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Access to Pediatric Neurology Training and Services Worldwide

A Survey by the International Child Neurology Association

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Abstract

Pediatric neurology is the medical subspecialty responsible for diagnosing and managing diseases and disorders of the nervous system in childhood and adolescence. In many, but not all, regions of the world, the discipline of pediatric neurology is recognized as a specialty or subspecialty of either neurology or pediatrics. Significant knowledge and competencies in this area are necessary to be effective in clinical practice. The need for this is driven by the high burden of disease from neurologic conditions in children and the effect on their families. As the first part of a multistaged project under the auspices of the International Child Neurology Association, in collaboration with key stakeholders, a survey was undertaken to establish which countries have practicing child neurologists. For those countries that have child neurologists, the survey established the number of practitioners and which countries have access to in-country child neurology training. Responses were obtained from 177 countries. Worldwide, there is a median of 0.07 and mean of 0.39 child neurologists per 100,000 population. The greatest deficits in child neurology specialists and access to training were evident in countries which fell under the World Bank rating of low-income country status (range of 0–0.008 child neurologists per 100,000 population). Seventy-three percent of low-income countries lack access to child neurologists: The majority are in the African and South-East Asia regions. For the population of 1.37 billion in the continent of Africa, there were 324 child neurologists, equating to a median of 0.01 per 100,000 population in comparison with a median of 0.59 child neurologists per 100,000 across high-income countries. Ninety-four countries had capacity to support in-country pediatric neurology training. Worldwide, there are inadequate numbers of child neurologists and a great need for increased training capacity.

Introduction

The first observations of pediatric neurologic disorders date back to Hippocrates.[1] Advances in neurology and pediatrics into the early 20th century consolidated the discipline's scientific recognition as a unique discipline. Subsequently it evolved, primarily as an outgrowth of pediatrics in Europe vs adult neurology in the United States.[2,3]

Neurologic conditions in children contribute to premature mortality and years lived with disability, leading to a significant effect on the global burden of disease.[4] Despite the high burden of neurologic diseases in children, there is scarcity of child neurologists in many regions

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Pediatric Neurology Training Study Group coinvestigators are listed in the appendix at the end of the article.

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Glossary

APFP = African Paediatric Fellowship Program; **CNS** = Child Neurology Society; **EPNS** = European Pediatric Neurology Society; **HIC** = high income country; **ICNA** = International Child Neurology Association; **IGAP** = Intersectoral Global Action Plan; **ILAE** = International League Against Epilepsy; **LIC** = low income country; **LMIC** = low middle income country; **UMIC** = upper middle income country; **WHO** = World Health Organization.

of the world.[5] Care is often delivered by practitioners, including general pediatricians, psychiatrists, and adult neurologists, with limited training in pediatric neurology.[6,7]

To reach greater understanding of the global need for child neurologists, the advocacy and education committees of the International Child Neurology Association (ICNA) and affiliated members undertook to explore the following components: (1) Which countries have child neurologists? (2) What is the ratio of child neurologists per population? (3) Which countries currently provide pediatric neurology training? (4) What are the main components of core curricula? (5) What is the ideal or essential curricula content? This report focuses on the first 3 questions. This study is intended not only for child neurologists but to provide key personnel with the necessary information to lobby for resource allocation and policy change toward improved access to child neurology care both at the ministry of health level and from international organizations.

Methods

The working group identified contact persons from among (1) pediatric neurology country leads, (2) peers recognized as best placed lead contacts, and (3) corresponding authors in relevant peer-reviewed literature. Respondents were asked to complete a proforma either using a Microsoft Word document or directly using the ICNApedia education research portal (eAppendix 1: Training survey proforma, links.lww.com/WNL/D8).[8] Respondents were asked to (1) confirm the number of child neurologists practicing in their countries (if any); (2) state whether training occurs within their country or abroad; and (3) state whether pediatric neurology as a discipline is supported by a national association or organization, specifying pediatric, pediatric neurology, adult neurology, or other. Finally, if training was based in the country, a link to upload the curriculum was provided for the next project stages. Translation for preferred language was available. For many of the countries, this was straightforward because the ICNA board is well-represented regionally and supported by other affiliated associations such as the European Pediatric Neurology Society (EPNS), the Asian and Oceanic Child Neurology Association, and the Child Neurology Society (CNS, North America). A previously completed assessment for Europe was pooled with updates, where necessary, through engagement from the EPNS.[2] In resource-limited regions of Africa, South-East Asia, and Latin America, which lacked national bodies or readily accessible representatives in the field of child neurology, contacts were identified through reaching out to colleagues in general pediatrics and adult neurology and through the World Federation of Neurology, the International League Against Epilepsy (ILAE), and the World Health Organization (WHO). Where duplicate proformas were completed, data were combined and discrepancies clarified directly with respondents. For centers with multiple respondents, countries were asked to identify preferred contact persons in preparation for the next stages of the project.

Data were collated for ratios of child neurologists per 100,000 population and transferred into a heat map (Figure 1) (eAppendix 2: Raw data excel files, links.lww.com/WNL/D9). Median (with interquartile range) and mean (with standard deviation) values were documented and compared across WHO regions (Table 1, Figure 2, A and B) (eAppendix 3: Stats, links.lww.com/WNL/D10). Countries which were not listed as member states were included in the closest geographic WHO region. Data on numbers of pediatric neurologists (Figure 2, C and D) and access to training (Figure 3, A and B) were also stratified by location into low-income country (LIC), low middle-income country (LMIC), upper middle-income country (UMIC), and high-income country (HIC), according to the World Bank status (Table 1).[9] The primary location of training within or external to the country and the presence of a national body or association were also assessed (Table 1). Open comment option encouraged documentation of barriers to training and any other relevant points (Figure 4 and eTable 1, links.lww.com/WNL/D12).

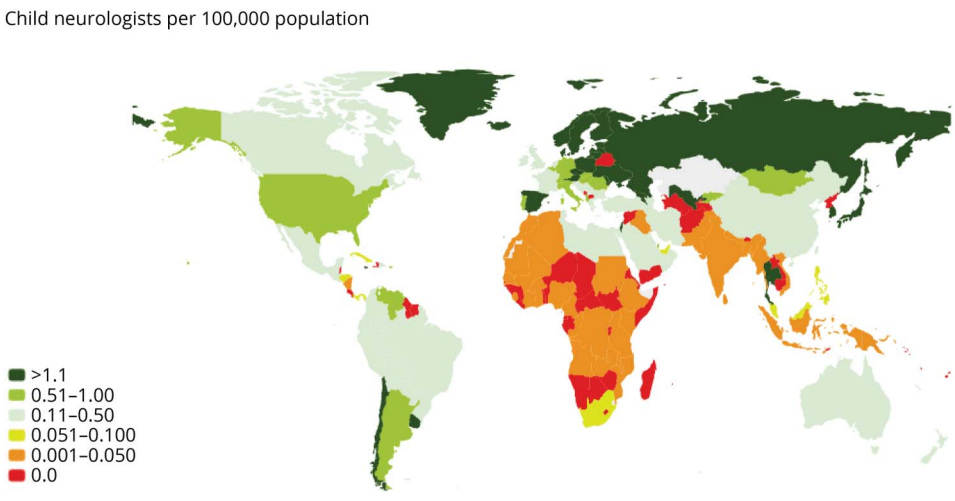
Data Availability

Raw data are posted on the ICNApedia website and as supplemental files (eAppendix 2: Raw data excel files, links.lww.com/WNL/D9 and eAppendix 3: Stats, links.lww.com/WNL/D10).

Results

Of the 194 countries listed as the WHO member states, data were captured from 174 countries (90%). Three additional nonmember state countries (Palestine territories, Hong Kong and Taiwan) with access to pediatric neurologists and/or in-country training capacity were included in the most relevant

Figure 1 Color-Coded Map of Ratios of Child Neurologists per 100,000 of Country Populations Worldwide



Colors, explained in the key, demonstrate the range of low to high prevalence in different regions.

WHO geographic region. In total, data from 177 countries were recorded. Noncaptured entities typically had very small populations of less than 1 million or did not have health care services (Table 1).

Figure 1 presents a visual overview of the ratio of child neurologists per 100,000 of country populations illustrating the regional variations and discrepancies as well as the many countries with no child neurologists.

Based on the WHO regions, Table 1 summarizes regional responses inclusive of the mean and median numbers of child neurologists per 100,000, access to in-country training, and pediatric neurology associations. Figure 2, A and B provides box plot visual illustration of regional variances and outliers. The North American and European regions were the best resourced in all areas. The least resourced across all areas were the African and South-East Asian regions. Wide ranges in capacity of some countries, especially in the Western Pacific region, skewed the mean values. The Western Pacific region had 6 countries with no child neurologists, 2 had 2 child neurologists, 5 had between 11 and 21 child neurologists, and 5 had between 70 and 250 child neurologists. Japan had 1,226 and China 2,300 child neurologists. In the South-East Asia region, 4 countries had no child neurologists, 2 had less than 10 child neurologists, 2 had between 11 and 30 child neurologists, and 3 (Indonesia, Thailand and India) had between 90 and 150 child neurologists. The African region, which had the lowest resources of any region, had 26 countries (57%) with no child neurologists. Figure 4 presents an infographic of key findings for sub-Saharan Africa. Twenty-eight countries had no national body to lobby for pediatric neurology support.

Notable comments from regions included that in Brazil, child neurology, although accepted as an area of expertise, is not a recognized specialty. The national association, Sociedade Brasileira de Neurologia Infantil, is legally addressing this. The responses from Africa contained the most qualitative comments (Figure 4). Key points were that some countries were still developing pediatric programs or even undergraduate medical schools. This hindered the capacity to teach neurology in the general medical curricula. Inadequate financial support was a recurring theme exacerbated by lack of government support for or prioritization of child neurology. Dependence on training overseas, often by self-funding and subsequent "brain drain", that is, loss of physicians to other countries, was a key concern. Some child neurologists were very isolated, often the only clinician supporting a vast region, and unable to afford conferences to maintain skills and develop collaborations. In the Eastern Mediterranean region, Bahrain and Sultanate of Oman, as well as some African region counties, concern for insufficient child neurologists to support in-country child neurology training was raised. eTable 1 (links.lww.com/WNL/D12) summarizes comments from the South-East Asia and Western Pacific regions.

Based on the World Bank categories, collated data from this grouping are presented in Table 1, Figure 2, C and D, and eFigure 1 (links.lww.com/WNL/D11).[9]

For the LICs, only 10 of 28 (36%) had access to child neurologists, equating to one per country for 5 countries and between 2 and 7 for the remaining 5 countries. Training was available in one country (Zambia). No countries had a standalone child neurology association while a small proportion noted support through general pediatric or adult associations (n = 7). Of the responding LICs, 24 of 28 were based in sub-Saharan Africa.

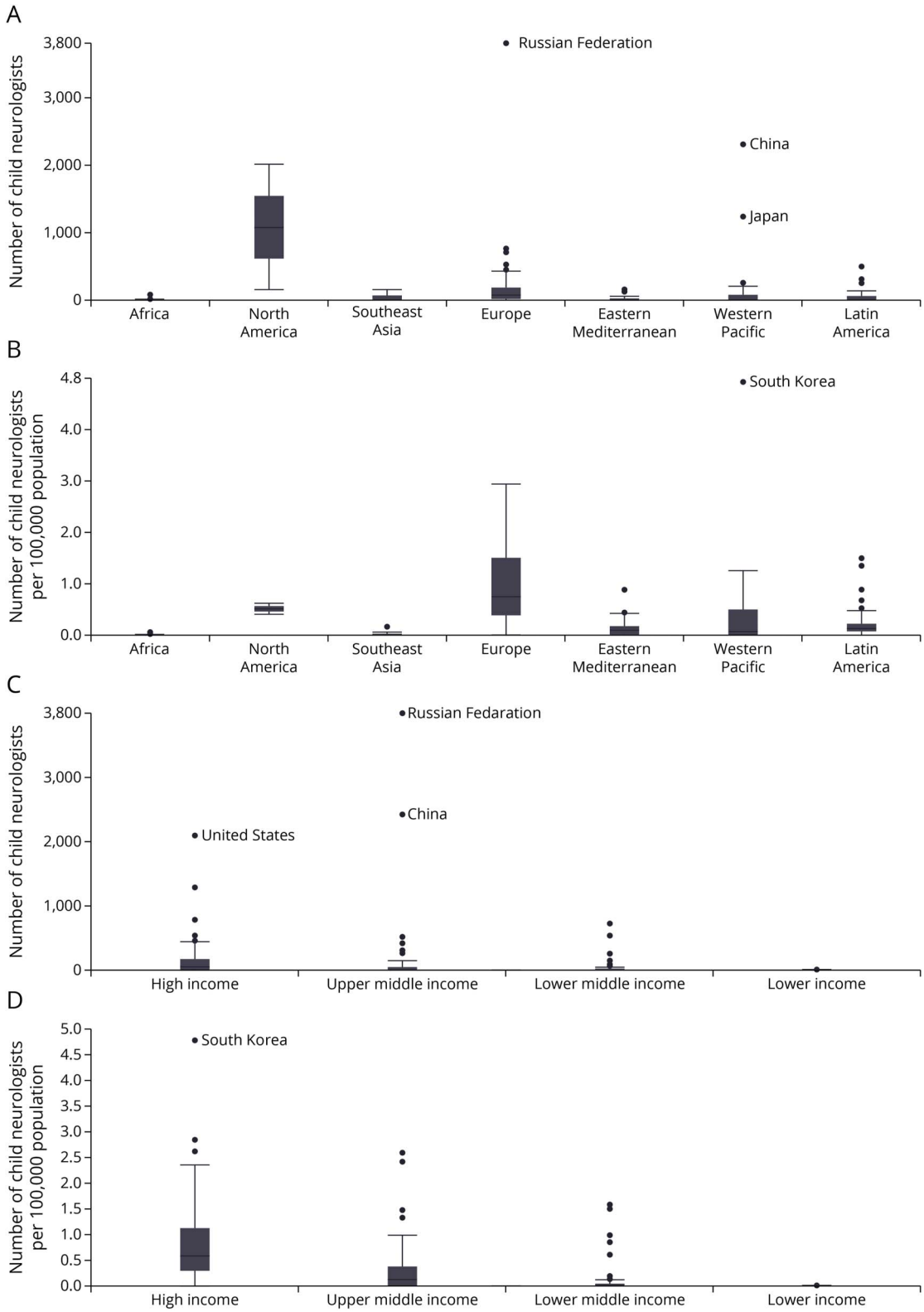
In LMICs (n = 52/55), there were no child neurologists in 18 countries, 13 countries had between one and 8 child neurologists, 5 countries between 10 and 13 child

Table 1 Summary of World Health Organization Regions and World Bank Country Income Categories for Mean and Median Child Neurology Ratios per 100,000, Access to Training, and Pediatric Neurology Associations

Region (total countries in region)	Number of countries (+Additional countries[a]) = total	Missing countries[b]	Mean child neurologists per 100,000 (standard deviation)	Median child neurologists per 100,000 (interquartile range)	Access to in-country training[c] (%)	Pediatric Neurology Association (%)[d]
The Americas—North America (2)	2	0	0.5 (0.146)	0.5 (Q1 0.397)	2 (100)	2 (100)
The Americas—Latin America (33)	26	7	0.27 (0.385)	0.14 (Q1 0.058–Q3 0.271)	14 (54)	13 (50)
European (53)	50	3	0.96 (0.76)	0.74 (1.133)	42 (82)	40 (78)
African (47)	46	1	0.007 (0.013)	0 (0.007)	7 (15)	4 (8)
Eastern Mediterranean (21)	21 (+1) = 22	0	0.13 (0.19)	0.09 (0.169)	12 (55)	10 (45)
South-East Asia (11)	11	0	0.03 (0.044)	0.01 (0.033)	5 (45)	2 (18)
Western Pacific (27)	18 (+2) = 20	9	0.47 (1.068)	0.09 (0.57)	12 (60)	10 (50)
High Income (82)	53	29	0.87 (0.856)	0.59 (0.854)	41 (77)	—
Upper Middle Income (54)	44	10	0.34 (0.601)	0.14 (0.437)	27 (61)	—
Lower Middle Income (55)	52	3	0.137 (0.346)	0.016 (0.08)	24 (46)	—
Low Income (28)	28	0	0.002 (0.004)	0 (0.005)	1 (3.5)	—

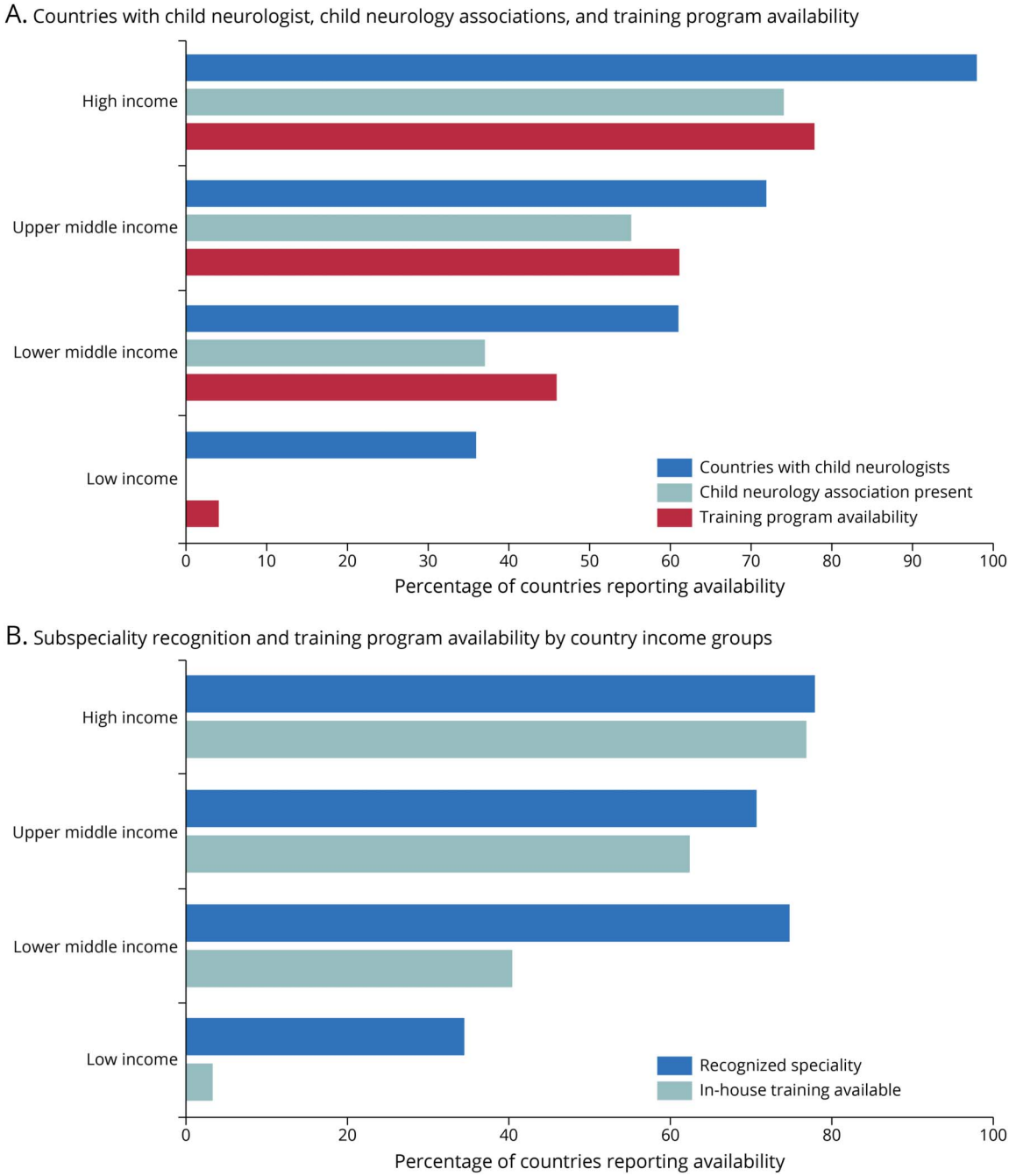
[a] Nonmember state countries included: Eastern Mediterranean region: Palestine territories. Western Pacific region: Hong Kong and Taiwan.
[b] Missing data: Latin America: Antigua and Barbuda, Barbados, Dominica, Grenada, Saint Kitts and Nevid, Saint Lucia, Saint Vincent, and the Grenadines. European region: Andorra, Monaco, and San Marino. African region: Congo. Western Pacific region: Cook Islands, Kirbtai, Marshal Islands, Nauru, Niue, Palau, Samao, Tonga, and Tuvalu.
[c] Accreditation status in WHO regions: Latin America: 3 accredited, 1 in process. African: 4 accredited, 1 in process, 2 not recognized. Eastern Mediterranean: 8 accredited, 2 in process, 2 not recognized. South-East Asia: 3 accredited, 2 in process. Western Pacific: 9 accredited, 3 in process.
[d] Additional associations supporting child neurology in country. African: 12 adult neurology, 2 pediatric. South-East Asia: 3 pediatric, 2 adult.

Figure 2 Distribution of Child Neurologists According to WHO Region (A and B) and World Bank Country Income Groups (C and D)



(A) Box plot of the actual number of child neurologists according to WHO region demonstrating the range and outliers. (B) Box plot based on WHO regions for the number of child neurologists per 100,000 population demonstrating the range and outliers. (C) Box plot of the number of child neurologists according to the World Bank country income status groups showing ranges and outliers. (D) Box plot of the number of child neurologists per 100,000 according to the World Bank country income status groups showing ranges and outliers.

Figure 3 Worldwide Access to Pediatric Neurology Training Programs



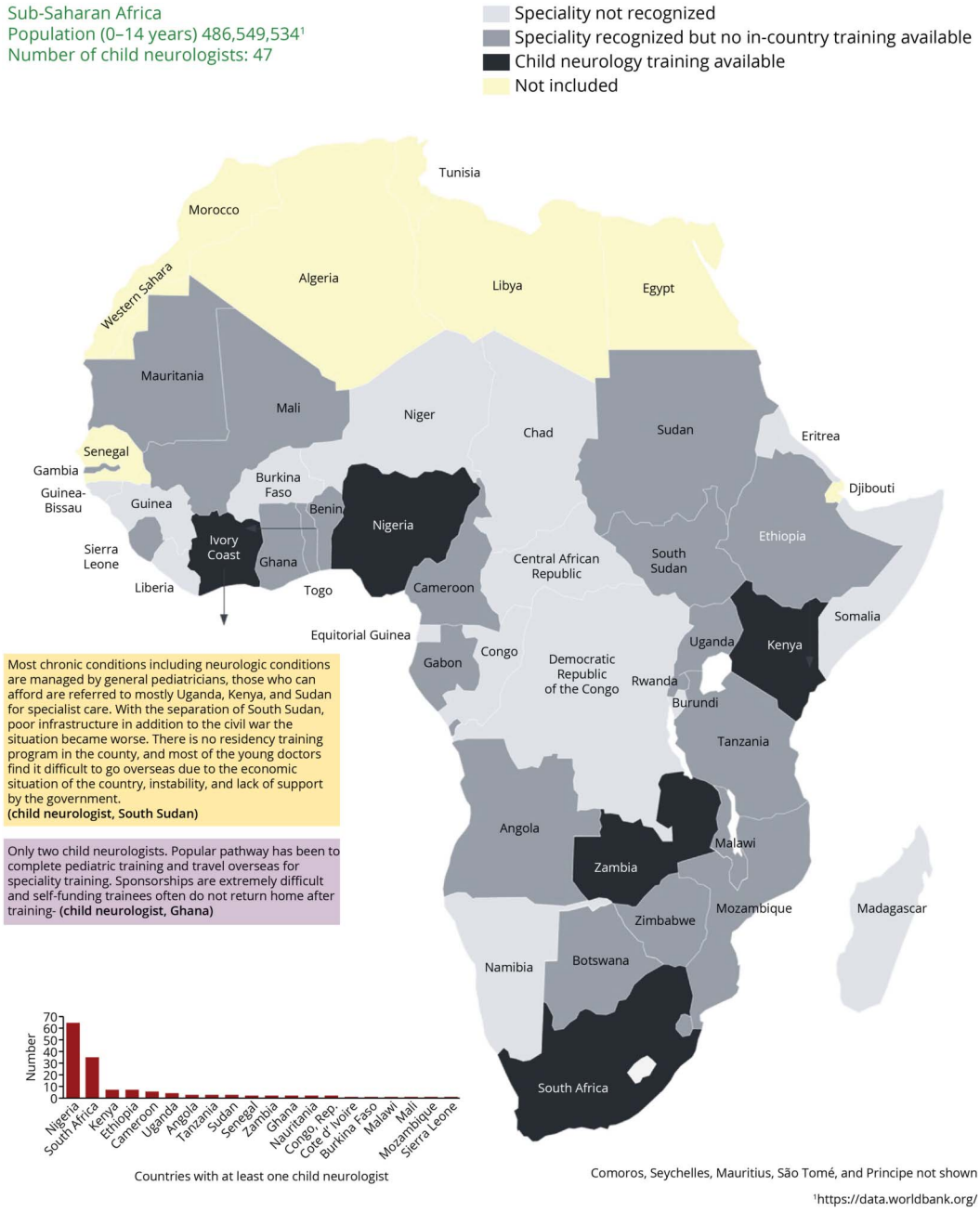
(A) Percentage comparisons of the proportions of child neurologists, access to training, and capacity for in-country training across LICs, LMICs, UMICs, and HICs. (B) Subspecialty recognition and training program availability by country income groups. HIC = high-income country; LIC = low-income country; LMIC = low middle-income country; UMIC = upper middle-income country.

neurologists, 10 countries between 20 and 97 child neurologists, and the remainder between 115 and 700 child neurologists. The greatest numbers reported were from Uzbekistan (n = 515) and Ukraine (n = 700). Nineteen countries had child neurology associations.

In UMICs (n = 44/54), there were no child neurologists in 15 countries, one country had 2 child neurologists, 10 countries had between 10 and 20 child neurologists, another 10 countries had between 21 and 100 child neurologists, 5 countries had between 107 and 500 child neurologists, and the greatest numbers were reported from China (n = 2,300) and the Russian Federation (n = 3,800). Twenty-four countries had child neurology associations.

In HICs (n = 53/82), 15 countries also with small populations had between 2 and 7 child neurologists, 4 countries had between 11 and 20 child neurologists, 16 countries had between

Figure 4 Infographic for the Sub-Saharan Africa Child Neurology Capacity Inclusive of Key Open Comments That Echoed Common Themes



25 and 97 child neurologists, 12 countries had between 135 and 250 child neurologists, and 4 countries had between 441 and 750 child neurologists. The highest numbers were in Japan (n = 1,226) and the United States (n = 2,000). The HICs had no response from 28 countries, which were often islands with small populations. Forty countries had child neurology associations.

Overall, for the 177 countries with data recorded, there is a median of 0.07 and mean of 0.39 child neurologists per 100,000 population. Ninety-four countries had capacity to support in-country pediatric neurology training. The continent of Africa with a population of 1.37 billion had 324 child neurologists, with a per-country median of 0.01 per 100,000 population.

Discussion

This report provides an overview of the geographic distribution of pediatric neurologists and of the capacity for training in the discipline. The small number of child neurologists, especially in LICs, was noted in the 2017 WHO/WFN report on neurologic services.[5] The lack of health care professionals in these regions is a challenge across all levels of care. The WHO

has established that 18 million more health workers are needed to achieve Universal Health Coverage by 2030 in LICs and LMICs and that 9 million more nurses and midwives are needed by 2030 to reach Sustainable Development Goal 3 on health.[10] As such, should we be motivating for specialists? Currently, care for children with neurologic diseases in many regions falls to pediatricians, adult neurologists, and psychiatrists with an interest in pediatric neurology, as well as community or primary health care workers who are ill-equipped to deliver care.[6,7,11] Creating a body of specialists, even in small numbers, is an opportunity to shift the paradigm, promote brain health, and enhance care for children with neurologic disorders across the world.[12]

Of the 114 countries which responded in the WHO/WFN Atlas report, the global median total neurology workforce (i.e., total number of adult neurologists, neurosurgeons and child neurologists) was 3.1 per 100,000 population.[5] Similar to our study, there were disparities for access to specialists in LICs with a median of 0.1 per 100,000 population, compared with a median of 7.1 per 100,000 population in HICs. Specifically for child neurologists, the report found 0.002 per 100,000 population in LICs compared with 0.39 per 100,000 population in HICs. In our study, the median value was zero for LICs and 0.59 per 100,000 for HICs. The discrepancy in these estimates could be explained by ICNA's more effective connections to national pediatric and pediatric neurology representatives in most countries of the world, as is reflected by our study recruiting responses from 177 countries compared with the WHO/WFN Atlas report's 114 country responses. In addition, there is a five-year gap between these 2 studies, and over this time, fluctuations in health care provision are inevitable, especially with recent political and health care upheavals.

Specific to the first 2 objectives of the project ((1) which countries have child neurologists? (2) what is the ratio of child neurologists per population?), the lowest number of child neurologists (0.007 per 100,000 population) was seen in the African region. Our study found a median of 0.01 per 100,000 population that was marginally better than the WHO/WFN Atlas report but still far below critical needs. The report highlighted the strikingly low number of child neurologists across all income categories and WHO regions and considered this of particular concern. Our research supports the WHO/WFN Atlas report conclusion that emphasized the deficit of adult and child neurologists and neurosurgeons in LICs and LMICs, especially in the African and South-East Asia regions. These regions are notable for their burden of disease, related to the high incidence of prematurity, neonatal brain insults, and infections of the central nervous system.[4] The Latin American region has additional barriers to developing child neurology care related to political crises, as well as the worldwide health care disruptions, which occurred with the COVID-19 pandemic.[11]

Where there has been lack of awareness, diagnosis, or treatment of many neurologic disorders in childhood, there is gross underestimation of their prevalence. Subsequently, with growth in specialists, there is an increase in identification of disease. Once clinicians return to their home setting and establish new services, this unleashes a flood of health care service demands and the need to train further clinicians to avoid burnout in the returned clinicians.

The Intersectoral Global Action Plan (IGAP) on Epilepsy and Other Neurological Disorders 2022–2031 was adopted unanimously by all countries at the 75th World Health Assembly.[13] This commits the governments of countries represented in the WHO to prioritize brain health over the next decade and facilitates placing brain disorders as priority agenda items to policymakers. The IGAP has 5 strategic objectives concerning neurologic diseases throughout the life cycle (thus explicitly including neurologic diseases of childhood) to reach by 2031. Training and education are key areas promoted in the report.

The third project objective was to answer "which countries currently provide pediatric neurology training?" We found wide regional variance to the disadvantage of LICs and the African region (Table 1). The magnitude of achieving Universal Health Coverage inclusive of adequate numbers of qualified health care providers can be overwhelming and requires strategic planning. The migration of pediatric neurology specialists to HICs when trained abroad remains a huge problem in LICs, LMICs, and even UMICs. The African Paediatric Fellowship Program (APFP) coordinates training of African doctors within Africa such that the international level of training still accommodates for the local health care challenges and supports the clinician after training as they establish services where often nothing has existed before.[12] To date, 10 clinicians have completed child neurology specialist training and returned to 8 African countries, often as the first such specialist. These individuals must be supported to be positioned as leaders and advocates in their fields. Their knowledge and insight into local systems increases their likelihood of success in developing services with an effect at an operational level and then at the macro and institutional level.[14] The APFP model of partner centers actively recruiting trainees and capacitating positions for their return increases the retention in public health services. This can be very challenging to implement, and the trend that returning specialists move into more lucrative private practice is a further barrier to broader health care access.[15] This is a problem in most resource-poor regions, including Latin America, South-East Asia, and Africa. Doctors may work in both public and private systems. Without government support and adequate infrastructure, services in the public setting are limited. The involvement of private practitioners with specialized training in collaborative efforts to support the public sector may improve child neurology care. Successful training models will be explored in the next phase for objectives 4 and 5 of the project. These include, along with the APFP, innovative training collaborations across groups such as the neurology department in Sfax, Tunisia, which has trained Algerian

pediatricians in pediatric neurology since 2017. A certificate between Tunisia, Guinea, and Morocco on neurologic diseases of children is available in French since 2019 at the Faculty of Medicine of Sfax. Kenya and Zambia have recently established in-country training in pediatric neurology. The Global Regional Initiative Program (GRIP) developed by the ICNA is a project whereby a specific area is identified for elevating skills in child neurology. The 2022–2023 GRIP aims to improve child neurology capacity in Zimbabwe.[16] The ICNA, CNS, the Japanese Child Neurology Society, and APFP have pooled resources to support the project. This concept has been accepted across other leading child neurology bodies and a joint committee formed to support further projects, until sustainability is evident. The open comments from the African and Eastern Mediterranean regions especially noted the major barriers faced in resource-limited settings to upskill care delivered. The points noted will be included in the subsequent development of concepts to upscale child neurology clinician training.[17,18] The US collaboration in Armenia highlights similar issues and the need to be innovative through the onsite mentorship by visiting specialists.[19]

Limitations: Our survey dissemination included a targeted sampling frame and the EPNS survey pooled data. As such, some nonprobability samples potentially resulted in self-selection bias. Respondents were encouraged to communicate with colleagues, nominate the most equipped respondent, and verify the survey responses. Some ratios were disparate, with higher numbers of child neurologists reported for a population compared with other apparently similarly resourced settings, for example, Eastern European countries. This report aimed to attain information on numbers of clinicians providing dedicated care for children with neurologic conditions. As such for some of the respondents, this equated to "a doctor who has expertise in diagnosing and managing a range of neurological disorders affecting children from the neonatal period through adolescence" rather than the WHO definition of "a medical doctor with successfully completed subspecialist training in child neurology in a recognized teaching institution."[5] Our survey did not address the distribution of subspecialist expertise in remote or rural areas vs urban areas. This should be a further area for exploration. In countries with no child neurologists, it was often challenging to find the optimal contact point. These regions were viewed as being of critical importance and as targets for future support, both identifying structures to aid in access to child neurologists but also to identify effective collaborators ideally from the same region with insight into the local challenges and health care needs.

Conclusions

The lack of child neurologists in the world is an obvious problem driven by limited capacity to provide training, followed by lack of prioritization to create opportunities to develop child neurology services from a government level. Nonetheless, clinicians must also have the desire and interest to undertake a career in neurology, especially child neurology. "Neurophobia" (the fear of basic neural sciences and clinical practice neurology) was the leading cause behind medical students' and practitioners' perception of neurology as the most challenging specialty.[20-22] Demand for neurologists working in the United States by 2025 is estimated to exceed supply by 19%.[20] Despite this need, in 2022, 9.6% (16 of 166) of the child neurology positions in the United States were unfilled.[23] Undergraduate medical curricula are criticized as being disconnected with the subsequent reality of clinical practice.[24] This aligns with the need for social accountability in medical education as defined by the WHO in 1995, which promoted that education, research, and service activities should focus on the priority health concerns of the community, region, and/or nation they serve.[25] In light of the high burden of both acute and chronic neurologic diseases, this further supports the need to prioritize education in this field.[4] The aim should be to produce a generation of clinicians with neurophilia, eager to pursue a career in child neurology, and to enable them to do it successfully.

The concept of what defines a child neurologist differs across regions, and time required for accreditation is variable. In Nigeria, many clinicians caring for pediatric neurologic disorders previously lacked access to formal training. Training and subsequent skills support should be available and targeted at equipping the practitioner with the resources to deliver effective care to their patients. Objective 4 will explore "what are the main components of core curricula?" and will use the Delphi method for achieving consensus about a final curriculum. Objective 5 directed to evaluate "what constitutes the essential curricula content?" ultimately aims to provide a resource for centers that intend to establish their own pediatric neurology training programs. This curriculum will provide a roadmap for core domains, competencies, and learning objectives. It should be adapted for the local setting to strengthen relevance. The final part of the project will include innovative models to expand child neurology training to regions in need of additional expertise, inclusive of telehealth models and virtual learning platforms, as illustrated by the British Paediatric Neurology Association distance courses, the ILAE academy, and the International Child Neurology Teaching Network modules.

Recommendations

The authors propose the following recommendations to improve child neurology training and practice in poor-resource settings.

1. The current number of pediatric neurologists in the world is inadequate, and as a child right, issues need to be addressed urgently.
2. Improved access to pediatric neurology training programs worldwide, especially in LMICs, is necessary.

3. National and international medical societies should foster HIC to LMIC collaborations to provide training, improve infrastructure, and foster research to the benefit of local communities.
4. Collaborations with colleagues from resource-equipped settings should be sensitive to LMIC disease profiles and local infrastructure.[26-28]
5. The demand for child neurology care will increase as specialists begin to recognize and treat the different neurologic disorders.
6. Newly trained child neurologists need ongoing support from local governments and health ministers.
7. Educators should incorporate neuroscience in the medical education curriculum.
8. Virtual platforms should be promoted to support the potential for international collaborative activities.
9. Collaborative projects and local governments need to support multidisciplinary teams needed for the practice of child neurology, especially to comanage complex patients (for example, (neuro)psychologists, child psychiatrists, neurosurgeons, rehabilitation therapists, technologists, nurses).
10. Incorporation of innovative technology and effective tools should be promoted and included in training programs to improve diagnosis, management, and treatment of child neurology diseases.
11. Promotion of large multisociety collaborative programs in line with the Intersectoral Global Action Plan on Epilepsy and Other Neurological Disorders is needed.

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J.M. Wilmshurst serves on the advisory board for the South African branch of Novartis and Sanofi. Honoraria received for work as associate editor for Epilepsia and chief editor for the pediatric neurology subsection of Frontiers in Neurology. C. Catsman-Berrevoets reports no disclosures relevant to the manuscript. D.L. Gilbert reports no disclosures relevant to the manuscript. L. Nagarajan received Honoraria from UCB, Novartis, and Biogen. P. Samia reports no disclosures relevant to the manuscript. E. Serdaroglu reports no disclosures relevant to the manuscript. C. Triki reports no disclosures relevant to the manuscript. J. Vidaurre reports no disclosures relevant to the manuscript. B. Hameed reports no disclosures relevant to the manuscript. Go to Neurology.org/N for full disclosures.

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Name	Location	Contribution
Jo M. Wilmshurst, MB, BS, MRCPaed, FCPaed, MD	Department of Paediatric Neurology, Red Cross War Memorial Children's Hospital, Neuroscience Institute, University of Cape Town, South Africa	Drafting/revision of the manuscript for content, including medical writing for content; major role in the acquisition of data; study concept or design; analysis or interpretation of data
Coriene Catsman-Berrevoets, MD	Department of Paediatric Neurology, ErasmusMC / Sophia Childrens Hospital, Rotterdam, the Netherlands	Drafting/revision of the manuscript for content, including medical writing for content; major role in the acquisition of data
Donald L. Gilbert, MD, MS	Division of Neurology, Cincinnati Children's Hospital Medical Center; Department of Pediatrics, University of Cincinnati College of Medicine, OH	Drafting/revision of the manuscript for content, including medical writing for content; major role in the acquisition of data
Lakshmi Nagarajan, FRACP	Department of Neurology, Perth Children's Hospital; Faculty of Health and Medical Sciences, UWA; Telethon Kids Institute, Perth, Australia	Drafting/revision of the manuscript for content, including medical writing for content; major role in the acquisition of data
Pauline Samia, MPhil	Department of Paediatrics and Child Health, Medical College, Aga Khan University, Nairobi Kenya	Drafting/revision of the manuscript for content, including medical writing for content; major role in the acquisition of data
Esra Serdaroglu, PhD	Department of Child Neurology, Gazi University School of Medicine, Ankara, Turkey	Drafting/revision of the manuscript for content, including medical writing for content; major role in the acquisition of data
Chahnez Triki, MD	Child Neurology Department, Hedi Chaker Hospital, University of Sfax, Tunisia	Drafting/revision of the manuscript for content, including medical writing for content; major role in the acquisition of data
Jorge Vidaurre, MD	Pediatric Clinical Neurophysiology Fellowship, Nationwide Children's Hospital, The Ohio State University	Drafting/revision of the manuscript for content, including medical writing for content; major role in the acquisition of data
Biju Hameed, PhD	Department of Paediatric Neurology and Neurodisability, Great Ormond Street Hospital for Children, London	Drafting/revision of the manuscript for content, including medical writing for content; major role in the acquisition of data; study concept or design; analysis or interpretation of data

Appendix 2 Coinvestigators

Name	Location	Role	Contribution
Anna Basu PhD	Population Health Sciences Institute, Newcastle University and Paediatric Neurology, Great North Childrens Hospital, Newcastle upon Tyne, Uk	Coinvestigator	Involved in early discussions; Supervision of student data collection; assistance with data collection; reviewed manuscript
Hans Hartmann, PhD	Hannover Medical School, Hannover, Germany, Clinic for Paedatric Kidney-, Liver- and Metabolic Disorders	Coinvestigator	Data acquisition (Europe), revision of manuscript
Anaita Hedge, MD	Narayan Health, Paediatric Neurology Department, Mumbai, India	Coinvestigator	Data acquisition, Asia
Elmina Kuc, MB ChB	Charite University Berlin	Coinvestigator	Medical elective project, support early analysis of data
Thuvina Aruku Naidu, MBBS	Gateshead Health NHS Foundation Trust	Coinvestigator	Involved in early discussion and planning of the project, assisted with data collection
Javarayee Pradeep, MD	Department of Neurology, Medical College of Wisconsin, Milwaukee, WI, USA	Coinvestigator	Initial planning of the project, reviewing the manuscript.
Arya Ravindra, MB BS	Division of Neurology, Cincinnati Children's Hospital Medical Center, Cincinnati, Ohio, USA	Coinvestigator	Initial planning of the project
Pratibha Singhi, PhD	Pediatric Neurology Amrita Hospital Faridabad	Coinvestigator	Initial planning of the project
Silvia. Tenenbaum MD	National Pediatric Hospital Dr. J. P. Garrahan Buenos Aires, Argentina	Coinvestigator	Initial planning of the project, data acquisition

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