with countries throughout South America, Asia, and Africa.²³

Study Limitations

This analysis represents a review of trainee research requirements across the globe via internet query of guidelines produced by certifying and/or accrediting bodies, as well as regional research productivity via advanced search of the PubMed database. We recognize that our study is limited in scope because of its third-person analysis of published requirements, rather than direct survey of individuals from the various nations. While we can comment on the presence or absence of documented guidelines or requirements, we cannot determine the way in which these requirements are enforced, nor how they are perceived by trainees and faculty. Additionally, our study is inherently biased toward English-language literature based on the restriction of our literature search to the PubMed database. Publication within the major peer-reviewed journals of the field is considered a gold standard for the dissemination of research. However, barriers to publication do exist, such as language differences and financial limitations. Various initiatives have been undertaken by neurosurgical publishers to promote access to neurosurgical literature by stakeholders across the world. As an example, the *Neurosurgery Speaks* program, undertaken by *Neurosurgery*, provides written and oral abstracts for dozens of publications translated into 10 different languages by native speakers.⁸ We also cannot fail to acknowledge the importance of international scholarly contributions outside of the peer-reviewed literature, including social media posts and digital teaching. The website Neurosurgical.TV (<https://www.neurosurgical.tv/>) provides a forum for hosting video conferences by neurosurgeons across the globe and is broadly shared across neurosurgery pages on social media platforms such as Facebook and Twitter. While these are not a substitute for the peer-review process, they are important modalities for improving international dissemination of neurosurgical research and knowledge. We anticipate that as social media continues to rise in prominence within neurosurgery and the field of medicine as a whole, tools for the assessment of scholarly productivity will adapt to account for such contributions.

Recommendations and Future Directions

Clinical experience must remain the focus of neurosurgical training to maintain the most appropriate care for patients. However, the importance of research and scholarship in establishing training programs and evolving care cannot be understated. Protected research time is common in training programs throughout developed countries, but is often reliant on an established research infrastructure. Thus, partnerships permitting integration of local train-

ees into the scholarly activities of an outside institution may circumvent a lack of resources in less-developed programs.²⁸ Institutions in developed countries seeking to aid in global surgical efforts can effect some of the greatest changes by assisting in the development of local training programs, as has been accomplished via Duke University and Mulago Hospital in Uganda.¹³ Such efforts should include training in research methodologies and collaborative projects to characterize aspects of neurosurgical care in developing countries and assess the impact of any interventions that are instituted. Finally, we believe instituting a requirement can help establish research involvement in the culture of an institution and/or nation. Future prospective research in the form of surveys administered to trainees and faculty across the globe would provide a more direct assessment of the requirements and understanding of individuals' personal experiences. We believe it is critical for such perspectives to be collected to inform efforts targeted at augmenting research productivity.

Conclusions

Overall, we found that research requirements during training or prior to board certification are common in neurosurgical programs across the globe as an incentive to contribute novel knowledge to the field while maintaining research productivity and academic standing. These requirements vary in intensity and timing during training, ranging from exposure to research methodology or critical literature evaluation to completion of a thesis and publication in a peer-reviewed journal. While our analysis is quite limited, we failed to demonstrate a correspondence between the presence of requirements and research output. We hope that this study will provide a set of novel preliminary data through which the global neurosurgery community can begin to systematically assess the importance of research participation throughout the spectrum of neurosurgical training.

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Disclosures

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