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Access to training in neurosurgery (Part 2): The costs of pursuing neurosurgical training

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ABSTRACT

Introduction: Opportunities for in-country neurosurgical training are severely limited in LMICs, particularly due to rigorous educational requirements and prohibitive upfront costs.

Research question: This study aims to evaluate financial barriers aspiring neurosurgeons face in accessing and completing neurosurgical training, specifically in LMICs, in order to determine the barriers to equitable access to training.

Material and methods: In order to assess the financial costs of accessing and completing neurosurgery residency, an electronic survey was administered to those with the most recent experience with the process: aspiring neurosurgeons, neurosurgical trainees, and recent neurosurgery graduates. We attempted to include a broad representation of World Health Organization (WHO) geographic regions and World Bank income classifications in order to determine differences among regions and countries of different income levels.

Results: Our survey resulted in 198 unique responses (response rate 31.3%), of which 83% (n = 165) were from LMICs. Cost data were reported for 48 individual countries, of which 26.2% were reported to require trainees to pay for their neurosurgical training. Payment amounts varied amongst countries, with multiple countries having costs that surpassed their annual gross national income as defined by the World Bank.

Discussion and conclusions: Opportunities for formal neurosurgical training are severely limited, especially in LMICs. Cost is an important barrier that can not only limit the capacity to train neurosurgeons but can also perpetuate inequitable access to training. Additional investment by governments and other stakeholders can help develop a sufficient workforce and reduce inequality for the next generation of neurosurgeons worldwide.

1. Introduction

The magnitude of the global neurosurgical workforce deficit has been widely acknowledged, as has the need for neurosurgeons worldwide, with an estimated 23,300 additional neurosurgeons required globally to perform the needed neurosurgical procedures (Dewan et al., 2018). In some regions, such as East Africa, the neurosurgeon to population ratio can be as low as 1:10 million people (Fuller et al., 2015). When it comes to neurosurgical training to address this need, the prohibitive upfront costs and structural barriers related to gender and socioeconomic status can limit training opportunities. This is especially true for medical school graduates from low- and middle-income countries (LMICs), who frequently have to pay exorbitant costs in order to pursue neurosurgical training, often with no potential for commensurate compensation.

Neurosurgical training and education has, from its inception, prioritized excellence through the development of competent and effective neurosurgical trainees (Benzel, 2010). Among the most important elements cited for effective neurosurgical training are adequate infrastructure for surgical education, a well-developed resident educational plan, and methods for self-assessment with graduated responsibility (Teman et al., 2014). In order to become a neurosurgeon, one must adhere to rigorous educational requirements, all of which are associated with significant costs. Within high-income countries (HICs), neurosurgical training usually requires medical school graduates and aspiring trainees

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to complete four years of medical school, followed by standard licensing, after which they submit to several arduous years of residency training. This process involves multiple costs, including medical school education, medical licensing examinations, and applications to neurosurgical training programs (Gordon and Malik, 2021). Within the United States, the cost of applying to neurosurgical residency alone costs approximately $10,000,[6] and neurosurgical training can cost $1,200,000 for a single resident over the course of their seven year training (Gordon et al., 2020). In some low- and middle-income countries (LMICs) this cost of training can be borne by the trainees as neurosurgical residents have to pay for their training. As a result of these challenges, neurosurgery residency training positions in high-income countries (HICs) remain highly sought after by International Medical Graduates (IMGs), with the most successful candidates hailing predominantly from the Middle East, Europe, and South America (Scheitler et al., 2020).

Although there is increased momentum behind training neurosurgeons in LMICs, there remain many barriers to accessing and completing accredited neurosurgical training programs. For example, a recent study conducted in Ethiopia demonstrated a dearth of educational resources as a significant barrier to resident education (Cadotte et al., 2013). In addition, a lack of educational tools and clear goals for each level of residency training were also highlighted as prominent challenges. There also exists a tremendous propensity for self-directed learning among these same residents, thereby indicating a paucity of educational resources was the primary limitation, and not intrinsic motivation (Sader et al., 2017). Novel methods to alleviate the global burden of neurosurgical disease and the workforce deficit continue to be developed, such as international collaborations, fellowship models, and online education (Almeida et al., 2018); however, a closer examination of the barriers to neurosurgical training in LMICS is necessary in order to comprehensively address inequalities in access to care worldwide.

This study aims to address that issue by evaluating the financial barriers aspiring neurosurgeons face in accessing and completing neurosurgical training in several nations. Such data may be useful in determining the necessity and impact of additional investment in training programs by governments and member societies worldwide. We describe here the results of our survey questionnaire to assess neurosurgical training capacity and the costs of training in countries across the globe, with a particular focus on LMICs. It is the second part of a two-part study on the barriers to accessing neurosurgical training globally.

2. Methods

This study is the result of collaboration between members of the Harvard Program in Global Surgery and Social Change, World Federation of Neurosurgical Societies Global Neurosurgery Committee, and the Ribat University Hospital of Sudan. The study was approved by the Harvard Medical School Institutional Review Board (IRB20-1372).

2.1. Survey design

A 12 to 23-question survey was developed using the EQUATOR checklist (Kelley et al., 2003) to assess the demographics and barriers to neurosurgical training globally, with a focus on LMICs. Questionnaire length varied based on participant responses. Specific questions were developed to assess the demographics of training programs, cost of entry, and cost of training. The survey questionnaire is included in the supplementary Appendix 1.

2.2. Identification of participants

We surveyed medical students and medical officers aspiring to enter neurosurgical training, current neurosurgical trainees, and recent graduates within the past four years. We attempted to include a broad representation of World Health Organization (WHO) geographic regions and World Bank income classifications, with a focus on LMICs. In order to achieve this, our recruitment efforts focused on dissemination through international organizations that contained our target groups, including the Global Surgery Student Alliance, Young African Neurosurgeons, and the Neurosurgery Cocktail Facebook group. We utilized email, social media platforms such as Twitter and Facebook, and messaging apps such as Telegram and WhatsApp. In addition, requests were made for word-of-mouth dissemination through personal contacts of the study authors and study participants.

2.3. Survey distribution

The survey was administered in English only. Participants were invited via a Google Forms (Google, Mountainview, CA) request. If they consented by completing the form, they were then sent a link to complete the survey. Study data were collected and managed using REDCap electronic data capture tools hosted at Harvard Medical School (Harris et al., 2009). REDCap (Research Electronic Data Capture) is a secure, web-based application designed to support data capture for research studies, providing: 1) an intuitive interface for validated data entry; 2) audit trails for tracking data manipulation and export procedures; 3) automated export procedures for seamless data downloads to common statistical packages; and 4) procedures for importing data from external sources. Responses were collected from September 7th to November 10th' 2020. Reminder emails were sent out to all invited participants who had not yet responded at 2, 4, and 6 weeks after the initial invitation in order to improve the response rate (Hoddinott and Bass, 1986).

2.4. Data analysis

Results were exported into Microsoft Excel© 2016 and analyzed with SPSS (SPSS Inc. Released, 2009. PASW Statistics for Windows, Version 18.0. Chicago: SPSS Inc.). Data on cost were converted to United States dollars (USD) from their reported currencies using the Morningstar Currency Exchange database (Morningstar Research Services LLC, USA) on November 23rd, 2020. Average national income per capita for each country was collected from the World Bank database for GNI per capita, converted to current USD by the Atlas method (The World Banka). Countries were grouped into high-income (HIC) or low- and middle-income (LMIC) using the World Bank income classification, where low-income, lower-middle income, and upper-middle income countries were all classified as LMIC (The World Bankb). Non-parametric comparison of the means using the Mann-Whitney U test was performed, comparing the HIC to LMIC group.

3. Results

3.1. Respondent demographics

In total, 633 participants received email invitations to participate in the study. We received 198 responses to the survey, giving a response rate of 31.3%. Although 69 different countries were represented, data on cost was reported for only 48 countries (Fig. 1). Of the respondents, 33 (16.70%) were from HICs and 165 (83.30%) were from LMICs. The majority of respondents were men (72%), while 27% were women, and 0.5% identified as non-binary. The mean age of the participants was 32.5 $\pm$ 8.4 years. Aspiring neurosurgeons comprised 37% of respondents, while current neurosurgery trainees comprised 36% and recent neurosurgery graduates (i.e. consultant neurosurgeons) comprised 27%. The mean year in training for the current neurosurgery trainees was 3.6 $\pm$ 1.7, and 43.1% reported working more than 80 h per week on average. There were 33 respondents currently enrolled in medical school in different countries than their country of origin, while 15 respondents started neurosurgery residency in different countries than their medical school.

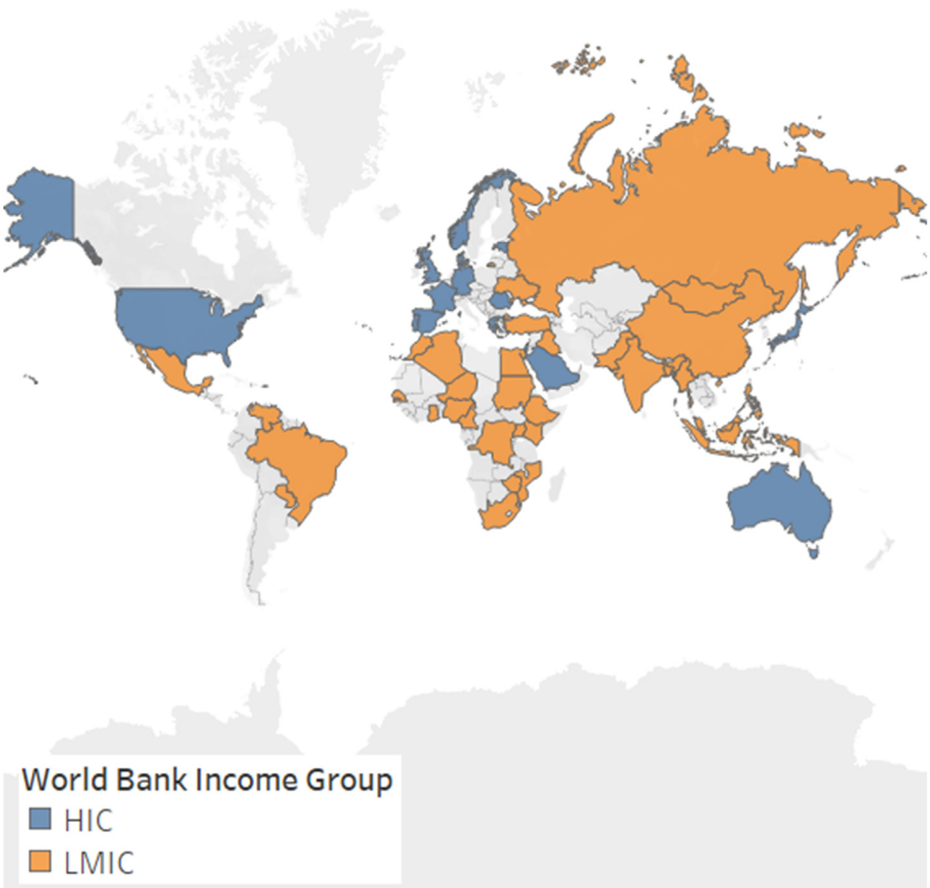

Fig. 1. Map view of country representation for reported data on cost of training. Each color-filled country had at least one respondent from that country. Number of respondents from each country is not shown here. Blue countries are categorized as high-income and orange countries are categorized as low- or middle-income based on World Bank income classification. (The World Bankb). (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

3.2. Cost of training

Approximately one-third of respondents (32.1%) reported having to pay for their neurosurgical training, while 61.9% reported being paid during their neurosurgery residency. Of the represented countries, 13 (31%) - all of which were LMICs except Greece - were reported to require trainees to pay for their training in at least one of their training programs (Fig. 2). There was wide variability in reported costs on licensing and entrance exams for neurosurgical training, from no cost to USD 10,000 reported in Bangladesh (Table 1). These costs just for exams varied in affordability as well, as some countries such as the Democratic Republic of the Congo reported costs that equated up to 943% of the average annual income for the country, reported as GNI per capita by the World Bank (The World Bankc). This variability was seen in the annual cost of training as well. For those who had to pay for their training, there was a wide range from 11% of the average annual income in Paraguay to 641% in Uganda. Annual salaries for trainees varied widely from 6% of the average annual income in Brazil to 699% in Nigeria (Table 1). This data reflects the costs incurred for training in the index country related to that country's average annual income.

3.3. Comparative analysis

Low- and middle-income country (LMIC) respondents were statistically significantly more likely to report having to pay for their neurosurgical training compared to their high-income country (HIC) colleagues ($p = 0.006$) (Table 2). Due to multiple confounding variables that affect cost, no comparative analysis was done regarding the specific financial amounts.

4. Discussion

Expanding the neurosurgical workforce is a critical part of surgical systems strengthening in order to increase access to care, and this begins with the training of neurosurgeons (Dewan et al., 2018). Yet, there are multiple barriers for medical students who wish to pursue neurosurgical training. Some of our respondents ultimately attended medical school or sought neurosurgical training in a country outside of their country of origin. Although we did not assess the individual reasons for this, it suggests a dearth in availability of neurosurgery training programs. This could also increase the likelihood of brain drain as countries without local training have higher emigration rates of their healthcare workers and training in another country is a motivating factor to stay (Adovor et al., 2021; Skelton et al., 2020). The cost of neurosurgery training is also an important consideration for graduates and aspiring trainees from LMICs. Frequently, these prohibitive costs may be what limit aspiring neurosurgeons from continuing the pursuit of neurosurgery, whether in-country or elsewhere.

Our study found prohibitive costs as high as USD 10,000 and 943% of the national average annual income for licensing and entrance examinations required for entry into neurosurgical training. This further exacerbates the existing disparities in access to neurosurgical training, especially in LMICs where graduates often invest a greater percentage of their annual income and earnings without commensurate financial remuneration. Even in the United States, the average cost for applying to neurosurgical residency is USD 10,300 - higher than the cost of applying to other surgical specialties. The largest component of this cost is interviews, averaging USD 7,180 for applicants (Agarwal et al., 2017). Clearly, entrance fees for neurosurgery training remain an area of exorbitant costs, necessitating further clarification and intervention by governing bodies as part of their strategies to improve equitable access to

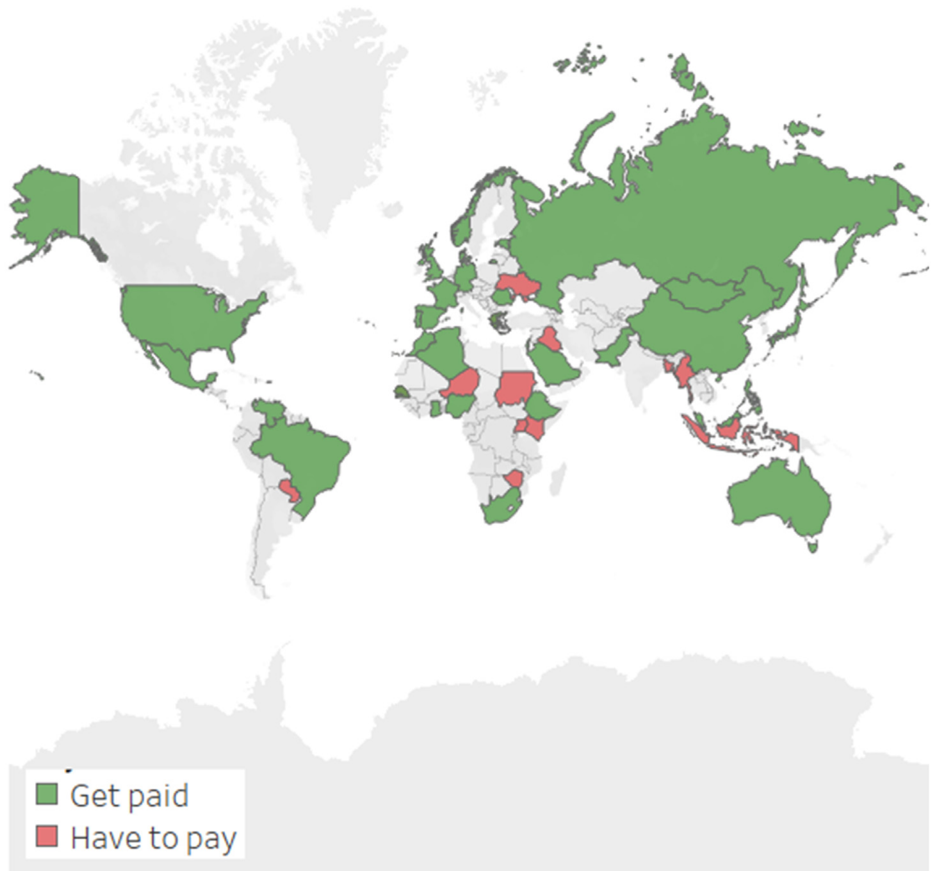

Fig. 2. Geographic heatmap of countries that pay trainees during neurosurgical training (green) and countries that require trainees to pay for their neurosurgical training (red). (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

training opportunities.

Furthermore, 31% of countries were reported to have programs requiring neurosurgical trainees to pay for their training. This was more common in LMICs, as only one of the 13 countries in which respondents reported having to pay was a HIC. This can be a tremendous burden for trainees and could significantly limit the number of students who wish to pursue training for half a decade. In addition, this creates an inequitable environment for entry to training as only those who can afford to pay can undertake the training. Accordingly, the costs are frequently exorbitant, as some trainees report having to pay up to 641% of the national average annual income per year, compounded over the average 4–7 years of training.

Even for those who were paid during their training, the annual salary could be as low as only 6% of the national average annual income, making it difficult for those without the means to bear the cost. In some LMICs with unstable exchange rates and heavy fluctuation of their national currency, there is an extra burden for trainees as the actual cost of neurosurgical training can rapidly increase from one year to the next. These high costs, along with the long duration of training and often inadequate compensation after graduation, make a career in neurosurgery unattractive and challenging for many (Ozgediz et al., 2008). In addition, the absence of a reliable and sufficient salary for neurosurgical trainees in LMICs can often lead to the need to find other part-time jobs unrelated to neurosurgery, hindering their ability to focus on their training. After training, they may then seek employment in the private healthcare sector, where salaries can be higher, in order to compensate for these high costs. This in turn leads to inequitable access to care for patients as the public health sector suffers.

These findings make a strong case for investment not only in the number of neurosurgical training programs in LMICs, but also ensuring their financial attractiveness and affordability by eliminating fees and paying a competitive and living salary. Many of the costs that are difficult for LMIC trainees to bear can be affordable by HIC standards. As an example, in Zimbabwe our respondents reported having to pay USD 4,500 per year for 5 years to complete neurosurgical training. This is a cost for trainees that is 324% of the national average annual income, but is only a total of USD 22,500 to train a neurosurgeon - approximately one-third of the national average annual income in the United States. Looking at it from the donor perspective, the investments needed to subsidize neurosurgery training in LMICs may be modest but the future impact of these surgeons is massive considering the current estimate of 5 million unmet neurosurgical operations in LMICs (Dewan et al., 2018). The donor/subsidy model should be used as a stop-gap measure as countries develop comprehensive strategies that aim to meet their health workforce gaps. These strategies should include policies that not only remove the financial barriers but also strive for trainee salaries that would incentivize more people to enter and stay in their surgical professions. Such policies will help increase the neurosurgical workforce and improve equity within the specialty. In addition, these subsidies may improve the quality of the training programs as more resources can create the opportunity to provide educational tools such as surgical skills labs. This relation between cost and quality is unclear, and further studies on cost-effectiveness are needed. Nonetheless, the return on investment can be significant - within the United States, previous studies have demonstrated that the financial value of neurosurgical trainees to hospitals far exceeds the costs of their training, with a median net profit of approximately USD 200,000 from the work of a neurosurgical trainee (Gordon et al., 2020). A similar benefit to hospitals in LMICs can be expected, but further illumination is needed.

Table 1
Country reported data on the cost of training. Trainees reported whether they have to pay or are paid for their neurosurgical training. Countries that had respondents who reported both are listed twice. Training length is reported in years; for those countries that had different lengths of training reported, the range is listed. Mean and standard deviation for the cost of licensing and entrance exams is also reported, as well as the mean and standard deviation for the annual cost/salary of training. All reported currencies were converted to United States dollars (USD) using the Morningstar Currency Exchange database (Morningstar Research Services LLC, USA) on November 23rd, 2020. Costs were then compared to the average annual income for the respective country, as reported by the World Bank as GNI per capita, converted to current USD by the Atlas method. (The World Bankc) LIC = low-income country; LMIC = lower-middle income country; UMIC = upper-middle income country; HIC = high-income country; SD = standard deviation.

Country	Country Income Group	Pay	Training length (Years)	Mean cost of exams (±SD; USD)	Percentage of annual income	Mean annual cost of training (±SD; USD)	Percentage of annual income
Algeria	LMIC	Get paid	5	1.30 ± 2.25	0.03%		
Australia	HIC	Get paid	6	2,914.40	5%	72895	132%
Bangladesh	LMIC	Have to pay	5	10,000	515%	2000	103%
Brazil	UMIC	Get paid	5	165.40 ± 155.95	2%	514.6	6%
Cameroon	LMIC			591.21 ± 818.22	39%		
China	UMIC	Get paid	4–7	0	0%	6000	58%
Denmark	HIC	Get paid	5	0	0%	87517.67 ± 22507.24	137%
DR Congo	LIC			5,000	943%		
Egypt	LMIC			200	7%		
Estonia	HIC	Get paid	5	0	0%	23691.4	102%
Ethiopia	LIC	Get paid	5	750 ± 1,060.66	88%	1986.5 ± 2102.23	234%
France	HIC	Get paid	5	0	0%	6100 ± 8343.86	14%
Germany	HIC	Get paid	7	0	0%	47380.8	97%
Ghana	LMIC	Get paid	4–8	780.11 ± 730.62	35%	11315 ± 1859.69	510%
Greece	HIC	Get paid	9	0	0%	14214.24	72%
Greece	HIC	Have to pay	9			1184.34	6%
India	LMIC			150.05 ± 103.76	7%		
Indonesia	UMIC	Have to pay	5–6	6,676.47 ± 10,000.79	165%	1886.1 ± 555.11	47%
Iraq	UMIC	Have to pay	5	0	0%		
Israel	HIC	Get paid	6				
Japan	HIC	Get paid	5		0%	16654.7	40%
Kenya	LMIC	Have to pay	6	346.72 ± 305.71	20%	2333.33 ± 1154.7	133%
Malaysia	UMIC	Get paid	4	97.79 ± 138.30	0.90%		
Mexico	UMIC	Get paid	6	165.49 ± 116.65	2%	1000	11%
Mongolia	LMIC	Get paid	1	151.67 ± 147.51	4%	250 ± 86.6	7%
Morocco	LMIC	Get paid	5	0	0%	8292.76	260%
Mozambique	LIC		5	0	0%		
Myanmar	LMIC	Have to pay	8				
Niger	LIC	Have to pay	5		0%	453.52	76%
Nigeria	LMIC	Get paid	4–10	716.16 ± 519.18	35%	14191.85	699%
Norway	HIC	Get paid	6	0	0%	132898.8	161%
Pakistan	LMIC	Get paid	3–5	93.94 ± 42.56	7%	2120.93 ± 2148.05	150%
Paraguay	UMIC	Have to pay	5	0	0%	600	11%
Philippines	LMIC	Get paid	5–6	53.68 ± 122.47	1%	6817.67 ± 4600.63	177%
Portugal	HIC	Get paid	6	0	0%	33167.96	143%
Romania	HIC	Get paid	6	0	7%	1539.94	12%
Russia	UMIC	Get paid	2–5	785.05 ± 930.11	7%	1500 ± 424.26	13%
Saudi Arabia	HIC	Get paid	6	186.66	0.80%	2132.78	9%
Senegal	LMIC	Get paid	1–5	453.52 ± 641.37	31%	0	0%
Senegal	LMIC	Have to pay	1–5			1173.29	80%
South Africa	UMIC	Get paid	5	493.09	8%		
Spain	HIC	Get paid	5	3553.05	12%	41462.05	137%
Sudan	LIC	Have to pay	6	122.31 ± 272.73	21%	278.44 ± 284.52	47%
Turkey	UMIC			0	0%		
Uganda	LIC	Have to pay	4–7	1,016.67 ± 975.11	130%	5000 ± 2828.43	641%
UK	HIC	Get paid	8	1,465.30 ± 753.32	3%	53,331.2	126%
Ukraine	LMIC	Have to pay	6	0	0%	4,000	119%
USA	HIC	Get paid	7	4,615 ± 1610.25	7%	65,000	98.70%
Venezuela	UMIC	Get paid	5	50	0.40%	12,000	91.70%
Zimbabwe	LMIC	Have to pay	5	70	5%	4,500	324%

Table 2
Comparison of LMIC and HIC responses regarding whether neurosurgical trainees were paid or had to pay for their training. Comparison was performed using the sum of ranks Mann-Whitney *U* test.

Income Group	Mean of responses (1 = get paid, 2 = have to pay)	Standard Deviation	Mean Rank	Sum of Ranks	Mann-Whitney U	p-value
LMIC	1.38	0.49	59.58	5540.5	597.5	**0.006**
HIC	1.05	0.23	41.45	787.5		

4.1. Limitations

Our study is far from a comprehensive picture of the global training cost of neurosurgeons or all of the costs borne by neurosurgical trainees; however, it provides an important view of the financial obstacles to increasing the neurosurgical workforce in LMICs and improving equity. Importantly, data on the indirect costs of training, such as cost of living, were not included in this study, and can be a heavy burden especially for those who pursue training in countries outside of their home country. In addition to the limited scope of the study, there were other limitations. The reported financial data are not official figures. In many countries that had multiple respondents, significant standard deviations existed. This could be due to variations among training programs in a country. In addition, costs and salaries can change from year to year, adding additional variability to the data. All cost data were converted to USD but exchange rates vary through time, adding potential error as respondents completed the survey over a period of months but all financial data was converted on the same day at the end of the data collection period. These limitations make it difficult to compare country and regional data on specific costs, allowing only for comparison of trainees getting paid or having to pay for training. This emphasizes the need for accurate and transparent data collection on this matter in order to drive policy and practice changes.

5. Conclusion

Opportunities to receive formal neurosurgery training are severely limited, especially for graduates of LMIC medical schools. Cost is an important barrier that can not only limit the ability to train neurosurgeons, but also raises issues of equitable access to training programs. Given these prohibitive costs, additional investment by governments and training programs may be warranted in order to help develop a sufficient workforce for the next generation of neurosurgeons worldwide.

Conflict of interest

We would like to submit a manuscript entitled “Global Neurosurgical Training (Part 2): The Costs of Pursuing Neurosurgical Training” to be considered as an original article in the Brain and Spine Journal.

We declare that this manuscript is original, has not been published before and is not currently being considered for publication elsewhere.

There was no conflict of interest associated with this manuscript. As a corresponding author, I confirm that The manuscript has been read and approved for submission by all contributing authors.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.bas.2022.100927.

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