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The challenges of establishing centers for the surgical management of epilepsy in low- and middle-income countries

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ABSTRACT

Epilepsy affects over 50 million individuals globally, with more than 80 % residing in resource-limited countries. While the majority of patients achieve seizure control with antiseizure medications, approximately one-third are diagnosed with drug-resistant epilepsy (DRE). For these individuals, epilepsy surgery represents a potentially effective therapeutic option. Expert consensus from the Surgical Therapies Commission of the International League Against Epilepsy (ILAE) recommends prompt referral for surgical evaluation upon diagnosis of DRE. Nevertheless, despite substantial supporting evidence, such referrals are frequently delayed—particularly in low- and middle-income countries (LMICs). This article examines the barriers to timely surgical evaluation and explores strategies to facilitate the development of epilepsy surgery programs in resource-constrained settings.

Introduction

Epilepsy affects over 50 million people globally, with more than 80 % residing in resource-limited countries.[1,2] The incidence of epilepsy in low- and middle-income countries (LMICs) is nearly three times higher (139.0 per 100,000; 95 % CI: 69.4–278.2) than in high-income countries (48.9 per 100,000; 95 % CI: 39.0–61.1).[3] This increased burden is attributed in part to higher rates of perinatal complications, traumatic brain injury, and infections involving the central nervous system—established risk factors for epilepsy.

In LMICs, the treatment gap—defined as the proportion of people with epilepsy (PWE) who require but do not receive treatment—exceeds 75 %.[4] This gap varies both across and within countries, often reflecting disparities between urban and rural healthcare infrastructure. While large medical centers with access to neurologists are typically located in major cities,[5] rural regions remain underserved. Additionally, diagnostic resources such as electroencephalography (EEG) and magnetic resonance imaging (MRI) are often scarce or unavailable.[6]

Drug-resistant epilepsy and epilepsy surgery

Most individuals with epilepsy achieve adequate seizure control with antiseizure medications. However, approximately one-third are diagnosed with drug-resistant epilepsy (DRE), defined as the failure to achieve sustained seizure freedom with adequate trials of two appropriately chosen and tolerated antiseizure medications.[7] Epilepsy surgery represents a potentially curative treatment option for this large patient population. It is estimated that up to 10 million individuals globally may be candidates for epilepsy surgery,[8] although this figure is likely an underestimation.

Recent International League Against Epilepsy (ILAE) guidelines recommend considering surgical referral even earlier in the disease course—for example, when a patient remains seizure-free on 1–2 medications but has an identifiable lesion in non-eloquent cortex.[9] Early intervention is particularly critical in children, where epilepsy surgery can not only reduce or eliminate seizures but may also improve cognitive outcomes and quality of life.[10,11] Surgical evaluation is therefore recommended promptly upon diagnosis of DRE.[9]

Barriers to establishing epilepsy surgery programs in LMICs

Despite growing evidence supporting the efficacy and safety of epilepsy surgery, referrals for surgical evaluation are frequently delayed worldwide, especially in LMICs. This delay reflects several systemic

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challenges, including the technology-intensive nature of epilepsy surgery and the limited availability of necessary diagnostic tools and infrastructure in resource-constrained settings.[12] Comprehensive presurgical evaluations—often involving video-EEG monitoring, high-resolution MRI, neuropsychological testing, and intracranial monitoring using subdural grids or depth electrodes—are costly and frequently inaccessible in LMICs, particularly in the public sector where health expenditures are limited (Table 1).

The ILAE Pediatric Epilepsy Surgery Task Force has delineated two levels of surgical centers based on available resources and competencies.[13] Basic (Level 1) centers serve children aged 9 years and older with single, well-defined lesions and require a pediatric epileptologist, a general pediatric neurosurgeon, video-EEG, and access to an MRI scanner with a magnet strength of at least 1.5 Tesla. Advanced (Level 2) centers provide comprehensive care for children of all ages in dedicated pediatric settings, with multidisciplinary teams trained in pediatric neurology, epilepsy, neurophysiology, neuroimaging, and epilepsy surgery. These centers should have access to high-field 3-Tesla MRI scanners, and may also utilize functional MRI (fMRI), PET, and SPECT imaging. They are equipped to perform intracranial EEG monitoring and conduct resections involving normal MRI, deep lesions, or regions near eloquent cortex. Level 2 centers also provide integrated specialty services such as pediatric intensive care and rehabilitation.

Surgical outcomes correlate closely with procedural volume, and the ILAE recommends that even lower-complexity centers perform a minimum of 15 surgeries annually, excluding vagus nerve stimulator (VNS) implantation.[14] To meet these thresholds, collaboration with high-volume centers is essential. Successful strategies in LMICs include training dedicated team members to develop local programs and forming partnerships with experienced epilepsy surgery centers.[15] Adaptations to local resource constraints are often necessary. For example, in cases with clearly defined unilateral lesions and concordant interictal EEG, ictal EEG monitoring may not be essential for presurgical evaluation.[16] Programs in LMICs should prioritize patient selection, focusing on lesional cases that are more likely to benefit from surgical intervention. This is especially relevant in pediatric populations, where DRE is frequently associated with developmental and epileptic encephalopathies.[17] Many of these patients are candidates for lesionectomy, hemispherectomy, or palliative procedures such as corpus callosotomy, all of which can result in substantial improvements in seizure control and quality of life. Some LMICs, including countries in Latin America and Asia, have made considerable progress in building surgical epilepsy capacity. In contrast, centers in sub-Saharan Africa are still in the early stages of program development.[18]

Table 1
List of selected Latin American and Caribbean countries by 2024 Gross Domestic Product (GDP) in US dollars. Percentage of their GDP invested in healthcare. Healthcare expenditures per capita for the biennium 2021-2022 Available at: https://datatopics.worldbank.org/health/ Accessed on 6/28/2025.

Selected Latin American and Caribbean countries	2024 gross domestic product (GDP) in USD	Percentage invested in healthcare in 2021	2021-2022 per capita healthcare expenditures USD
Uruguay	$23,053	9.36 %	$1,620
Panama	$19,369	9.68 %	$1,415
Costa Rica	$17,860	7.57 %	$949
Chile	$16,365	9.00 %	$1,381
Mexico	$13,972	6.08 %	$611
Argentina	$12,814	9.71 %	$1,045
Dominican Republic	$11,692	4.92 %	$417
Brazil	$10,296	9.89 %	$761
Peru	$8,316	6.15 %	$412
Colombia	$7,917	9.02 %	$558
Cuba	$7,599	13.79 %	$1,186
Ecuador	$6,758	8.29 %	$494
Guatemala	$6,295	6.90 %	$341
Paraguay	$5,869	8.03 %	$479
El Salvador	$5,607	9.72 %	$442
Venezuela	$4,019	4.04 %	$160
Bolivia	$3,920	8.16 %	$273
Honduras	$3,446	9.16 %	$254
Nicaragua	$2,878	9.68 %	$198

Regional experience: Latin America

In 2019, Latin America and the Caribbean accounted for 9.5 % of the global epilepsy burden, ranking third among world regions.[19] However, access to epilepsy surgery remains limited. A recent survey by the International Consortium in Epilepsy Surgery Education found that only five countries in the region had EEG and epilepsy training programs—Brazil (17), Argentina (9), Chile (5), Mexico (3), and Colombia (1)—and that most of these programs were based in private institutions.[20] According to Lemus et al. and Campos et al., 88 % of epilepsy surgery centers in Latin America and the Caribbean perform resective procedures, with temporal lobe resections accounting for 42.3 % of all surgeries.[21,22] Extratemporal resections and corpus callosotomies are also performed, although their availability varies by region. Of the 26 centers using invasive monitoring (depth and/or subdural electrodes), in Latin America and the Caribbean, 88 % were located in South America, and only 12 % in Central America.[21] A case example illustrates how sustained collaboration can lead to progress. The first author of this article is involved in the development of a pediatric epilepsy surgery program in El Salvador, supported by two U.S.-based level-4 epilepsy centers and two local pediatric neurologists. Over a 12-year period, the team has completed 21 surgeries, including hemispherectomies, temporal lobectomies, focal resections (with and without intracranial EEG monitoring), and VNS implantation.[23] The success of the program has hinged on strong local engagement and support from a local epilepsy foundation. Nevertheless, geographic disparities persist. In Colombia, for instance, although roughly 15 general hospitals could offer epilepsy surgery - concentrated in large cities such as Bogotá, Medellín, and Cartagena - only one pediatric hospital in the country has an established epilepsy surgery program (unpublished data, Pérez-Poveda JC).

Conclusion

Establishing epilepsy surgery programs in LMICs presents complex challenges, including limited awareness of surgical options, inadequate financial and infrastructural resources, and a shortage of specialized personnel. These constraints are compounded by a lack of EEG technologists, insufficient understanding of surgical benefits, and persistent stigma and misperceptions about epilepsy surgery.[25–27] Overcoming these barriers requires multifaceted strategies: engaging policymakers, allocating healthcare funding to epilepsy care, and building collaborative partnerships with established epilepsy centers. With sustained effort and strategic investment, it is possible to develop high-impact, resource-adapted epilepsy surgery programs that improve outcomes for patients in underserved regions.

Ethical disclosure and author contributions

The authors conducted a comprehensive review of the literature, drafted the initial version of the manuscript, and incorporated feedback and revisions from peer reviewers. The final version of the manuscript was edited using ChatGPT (OpenAI), with the specific intent of refining language, clarity, and structure to meet the standards of scientific journal publication. All authors reviewed and approved the final version of the manuscript prior to submission. Using AI in this manner is aligned with Elsevier's "Generative AI policies for journals" available at: https://www.elsevier.com/about/policies-and-standards/generative-ai-policies-for-journals#1-for-authors and accessed 6/30/2025.

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CRediT authorship contribution statement

Jorge Vidaurre: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Supervision, Writing – original draft, Writing – review & editing. **Juan C Pérez-Poveda:** Conceptualization, Data curation, Formal analysis, Investigation, Writing – original draft, Writing – review & editing. **Manuel Campos-Puebla:** Conceptualization, Data curation, Formal analysis, Investigation, Writing – original draft, Writing – review & editing. **Pedro Weisleder:** Data curation, Methodology, Supervision, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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