Needs, roles, and challenges of young Asian neurosurgeons

Javed, S.; Perez-Chadid, D.; Yaqoob, E.; Shlobin, N.A.; Ham, E.I.; Veerappan, V.R.; ... ; Esene, I.

Needs, Roles, and Challenges of Young Asian Neurosurgeons

Saad Javed[1], Daniela Perez-Chadid[2], Eesha Yaqoob[3], Nathan A. Shlobin[4], Edward I. Ham[5], Vigneshwar Raj Veerappan[6], Sachin Chemate[7], Faith C. Robertson[8], Sarah Cain[9], Federico Nicolosi[10], Megan E.H. Still[1,11], Zhihua Chen Jehan[12], Laura Lippa[13], Maria L. Gandía-González[14], Ana Cristina Veiga Silva[15], Ronnie E. Baticulon[16], Nqobile Thango[17], Zerubabbel K. Asfaw[18], Luxwell Jokonya[19], Angelos Kolias[20], Ernest J. Barthélemy[21], Ignatius Esene[22], WFNS Young Neurosurgeons Forum

BACKGROUND: **Asia has a marked shortage of neurosurgical care, with approximately 2.5 million critical cases left untreated. The Young Neurosurgeons Forum of the World Federation of Neurosurgical Societies surveyed Asian neurosurgeons to identify research, education, and practice.**

METHODS: **A cross-sectional study using a pilot-tested e-survey was circulated to the Asian neurosurgical community from April to November 2018. Descriptive statistics were used to summarize variables pertaining to demographics and neurosurgical practices. The chi-square test was used to explore the relationship between World Bank income level and variables on neurosurgical practices.**

RESULTS: **A total of 242 responses were analyzed. Respondents were mostly from the low- and middle-income countries (70%). Most represented institutions were teaching hospitals (53%). More than 50% of the hospitals had between 25and 50 neurosurgical beds. Access to an operating microscope ($P = 0.038$) or image guidance system ($P = 0.001$) appeared to increase in correlation to a higher World Bank income level. Limited opportunities for conducting research (56%) and hands-on operating opportunities (45%) were leading challenges in daily academic practice. The leading challenges were limited numbers of intensive care unit beds (51%), inadequate or absent insurance coverage (45%), and lack of organized perihospital care (43%). Inadequate insurance coverage decreased with increasing World Bank income levels ($P < 0.001$). Organized perihospital care ($P = 0.001$), regular magnetic resonance imaging access ($P = 0.032$), and equipment necessary for microsurgery ($P = 0.007$) increased with higher World Bank income levels.**

CONCLUSIONS: **Improving neurosurgical care hinges on regional and international collaboration and national policies to ensure universal access to essential neurosurgical care.**

Key words
- Advocacy
- Asia
- Barriers
- Education
- Global neurosurgery
- Low-and middle-income countries
- Neurosurgical capacity
- Research

Abbreviations and Acronyms
ICU: Intensive care unit
LMIC: Low- to middle-income countries
WFNS: World Federation of Neurological Societies
YNF: Young Neurosurgeons Forum

INTRODUCTION

There are significant disparities in neurosurgical care in low- and middle-income countries (LMICs), especially in Asia.[1] In 2015, the *Lancet* reported that 5 out of 7

From the [1]Department of Neurosurgery, Holy Family Hospital, Rawalpindi Medical University, Rawalpindi, Pakistan; [2]Faculty of Medicine, Universidad CES, Medellin, Colombia; [3]Department of Public Health, Health Services Academy, Ministry of National Health Services Regulations and Coordination, Government of Pakistan, Islamabad, Pakistan; [4]Department of Neurological Surgery, Northwestern University Feinberg School of Medicine, Chicago, Illinois; [5]Stony Brook School of Medicine, Stony Brook, New York, USA; [6]University of York, York, United Kingdom; [7]Noble Hospitals, Pune, India; [8]Department of Neurosurgery, Massachusetts General Hospital, Boston, Massachusetts, USA; [9]Department of Neurosurgery, The Royal Melbourne Hospital, Parkville, Victoria, Australia; [10]Department of Medicine and Surgery, Neurosurgery Unit, University of Milano-Bicocca, Milan, Italy; [11]Department of Neurosurgery, University of Florida, Gainesville, Florida, USA; [12]Jiaotong University in Shanghai, Shanghai, China; [13]Department of Neurosurgery, ASST Ospedale Niguarda, Milan, Italy; [14]Hospital Universitario La Paz in Madrid, Madrid, Spain; [15]Neurosurgery Department of Post Graduation Program in Neuropsychiatry and Behavioral Sciences (PosNeuro), Federal University of Pernambuco, Recife, Brazil; [16]Division of Neurosurgery, Department of Neurosciences, Philippine General Hospital, University of the Philippines, Manila, Philippines; [17]Division of Neurosurgery, Department of Surgery, Neuroscience Institute, University of Cape Town, Cape Town, South Africa; [18]Department of Neurosurgery, Icahn School of Medicine at Mount Sinai, New York, New York, USA; [19]University of Zimbabwe in Harare, Harare, Zimbabwe; [20]Department of Clinical Neurosciences, Cambridge, United Kingdom; [21]Global Neurosurgery Laboratory, Division of Neurosurgery, SUNY Downstate Health Sciences University, Brooklyn, New York, USA; and [22]Neurosurgery Division, Faculty of Health Sciences, University of Bamenda, Bambili, Cameroon

To whom correspondence should be addressed: Saad Javed, M.S. [E-mail: saadjaved10095@gmail.com]

Citation: World Neurosurg. (2023) 177:e118-e125. https://doi.org/10.1016/j.wneu.2023.05.120

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

*Available online: **www.sciencedirect.com***

individuals lack access to safe, timely, and affordable surgical care.[2] Individuals in LMICs bear the brunt of this health inequity, particularly in subspecialty areas like neurosurgery.[2,3] Southeast Asia has a significant shortage of neurosurgical care, with approximately 2.5 million unmet neurosurgical cases on an annual basis.[1] There are 49,940 neurosurgeons worldwide, with the lowest number of surgeons in sub-Saharan Africa and southeast Asia. To alleviate this operative gap, it is estimated that 23,300 additional neurosurgeons are needed.[1] In India approximately 3500 neurosurgeons serve a population of more than 1.2 billion people. However, to provide adequate neurotrauma coverage for the entire nation, nearly double the number of neurosurgeons would be required.[4] *This estimate assumes only the neurotrauma-related neurosurgical disease burden is addressed and equitable workforce distribution throughout the country is found.*

Proper training and education are essential to attenuate neurosurgical disparities. The international neurosurgical community has responded by forging a consensus and elevating neurosurgery to the forefront of global surgery and health policy agenda. Physician recruitment is improving, as are the number of adequate quality training programs available, and the ability to retain established surgeons in their native countries is helping to mitigate workforce losses to human capital flight (i.e., "brain drain)."[5-7]

The Young Neurosurgeons Forum (YNF) of the World Federation of Neurosurgical Societies (WFNS) conducted a survey involving residents, fellows, and consultant neurosurgeons. This article aims to analyze the results from these surveys to identify the hurdles and catalysts of research, education, and practice in the Asian neurosurgical community.[8]

METHODS

Survey Design and Data Collection

A cross-sectional study using a pilot-tested e-survey consisting of 30 questions was conducted, as reported in previous studies.[8] The anonymous survey consisted of questions related to demographics, workplace information, neurosurgical service logistics, neurosurgical training, and the needs and interests of neurosurgery residents and consultant neurosurgeons. The survey was officially designed by the WFNS YNF members. The survey was circulated to the Asian neurosurgical community under the auspices of the WFNS and the supervision of the WFNS YNF. An e-mail containing the electronic link to the survey was circulated using the official mailing list of WFNS and WFNS YNF, personal contacts, social media websites (Twitter, Facebook, WhatsApp), and regional societies. Participants were informed that the WFNS YNF serves as the investigator and the purpose of the survey was to identify hurdles and catalysts of research, education, and practice in the Asian neurosurgical community.

The respondents consisted of a convenience sample of Asian neurosurgery residents and consultant neurosurgeons. Data were collected from April to November 2018. Responder bias was minimized by mainly using close-ended questions, optional name concealment, and a limited number of questions, while the online survey completion minimized social desirability bias. The selection of at least 1 response option was enforced, and 5 out of the 22 multiple-choice questions available were single-answer questions. Multiple options were applicable to the remaining questions. Duplicated entries were removed from the analysis by incorporating only the final set of responses provided by users with the same IP address.

Data Analysis

Descriptive statistics were used to summarize variables pertaining to demographic, neurosurgical practice, health institution logistics, neurosurgical education, and research as self-reported by respondents. Countries of origin were divided into South Asia, West Asia, East Asia & Pacific, and Central Asia. World Bank income groups were determined by using the organization's official website in 2018. Statistical analysis was performed using the Statistical Package for the Social Sciences version 26 (IBM, Armonk, New York, USA). Associations between variables and income status was conducted using the chi-square test for a trend. The study is reported in accordance with the Checklist for Reporting Results of Internet E-Surveys.[9]

RESULTS

Demographics

A total of 242 responses from 28 countries were acquired. Given the survey was distributed online through national neurosurgical societies, a precise response rate was unable to be calculated. Countries with the greatest number of responses included India (73; 30%), Saudi Arabia (28; 12%), and Pakistan (26; 10%) (**Table 1**), (**Figure 1**). Respondents were most commonly from the South Asian region (117; 48%) and LMICs (162; 70%) (**Figure 1**) (**Table 2**). Most respondents were male (214; 88%), and the most common age groups were 30–35 (96; 40%) and 36–40 (75; 31%). Respondents were most often consultant neurosurgeons with <5 years post residency (82; 40%), residents 5 or more years after medical school graduation (50; 21%), or residents <5 years post medical school graduation (44; 18%). Respondents most often conducted paid clinical work (210; 87%); a minority conducted both clinical and research work (30; 12%) or solely research (2; 1%). The most common subspecialties of interest were spine (70; 29%), cerebrovascular (66; 27%), and neurotrauma (55; 24%) (**Figure 2**).

Institutional Information and Resources

As reported by respondents, the majority of hospitals they worked at were university or teaching hospitals (129; 53%), followed by private hospitals (45; 19%). The catchment population was most commonly greater than 1.5 million (145; 60%). Bed capacity varied from ≤500 beds (90; 37%) to 500–1000 beds (81; 33.5%) to >1000 beds (71; 29%). Most hospitals had a dedicated neurosurgical floor/ward (171; 71%). Most hospitals had 25–50 neurosurgical beds (82; 34%) at their disposal. Most (238, or 98%) respondents had access to intensive care unit (ICU) beds, 227 (94%) to mechanical ventilators in the ICU, and 178 (74%) to rehabilitation specialists (**Table 3**). A total of 216 (89%) individuals had access to an operating microscope, 199 (82%) to a high-speed drill, and 110 (45.5%) to an image guidance system. Access to an operating microscope ($P = 0.038$) or image guidance system ($P = 0.001$) increased with higher World Bank income level.

Table 1. Representation by Region and World Bank Income Group

	World Bank Income Group			
Region	LIC	LMIC	UMIC	HIC
South Asia	2 (1%)	115 (47.5%)	0 (0%)	0 (0%)
West Asia	9 (4%)	2 (1%)	19 (8%)	31 (13%)
East Asia & Pacific	0 (0%)	45 (19%)	11 (4.5%)	1 (0.4%)
Central Asia	0 (0%)	7 (3%)	0 (0%)	0 (0%)

LIC, low-income country; LMIC, low-middle-income country; UMIC, upper-middle-income country; HIC, high-income country.

Challenges to Practice

Most significant hurdles in daily practice included limited opportunities for conducting research (136; 56%), hands-on operating opportunities (108; 45%), poor work-life balance (107; 44%), lack of access to organized teaching/training sessions (104; 43%), and long working hours (103; 43%). Notable challenges to providing neurosurgical services included limited numbers of ICU beds (124; 51%), inadequate or absent insurance coverage for a significant number of people (108; 45%), lack of organized prehospital/emergency hospital care (104; 43%), lack of organized rehabilitation care (102; 42%), and lack of access to equipment necessary for microsurgery (100; 41%). Inadequate insurance coverage decreased with increasing World Bank income levels ($P < 0.001$). Lack of organized prehospital/emergency care ($P = 0.001$), regular access to magnetic resonance imaging ($P = 0.032$), and equipment necessary for microsurgery ($P = 0.007$) decreased with higher World Bank income levels.

DISCUSSION

LMICs undeniably bear a significant proportion of the global neurosurgical burden, with estimates suggesting that up to 80% of

Table 2. Demographic Information of Respondents

Respondent Information	Counts	% of Total
Age (Years)		
<30	45	19%
36–40	75	31.0%
30–35	96	40%
41 or more	26	11%
Sex		
Male	214	88%
Female	28	12%
Profession		
Resident (<5 years after graduating from medical school)	44	18%
Resident (5 years or more after graduating from medical school)	50	21%
Consultant <5 years after finishing residency	82	34%
Consultant 5 years or more after finishing residency	36	15%
Fellow (defined as additional training near the end or after the end of residency)	26	11%
Other	4	2%
Paid Activities		
Clinical	210	87%
Clinical and I am paid to do research	30	12%
Research only	2	1%

the global neurosurgical needs are from LMICs.[1] Within LMICs, the Asian continent, Southeast Asia in particular, is the largest contributor to the neurosurgical burden, facing 3.7 million new neurosurgical cases and 5.8 million new cases that require neurosurgical consultation every year.[1] Our study identified several key challenges facing the neurosurgical workforce in Asia, focused around access to neurosurgical equipment, neurosurgical training and practice, and neurosurgical service delivery.

Barriers to Accessing Neurosurgical Equipment

While Asia has seen one of the fastest growths in neurosurgical workforce density, there are still significant challenges, with some countries within the continent, such as India and Bangladesh, not improving or, at times, seeing a fall in their workforce density.[5,10] Besides the actual magnitude of the neurosurgical workforce, Asian countries also face barriers in adequately and appropriately distributing their neurosurgical workforce geographically, resulting in increased neurosurgical burden located in rural regions.[11] These barriers faced by LMICs are not limited to the workforce itself but also to the availability of neurosurgical equipment.

Our study found a significant positive correlation between the World Bank income level of a country as a whole and access to neurosurgical equipment such as operating microscopes and image-guided systems. This finding is corroborated by Punchak et al,[12] who identified that only around 1 in 4 people had access to advanced microneurosurgery in the South Asian region. The lack of adequate funding for public health care poses a financial barrier to investing in adequate neurosurgical equipment, further compounded by LMICs reduced fiscal capacity to allocate more budget toward surgical services.[11,13] Many Asian countries also rely heavily on medical imports for equipment due to barriers in technologic innovation, health technology assessment infrastructure, and regulatory provisions.[14] While adequate funding is important to procuring and maintaining neurosurgical equipment, it may not be practical for LMICs with limited fiscal capacity to increase expenditure to the required level. LMICs can reduce expenditure on medical device imports by purchasing equipment from manufacturers who are geographically closer. Of the top 5 LMIC medical device manufacturers, 2 of them (India and China) are located within the Asian continent. Investing in manufacturing capacity locally can also aid in import expenditure reduction. There are also many examples of frugal innovations within the surgery that have enabled LMICs to technologically leapfrog and drastically reduce costs of medical devices, and this success can be replicated for neurosurgery. However, this will require active participation from universities and hospitals to foster an environment of innovation. However, it is important to consider that the correlation identified between the World Bank income level and access to neurosurgical equipment may not be accurate and generalizable, due to majority of respondents being from university or teaching hospitals, which are generally more well equipped. Studies have demonstrated that even in middle-income countries with access to neurosurgical equipment, there is a lack of adequate geographical distribution. A study based on data collected at a district or regional level, or predictive modeling studies where data are lacking, may yield a more accurate representation of the availability of neurosurgical equipment and its geographic distribution.

Barriers to Neurosurgical Training and Practice

Our study identified several barriers within neurosurgical training and practice. More than half of respondents highlighted limited research opportunities within their training or day-to-day practice. This may be because most respondents in our study were primarily within clinical roles and thus had limited academic exposure. However, several studies have corroborated the findings of limited research opportunities available to clinicians in LMICs and gone further in identifying notable barriers to surgical research opportunities in LMICs, ranging from cultural and social barriers to infrastructural barriers, such as dedicated time and training, and financial obstacles, such as lack of academic funding.[15] These barriers result in an inequitable global research environment where LMIC research is not adequately represented.[16,17] Ham et al[18] identified that only 20% of LMICs are represented within the global neurosurgical literature. Moreover, improving research opportunities among clinicians may also challenge hospitals and institutions to improve their data infrastructure, enabling more data to be collected on resource and workforce availability.

Our study also found that neurosurgical trainees in Asia found deficiencies in their training, such as hands-on training and organized teaching sessions. These deficiencies are echoed in other studies investigating neurosurgical training in other LMICs, with a study by Sader et al[19] highlighting a lack of physical resources, neurosurgical equipment, and organized training in neurosurgery in sub-Saharan Africa. Ferraris et al,[20] based on a study of 5 Asian countries, recommended the development of international collaborations with reciprocal certification, incorporation of in-service residency and fellowships, and improved funding as ways to improve neurosurgical training pathways. International collaborations can also be beneficial in allowing neurosurgical trainees in LMICs to work and gain experience in high-income countries.[21]

Digital training and technology enhanced training can also be used to make up for reduced neurosurgical equipment, resources, and case variety.[22,23] For example, widely available and easily accessible technologic resources such as open access online courses, tutorials, and grand rounds through social media, such as Twitter and Facebook, can be used to improve the minimum quality standards at low cost. Hence these interventions can be focused on medical students and neurosurgeons within the first 2 years of postgraduate training. On the other hand, simulation training, augmented reality, and digital training, while slightly more expensive, still provide high-quality surgical training at relatively low cost over time and hence can be used to train neurosurgeons who are later in their postgraduate training, thus improving the maximum standards of care.[24]

Barriers to Neurosurgical Service Delivery

There were also notable deficiencies in service delivery identified by our study. There was a correlation between insurance coverage and the World Bank income levels of the country. Neurosurgical interventions are inherently cost intensive, and despite mandates to insure government hospitals in many Asian countries, patients

Table 3. Institutional Information by Region

Institutional Information	South Asia	West Asia	East Asia & Pacific	Central Asia
Hospital				
University/Teaching Hospital	68 (58%)	29 (47.5%)	29 (51%)	3 (43%)
Private Hospital	35 (30%)	8 (13%)	2 (3.5%)	0 (0%)
Mixed Public & Private Hospital	12 (10%)	6 (10%)	13 (23%)	1 (14%)
Other Public Hospital	2 (2%)	18 (29.5%)	13 (23%)	3 (43%)
Catchment Population				
<50,000	1 (1%)	0 (0%)	1 (2%)	0 (0%)
50,000–200,000	6 (5%)	2 (3%)	3 (5%)	1 (14%)
200,000–500,000	20 (17%)	6 (10%)	7 (12%)	2 (29%)
500,000–1.5 million	24 (20.5%)	10 (16%)	11 (19.4%)	3 (43%)
>1.5 million	66 (56%)	43 (70.5%)	35 (61%)	1 (14%)
Bed capacity				
≤500 beds	45 (38.5%)	26 (43%)	15 (26%)	4 (57%)
500–1000 beds	36 (31%)	19 (31%)	23 (40%)	3 (43%)
>1000 beds	3 (31%)	16 (26%)	19 (33%)	0 (0%)
Dedicated neurosurgical floor/ward?"				
Yes	84 (72%)	41 (67%)	39 (68%)	7 (100%)
No	33 (28%)	20 (33%)	18 (3%)	0 (0%)
Number of neurosurgical ward beds				
<25	34 (29%)	15 (25%)	17 (30%)	0 (0%)
25–50	26 (22%)	31 (51%)	23 (40%)	2 (29%)
50–75	24 (20.5%)	8 (13%)	5 (9%)	0 (0%)
75–100	13 (11%)	4 (7%)	5 (9%)	4 (57%)
>100	20 (17%)	3 (5%)	7 (12%)	1 (14%)

inevitably incur out-of-pocket expenditures that push them into poverty.[25] Despite countries like India rolling out universal health coverage programs, there remain geographic, economic, and sociocultural barriers to these programs reaching the entire population. Several studies have demonstrated that neurosurgical patients bear a significant burden in terms of out-of-pocket expenditure and that out-of-pocket cost negatively impacts the patient's prognosis and rehabilitation.[26,27] Building health systems infrastructure and protecting patients from catastrophic health expenditure is an expensive process that requires more public health funding by the government and allied global health financing partners. This can be difficult in LMICs with limited fiscal capacity, but innovative financing methods can prove useful in funding underresourced surgical systems.[13] Apart from health coverage, around 40% of respondents in our study reported lack of neurosurgical service provision aspects, such as prehospital care, rehabilitation, and neurosurgical care. that are essential in ensuring a good quality of life.[28,29] These issues are immense in scope and require political will to address. While expanding neurosurgical care is an expensive and long-term affair, approaching neurosurgical burden from a public health standpoint can enable quick and cost-effective ways to reduce a country's neurosurgical burden. For example, public health interventions such as wearing helmets on 2-wheelers or folic acid fortification have proven effective in reducing neurosurgical burden in a cost-effective way.[28] Hence it is important that Asian countries or regions committing to a surgical framework, plan, or strategy identify and include their neurosurgeons in decision making processes. Advocacy is required on the part of neurosurgeons to ensure neurosurgery is approached at a public health level and with the support of policymakers at regional and national levels.[28-30]

Limitations

A response rate could not be calculated due to the method of distribution of this survey, rendering this survey prone to response

and nonresponse bias. Young neurosurgeons/trainees without an e-mail address, reliable Internet access, social media platform accounts, and electronic devices had a significantly diminished probability of participating in the survey. The lack of demographic homogeneity (i.e., equal numbers of participants of the same age, living in the same place, etc.) limits the study findings' generalizability. Of particular note, China, the largest country by population within the continent, had one of the lowest response rates. This could be due to the fact that the survey was disseminated through social media channels, such as Facebook and Whatsapp, which are not commonly used platforms in China. Thus future studies that want to capture data from countries such as China need to develop more targeted dissemination strategies.

The fact that the survey predated the COVID-19 pandemic does not reflect the related needs of neurosurgical health care providers during the pandemic. The data presented in this study were collected 5 years ago, and it is important to acknowledge that there may have been changes in the intervening period that could affect the current accuracy of the findings. However, despite the potential limitations associated with the time lag, we believe that the insights provided by this study still hold relevance and contribute to the existing body of knowledge in this field.

Owing to the limitations of the study, the study results cannot be generalizable to the population of all 28 Asian countries included in the study. As such, the study results and discussion should be interpreted as a broad overview of challenges faced by Asian neurosurgeons and to inform future studies that seek more granularity in scope and data within each country.

CRediT AUTHORSHIP CONTRIBUTION STATEMENT

Saad Javed: Acquisition of data, Formal analysis, Writing — original draft, Writing — review & editing. **Daniela Perez-Chadid:** Writing — original draft, Writing — review & editing. **Eesha Yaqoob:** Acquisition of data, Formal analysis, Writing — original draft, Writing — review & editing. **Nathan A. Shlobin:** Writing — original draft, Writing — review & editing. **Edward I. Ham:** Acquisition of data, Formal analysis, Writing — review & editing.

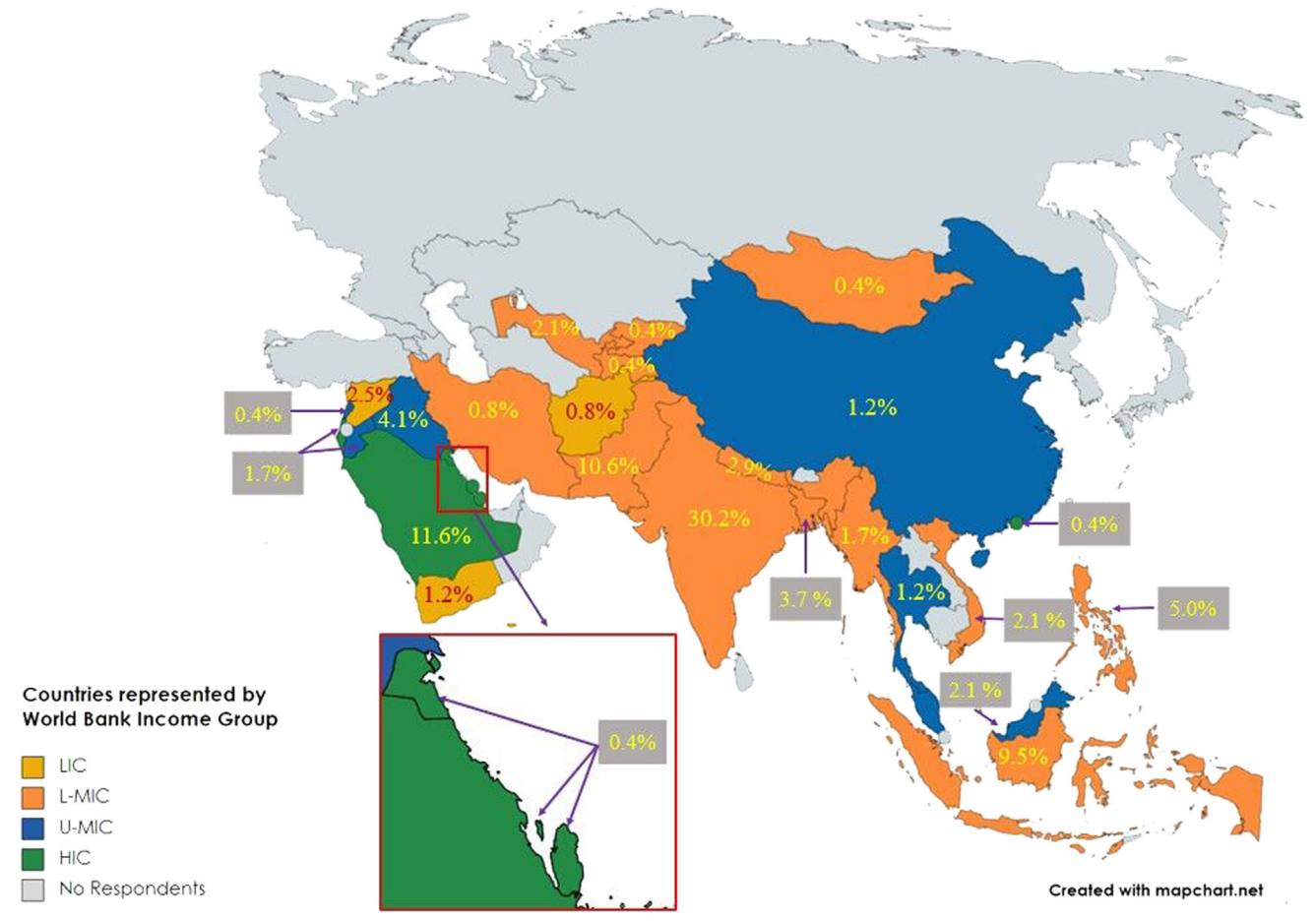

Figure 1. Map distribution of the respondents. HIC, high-income country LIC, low-income country; LMIC, lower-middle-income country; UMIC, upper-middle-income country.

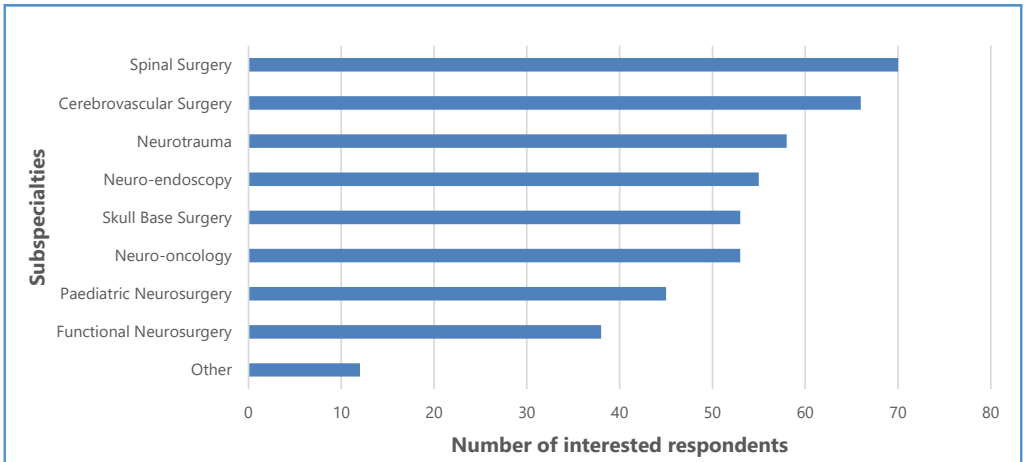

Figure 2. Subspeciality of interest.

Vigneshwar Raj Veerappan: Writing — original draft, Writing — review & editing. **Sachin Chemate:** Writing — review & editing. **Faith C. Robertson:** Acquisition of data, Formal analysis, Writing — review & editing. **Sarah Cain:** Writing — review & editing. **Federico Nicolosi:** Writing — review & editing. **Megan EH. Still:** Writing — review & editing. **Zhihua Chen Jehan:** Writing — review & editing. **Laura Lippa:** Writing — review & editing. **Maria L. Gandía-González:** Writing — review & editing. **Ana Cristina Veiga Silva:** Writing — review & editing. **Ronnie E. Baticulon:** Writing — review & editing. **Nqobile Thango:** Writing — review & editing. **Zerubabbel K. Afsaw:** Writing — review & editing. **Luxwell Jokonya:** Writing — review & editing. **Angelos Kolias:** Writing — review & editing. **Ernest J. Barthélemy:** Conceptualization, Methodology, Writing — review & editing. **Ignatius Esene:** Conceptualization, Methodology, Writing — review & editing.

REFERENCES

1. Dewan MC, Rattani A, Fieggen G, et al. Global neurosurgery: the current capacity and deficit in the provision of essential neurosurgical care. Executive summary of the global neurosurgery Initiative at the program in global surgery and social change. *J Neurosurg*. 2018:1-10.

2. Meara JG, Leather AJM, Hagander L, et al. Global Surgery 2030: evidence and solutions for achieving health, welfare, and economic development. *Lancet*. 2015;386:569-624.

3. Park KB, Johnson WD, Dempsey RJ. Global neurosurgery: the unmet need. *World Neurosurg*. 2016;88:32-35.

4. Corley J, Lepard J, Barthélemy E, Ashby JL, Park KB. Essential neurosurgical workforce needed to address neurotrauma in low- and middle-income countries. *World Neurosurg*. 2019;123:295-299.

5. Kanmounye US, Lartigue JW, Sadler S, et al. Emerging trends in the neurosurgical workforce of low- and middle-income countries: a cross-sectional study. *World Neurosurg*. 2020;142:e420-e433.

6. Karekezi C, El Khamlichi A. Takeoff of African neurosurgery and the world Federation of neurosurgical societies rabat training center alumni. *World Neurosurg*. 2019;126:576-580.

7. Hutch A, Bekele A, O'Flynn E, et al. The brain drain myth: retention of specialist surgical graduates in East, Central and Southern Africa, 1974—2013. *World J Surg*. 2017;41:3046-3053.

8. Robertson FC, Gnanakumar S, Karekezi C, et al. The world Federation of neurosurgical societies Young neurosurgeons survey (Part II): barriers to Professional development and service delivery in neurosurgery. *World Neurosurgery X*. 2020;8:100084.

9. Eysenbach G. Improving the quality of web surveys: the checklist for reporting results of internet E-surveys (CHERRIES). *J Med Internet Res*. 2004;6:e34.

10. Mukhopadhyay S, Punchak M, Rattani A, et al. The global neurosurgical workforce: a mixed-methods assessment of density and growth. *J Neurosurg*. 2019;130:1142-1148.

11. Dewan MC, Baticulon RE, Rattani A, Johnston JM, Warf BC, Harkness W. Pediatric neurosurgical workforce, access to care, equipment and training needs worldwide. *Neurosurg Focus*. 2018;45:E13.

12. Punchak M, Mukhopadhyay S, Sachdev S, et al. Neurosurgical care: availability and access in low-income and middle-income countries. *World Neurosurg*. 2018;112:e240-e254.

13. Reddy CL, Peters AW, Jumbam DT, et al. Innovative financing to fund surgical systems and expand surgical care in low-income and middle-income countries. *BMJ Glob Health*. 2020;5:e002375.

14. Sapkota B, Palaian S, Shrestha S, Ozaki A, Mohamed Ibrahim MI, Jakovljevic M. Gap analysis in manufacturing, innovation and marketing of medical devices in the Asia-Pacific region. *Expert Rev Pharmacoecon Outcomes Res*. 2022;22:1043-1050.

15. Siddiqui NA, Raees MA, Khan RN, Zafar F. Barriers in surgical research: a perspective from the developing world. *J Pak Med Assoc*. 2022;72(Suppl 1):S97-S102.

16. Griswold DP, Khan AA, Chao TE, et al. Neurosurgical randomized trials in low- and middle-income countries. *Neurosurgery*. 2020;87:476-483.

17. Velin L, Lartigue JW, Johnson SA, et al. Conference equity in global health: a systematic review of factors impacting LMIC representation at global health conferences. *BMJ Glob Health*. 2021;6:e003455.

18. Ham EI, Kim J, Kanmounye US, et al. Cohesion between research literature and health system level efforts to address global neurosurgical inequity: a scoping review. *World Neurosurg*. 2020;143:e88-e105.

19. Sader E, Yee P, Hodaie M. Barriers to neurosurgical training in Sub-Saharan Africa: the need for a Phased Approach to global surgery Efforts to improve neurosurgical care. *World Neurosurg*. 2017;98:397-402.

20. Ferraris KP, Matsumura H, Wardhana DPW, et al. The state of neurosurgical training and education in East Asia: analysis and strategy development

for this frontier of the world. *Neurosurg Focus*. 2020; 48:E7.

21. Henderson F, Abdifatah K, Qureshi M, et al. The College of Surgeons of East, Central, and Southern Africa: successes and challenges in standardizing neurosurgical training. *World Neurosurg*. 2020;136:172-177.

22. Higginbotham G. Virtual connections: improving global neurosurgery through immersive technologies. *Front Surg*. 2021;8:629963.

23. Senise RS, Yogui R, Cirne LF. Role of Science, technology, and innovation towards SDGS. In: Leal Filho W, Marisa Azul A, Brandli L, Lange Salvia A, Wall T, eds. *Partnerships for the Goals. Encyclopedia of the UN Sustainable Development Goals*. Springer, Cham: Springer International Publishing; 2021:1067-1078.

24. Walker B, Veerappan V, Nehme J. The role of technology and innovation. In: Kpodonu J, ed. *Global Cardiac Surgery Capacity Development in Low and Middle Income Countries. Sustainable Development Goals Series*. Cham: Springer; 2022.

25. Ferraris KP, Yap MEC, Bautista MCG, et al. Financial risk protection for neurosurgical care in Indonesia and the Philippines: a primer on health financing for the global neurosurgeon. *Front Surg*. 2021;8:690851.

26. Yoon S, Mooney MA, Bohl MA, et al. Patient out-of-pocket spending in cranial neurosurgery: single-institution analysis of 6569 consecutive cases and literature review. *Neurosurg Focus*. 2018; 44:E6.

27. El-Sayed AM, Ziewacz JE, Davis MC, et al. Insurance status and inequalities in outcomes after neurosurgery. *World Neurosurg*. 2011;76:459-466.

28. Veerappan VR, Gabriel PJ, Shlobin NA, et al. Global neurosurgery in the context of global public health practice—a literature review of case studies. *World Neurosurg*. 2022;165:20-26.

29. Park K, Warf B, Aukrust CG, et al. *Comprehensive Policy Recommendations for the Management of Spina Bifida & Hydrocephalus in Low-& Middle-Income Countries*. Springer, Cham: Springer Nature; 2021.

30. Draft Intersectoral global action plan on epilepsy and other neurological disorders 2022—2031. Available at: https://www.who.int/news/item/28-04-2022-draft-intersectoral-global-action-plan-on-epilepsy-and-other-neurological-disorders-2022-2031. Accessed December 2, 2022.

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 22 May 2023; accepted 30 May 2023

Citation: World Neurosurg. (2023) 177:e118-e125. https://doi.org/10.1016/j.wneu.2023.05.120

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

Available online: ***www.sciencedirect.com***