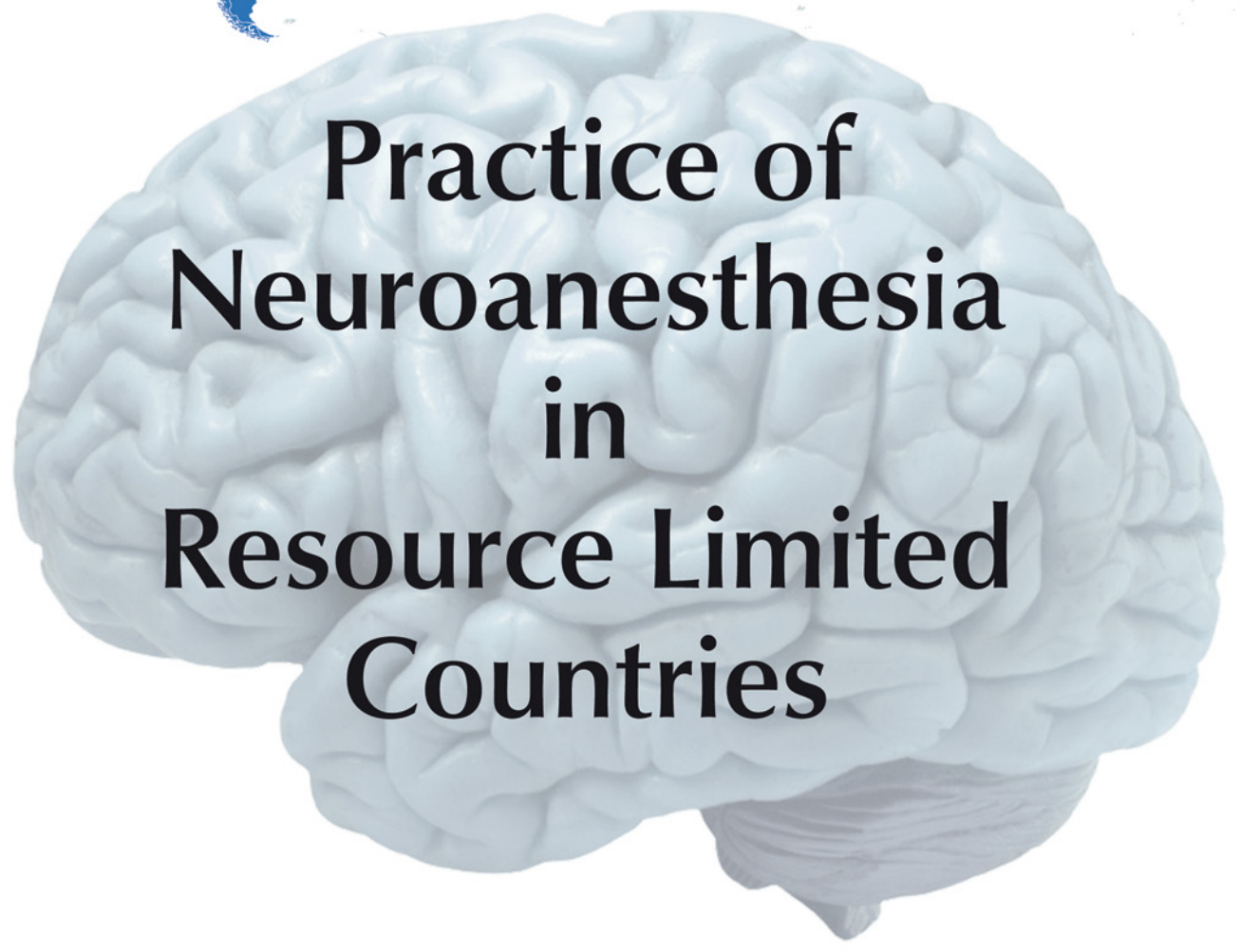
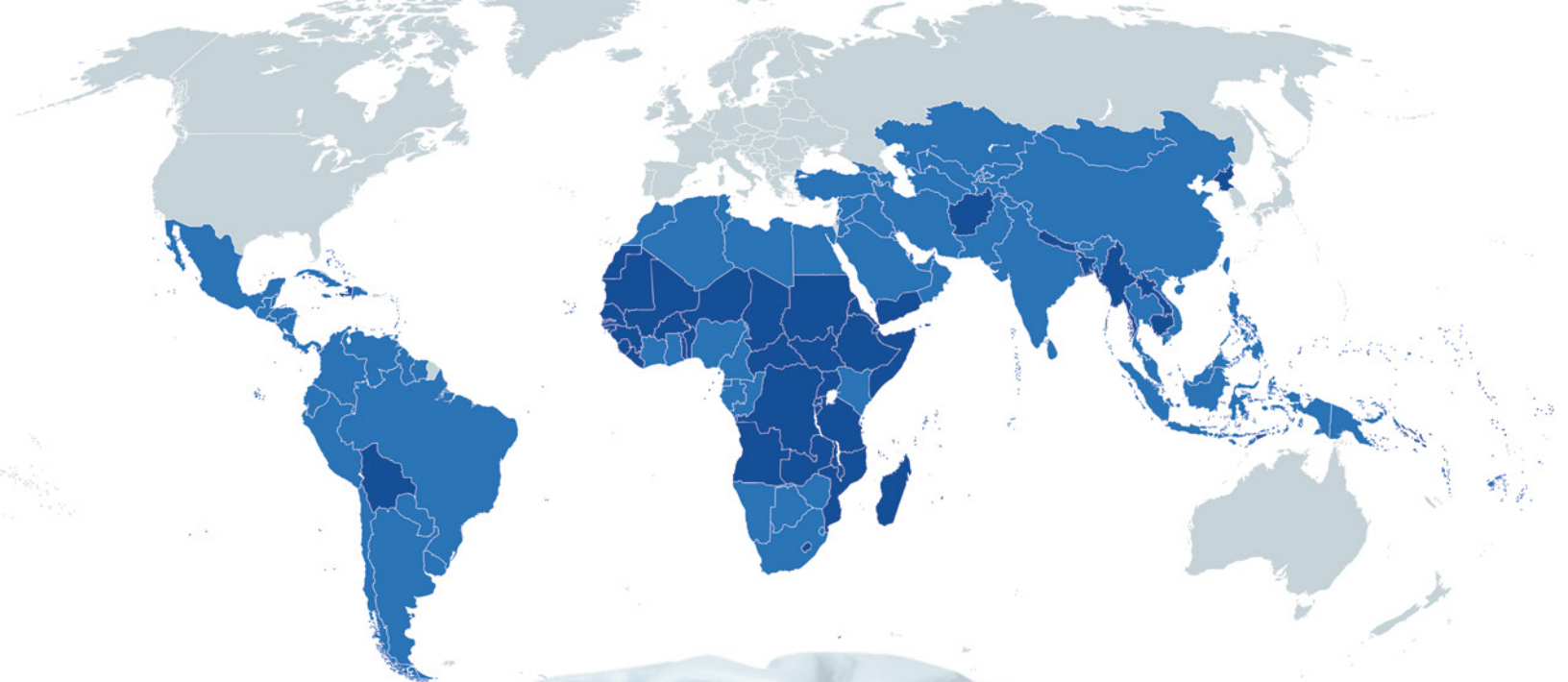




Practice of Neuroanesthesia in Resource Limited Countries

Edited by
Hemanshu Prabhakar
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Charu Mahajan



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Dedication

To the tireless clinicians, nurses, and healthcare workers across the world who deliver neuroanesthesia care with skill and determination—often in the face of limited resources, overwhelming challenges, and unseen sacrifice.

To all neuroanesthesia professionals working in the most resource-constrained corners of the world—who bring knowledge and compassion to the operating room each day, often without recognition, and sometimes without the equipment they need.

Your courage to care under pressure, innovate under constraint, and advocate for your patients in the face of adversity is the true inspiration behind this book. Your commitment to your patients, even when the equipment is few and the odds steep, is the true embodiment of excellence in medicine.

This book is for you.

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Foreword

Imagine a man who was injured in a road traffic accident and brought to a district hospital in the night. He was semiconscious with dilated pupils. There was no CT scanner available and no anesthesiologist on duty. His condition progressively deteriorated, and he died the following morning. Another patient presented with a sudden severe headache and lapsed into an unconscious state but regained consciousness within a few hours. He was brought to the hospital. A CT scan of his head showed a subarachnoid hemorrhage. However, the hospital had neither a neurosurgeon nor an intensive care unit to provide specialized care to the patient. In another case, a 15-year-old boy suffered generalized tonic-clonic seizures for 2 hours at home. In the hospital, he was administered injection of diazepam and phenytoin, but the seizures remained uncontrolled. No other antiepileptic drug was available in the hospital, and the seizures continued for another 24 hours. Although the seizures eventually stopped, the boy developed severe cognitive deficits. Such scenarios are not uncommon in middle- and low-income countries.

Patients with neurological conditions often lack financial resources and present late to the hospital with advanced disease states. This delays treatment, increases complexity of care, and results in higher morbidity and mortality.

Neuroanesthesia is a vital subspecialty that supports complex neurosurgical procedures and provides care for patients with critical neurological illness. Conditions such as traumatic brain injury, cerebrovascular diseases, epilepsy, and neuroinfections require specialized management. In resource-limited countries, however, the delivery of neuroanesthesia care is hampered by infrastructural deficits, workforce shortages, and limited access to essential drugs and equipment. This book explores the barriers to neuroanesthesia in such settings and proposes scalable strategies to improve the quality of care and patient outcomes.

Operating rooms in low- and middle-income countries often lack neurosurgery-specific equipment. Unreliable electricity and oxygen supply further compromise patient safety. Imaging modalities like CT and MRI are frequently unavailable or inaccessible. There is also a shortage of anesthesiologists trained in neuroanesthesia. There are limited opportunities for continuing education and subspecialty training in neuroanesthesia. High patient volumes, limited staffing, and the absence of essential drugs reduce care quality. Postoperative care is hindered by lack of neurocritical care units, while rehabilitation services remain underdeveloped, affecting long-term recovery of the patient. Brain drain—immigration of trained professionals to high-income countries—further undermines the health care.

According to the Lancet Commission on Global Surgery (www.thelancet.com, Vol. 386, August 2015), over five billion people worldwide lack access to safe, timely, affordable, and essential surgical and anesthetic care. Limited neurosurgical access contributes significantly to preventable mortality and disability. Patients with traumatic brain injury constitute 55–69 million cases every year.

Equitable distribution of healthcare resources is critical to achieving health for all. For example, Sub-Saharan Africa accounts for 11% of the global population and 24% of the disease burden but has only 3% of healthcare workers. Per capita healthcare expenditure remains below USD 100 for nearly 35% of the world's population, while only 15.6% of people benefit from annual spending above USD 1000 per head. Surgery is an indispensable part of health care. One hundred and forty-three million surgical procedures are required annually to save lives and prevent disability. Investment in surgical and anesthetic care not only saves lives but also promotes economic growth.

Several approaches can strengthen neuroanesthesia care in resource-limited countries. Capacity can be built by developing regional training centers and online education platforms to upskill general anesthesiologists. Mentorship programs, fellowships, and knowledge exchange programs can foster knowledge transfer. Standardized neuroanesthesia protocols tailored to available resources can be implemented. Checklists and simplified algorithms to guide perioperative management can be developed. Targeted investments in equipment, drug procurement, and infrastructure can be made. Private sector stakeholders can be engaged in developing neuroanesthesia capacity in public hospitals. Partnering with international neurosurgical and neuroanesthesia societies for training and research should be encouraged. The International Council for Perioperative Training in Neuroscience in Anesthesiology is an accrediting body that engages

with training programs internationally. Training programs in resource-limited countries should try accreditation by this body to maintain the quality of neuroanesthesia education. To address the issue of brain drain, trainees should be encouraged to return home after overseas training by offering career incentives and growth opportunities. Raising awareness about neurosurgical conditions and the importance of timely intervention is essential. Policymakers must recognize the importance of neurosurgical and neuroanesthetic care and allocate resources and manpower accordingly. Collaborative initiatives between high-income and resource-limited countries can accelerate training and infrastructure development.

This volume compiles knowledge and experience from experts mostly working in resource-limited countries. It provides insights into the realities of neuroanesthesia and neurocritical care in these countries. Progress in neuroanesthesia can be made by learning from one another. With strategic investment in training, infrastructure, and innovation, safe and effective neuroanesthesia care is achievable even in the most constrained settings.

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Preface

Neuroanesthesia is a critical and highly specialized branch of anesthesiology that plays a pivotal role in the management of patients undergoing neurosurgical procedures. It demands an intricate understanding of both neuroscience and anesthetic principles, with patient outcomes closely tied to the precision and timeliness of clinical decisions. While significant advances in neuroanesthesia have been made in high-resource settings, the practice in resource-limited countries remains a complex endeavor—marked by ingenuity, resilience, and an unwavering commitment to patient care despite often formidable constraints.

Practice of Neuroanesthesia in Resource Limited Countries is a timely and much-needed contribution to global medical literature. It offers a window into the challenges and adaptive strategies employed by neuroanesthesiologists working in environments where essential equipment may be scarce, training opportunities limited, and access to advanced monitoring or medications inconsistent. Yet, within these contexts, dedicated professionals continue to deliver safe, effective care—often using creative problem-solving, localized protocols, and shared experiential knowledge passed down through mentorship and collaboration.

This book brings together a wealth of expertise and real-world insight from renowned practitioners who have navigated these challenges first-hand. By doing so, it provides more than just a clinical manual; it offers a powerful narrative of innovation under constraint. Readers will find pragmatic guidance on optimizing care with limited resources and reflections on ethical dilemmas that arise when ideal standards must be balanced with practical realities. The authors bridge the gap between global best practices and local applicability, making this volume a vital resource for both current and aspiring neuroanesthesia providers in low- and middle-income countries (LMICs).

To those training in anesthesia, to those already working in challenging environments, and to educators and policymakers seeking to support these efforts, this book serves as both a guide and an inspiration. It affirms that high-quality neuroanesthesia is not the exclusive domain of technologically advanced centers but an achievable standard wherever there is dedication, adaptability, and a patient-centered ethos.

I commend the authors from different LMICs for compiling this significant work. Their commitment to advancing neuroanesthesia practice in under-resourced settings is evident on every page. This book stands not only as an educational tool but also as a testament to the quiet heroism of clinicians working behind the scenes, often with little recognition, but with immense impact.

Let this book inspire us all—to learn, to teach, to collaborate, and to act—toward a future where the quality of care is not dictated by geographical boundaries but defined by shared commitment and human dignity.

**Hemanshu Prabhakar
Indu Kapoor
Charu Mahajan**

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Part VII

Global collaboration, advocacy, and future directions

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Advocacy and global initiatives for neuroanesthesia in resource-limited countries

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19.1 Introduction

Globally, the burden of neurological diseases leading to disability and death is greatest in low- and middle-income countries (LMICs). Based on the Global Burden of Disease, Injuries and Risk Factors Study, in 2016, neurological disorders (including central nervous system cancers and traumatic brain and spinal cord injuries) were the leading cause of disability-adjusted life-years (DALYs; defined as years of healthy life lost due to premature death and disability) and the second leading cause of deaths worldwide. The bulk of this burden affected LMICs disproportionately (77.3% DALYs and 78.5% deaths; Feigin et al., 2019). In view of the burden of neurological disease in LMICs, there is a need for optimal neuroanesthetic care in LMICs, as part of a multidisciplinary team to improve patient outcomes.

The practice of neuroanesthesia is crucial to patient safety during neurosurgery and neurointerventional radiology procedures. Effective neuroanesthetic care can improve surgical outcomes, reduce morbidity and mortality, and enhance the quality of life for patients with neurological disorders (Khandelwal et al., 2021). However, providing comprehensive neuroanesthesia care faces significant challenges in LMICs, including resource and infrastructure limitations, workforce shortages, and organizational and policy barriers. Recognition of these challenges is important to designing strategies to overcome them. These strategies include national and international initiatives aimed at improving neuroanesthesia services in LMICs.

This chapter explores the challenges LMICs face in providing quality neuroanesthetic services, followed by national and international strategies that are able to strengthen neuroanesthetic practices in these settings. Finally, recommendations to align resources, training, policy, and research towards sustainable improvements are given.

19.2 Challenges faced in neuroanesthesia in low- and middle-income countries

19.2.1 Epidemiological burden

Many LMICs now face a double burden of disease, with communicable diseases remaining prevalent alongside a rapidly rising number of noncommunicable conditions. Neurological illnesses that were once seen mainly in high-income settings, such as stroke and traumatic central nervous system injury, are becoming more common in LMICs (Shrestha and Lamsal, 2020; GBD 2016 Traumatic Brain Injury and Spinal Cord Injury Collaborators, 2019).

The rapid increase in motor vehicle use in many LMICs has exceeded the development and enforcement of effective road safety and vehicle regulations. Weak enforcement of speed limits, low seatbelt and child restraint usage, and poor control of drunk driving significantly contribute to the rising incidence of traumatic brain and spinal cord injuries. At the same time, the ageing global population is causing a steady rise in fall-related TBI. In many LMICs, improvements in life expectancy have not been accompanied by the development of fall-prevention programs or sufficient geriatric care systems.

19.2.2 Workforce constraints

A critical barrier to the provision of optimal neuroanesthesia services in LMICs is the severe shortage of trained anesthesia providers. Based on the Global Anesthesia Workforce Survey conducted by the World Federation of Societies of Anesthesiologists, the total anesthesia provider density was 9.4 per 100,000 population in upper-middle-income countries, 3.5 per 100,000 in lower-middle-income countries, and 2.0 per 100,000 in low-income countries. This represents a 2.5- to 8-fold difference compared to high-income regions (Law et al., 2024). The number of anesthesiologists specialized in neuroanesthesia is even smaller.

There is a shortage of trained neuroanesthesiologist in many LMICs. Most anesthesia training programs in LMICs offer limited exposure to neurosurgical cases, and formal neuroanesthesia fellowships remain rare (Khandelwal et al., 2021). As a result, complex procedures are often managed by anesthesiologists without specialised training in neurophysiology, neuropharmacology, or intracranial dynamics.

19.2.3 Health system challenges

In many LMICs, anesthesia, and by extension neuroanesthesia, has historically received limited attention in national health policies. Many countries, primarily in low- and lower-middle-income countries, do not have dedicated anesthesia councils or regulatory bodies to oversee practice standards. Weak governance structures, fragmented leadership, and underdeveloped data systems contribute to poor planning and inadequate resource allocation in anesthesia service provision. Without policy recognition, neuroanesthesia will continue to remain on the margins of national health priorities.

Infrastructure gaps remain one of the most visible obstacles to safe neuroanesthesia care. Anesthesiologists in LMICs often work with basic monitoring tools, limited to noninvasive blood pressure, electrocardiography, and pulse oximetry, without access to capnography, invasive arterial monitoring, or temperature measurement. Equipment breakdowns are common, and with few biomedical engineers available, even simple faults can take weeks to repair. Outdated machines, defective vaporizers, and incomplete maintenance systems further compromise patient safety (Adams and Dobson, 2025).

Drug shortages are a persistent and frustrating reality for anesthesiologists in LMICs. The causes are complex and often interlinked, ranging from manufacturing and regulatory problems to fragile supply chains and, in some cases, stockpiling or smuggling. When essential agents such as propofol or short-acting opioids are unavailable, clinicians are forced to use less optimal substitutes. These alternatives can delay emergence, complicate postoperative neurological assessments, and increase the risk of medication errors. Beyond patient safety, such shortages carry significant cost implications for both institutions and patients (Khan, 2019).

Postoperative management of neurosurgical patients in LMICs is often limited by the lack of neurocritical care infrastructure. Advanced monitoring technologies such as continuous electroencephalography (EEG) or brain tissue oxygen monitoring are rarely available. Invasive intracranial pressure (ICP) monitoring is conducted only in a few centers, usually in urban tertiary hospitals. The shortage of neurointensivists, trained ICU nurses, pharmacists, and respiratory therapists adds to these difficulties and reduces the level of vigilance that complex neurosurgical patients require (Prabhakar et al., 2025).

19.2.4 Research and data gaps

Research capacity in neuroanesthesia across LMICs remains limited. Most existing guidelines and evidence are derived from high-income settings, which may make them difficult to apply in resource-limited settings. Few countries in LMICs have neurosurgical or anesthesia registries that capture neurotrauma- or neurosurgical-specific data (Rajajee, 2025).

This lack of reliable data weakens advocacy efforts for funding, equipment, and training. Systemic barriers such as limited time for academic work, lack of mentorship in research and writing, minimal funding for publication costs, and undervaluation of nonsignificant results also contribute to limiting scholarly productivity, thereby creating a barrier to improving neuroanesthesia care in LMICs.

In view of the many challenges to providing optimal neuroanesthesia care in LMICs, there must be advocacy efforts at the local level, along with global initiatives to drive improvement in this area. Examples of local and global strategies to establish effective neuroanesthesia care will be described in the next sections, along with suggestions on implementation.

19.3 Advocacy through healthcare policy

19.3.1 The National Surgical, Obstetric and Anaesthesia Plan

The National Surgical, Obstetric and Anaesthesia Plan (NSOAP) is a strategic, country-led framework designed to strengthen surgical, obstetric, and anesthesia (SOA) care as an essential component of national health systems. Originating from the *Lancet*

Commission on Global Surgery in 2015, the NSOAP framework aims to achieve safe, affordable, and timely SOA care for all populations, forming a foundation for the attainment of Universal Health Coverage by 2030. This framework provides a roadmap for national governments and ministries, implementing partners, funders, and other parties to improve SOA care through national health policies. It covers analysis of situation, engagement of stakeholders, drafting, monitoring, evaluation, financing, and governance (UNITAR, 2020). Several LMICs, including Zambia, Pakistan, and member states of the Southern African Development Community, have already developed and implemented their NSOAPs.

While NSOAPs primarily focus on ensuring access to emergency and essential SOA services, their principles are highly applicable to specialized fields such as neurosurgery and neuroanesthesia. Given the rising incidence of neurotrauma and noncommunicable neurological diseases such as brain and spine neoplasms, these specialties are essential for comprehensive perioperative and critical care. NSOAPs are structured around six core components: service delivery, workforce, infrastructure, information management, finance, and governance. These six core components are based on the World Health Organization's building blocks of health systems (Fig. 19.1). Each component can be adapted to address neuroanesthesia needs within national systems.

19.3.2 Service delivery

The goal of service delivery under NSOAP is to ensure safe, equitable, and timely access to SOA care across all levels of the health system. Implementation strategies are typically defined for three tiers of facilities: Level 1 (district), Level 2 (provincial), and Level 3 (tertiary).



FIGURE 19.1 Core components of National Surgical, Obstetric and Anaesthesia Plan for building a health system.

From United Nations Institute for Training and Research (UNITAR), 2020. National Surgical, Obstetric and Anaesthesia Planning Manual, United Nations Institute for Training and Research (UNITAR), Geneva, Switzerland.

At Level 1, strategies focus on establishing and strengthening essential and emergency surgical services, including trauma care and basic neurosurgical procedures such as burr hole drainage. Facilities are also expected to develop the capacity to identify and refer surgical oncology and congenital neurological conditions, such as brain and spine tumors, spina bifida, and hydrocephalus. Safe management of these cases requires reliable neuroanesthesia and neurocritical care services, especially during stabilization and interfacility transfers.

To support this, Level 1 hospitals' strategies include scaling up in-service anesthesia training and implementing mentorship networks for SOA providers at the district level. From a neuroanesthesia perspective, developing tiered referral systems with clear anesthetic stabilization and transfer criteria for head and spinal trauma is essential. Telemedicine may also support real-time neuroanesthetic guidance during pretransfer stabilization.

At Level 2 and Level 3 facilities, NSOAPs emphasize establishing comprehensive and specialized surgical and anesthesia services. Examples include the creation of trauma centers at secondary and tertiary hospitals, strengthening neurosurgical units, and developing dedicated spinal surgery services at major referral hospitals. These facilities are also encouraged to develop standardized intensive care unit (ICU) admission and management protocols, expand mobile health outreach for specialized services, and ensure the availability of highly trained neuroanesthesia staff.

19.3.3 Infrastructure, equipment, and supplies

For Level 1 facilities, the objective is to ensure basic infrastructure and standard equipment for essential and emergency SOA care. This includes reviewing and updating the standard equipment list in collaboration with end users and procuring anesthesia machines with built-in oxygen concentrators.

At Level 2 and Level 3 facilities, equipment procurement focuses on supporting safe and comprehensive surgical services. In neuroanesthesia, this includes acquiring basic neuromonitoring systems such as processed EEG, ICP monitors, and neurophysiological monitoring devices. Maintenance plans, service contracts, and local biomedical engineering support are vital to sustain functionality.

NSOAPs also advocate maintaining adequate stocks of essential drugs and consumables for advanced anesthesia care. For neuroanesthesia, this includes agents such as propofol and remifentanyl used in total intravenous anesthesia. Given the increasing reliance on these drugs, national protocols for substitute medications should also be defined to ensure continuity during supply shortages.

19.3.4 Human resources

Human resource strategies under NSOAP include workforce planning, training, and continuing professional development (CPD).

- **Workforce planning and training:** The goal is to expand and equitably distribute the SOA workforce across healthcare levels. This involves revising staffing structures, creating additional posts at district and tertiary levels, and aligning salary scales to retain specialized practitioners, including neuroanesthesiologists. Collaboration with universities and professional societies is encouraged to review curricula, fast-track training, and maintain educational standards. In neuroanesthesia, courses such as the *Emergency Neurological Life Support* program by the Neurocritical Care Society are examples of capacity-building initiatives suitable for inclusion in NSOAP training plans.
- **Continuous professional development:** Regulatory bodies are encouraged to set SOA-specific CPD requirements. Ongoing medical education, including advanced perioperative skills and trainer training in life support and neurocritical care, helps practitioners stay competent and up-to-date.

19.3.5 Information management and research

A strong health information management system forms the backbone of evidence-based planning, implementation, and evaluation within NSOAPs. The information management component of NSOAP highlights systematic data collection, accurate record-keeping, and routine analysis of service delivery and outcomes. These systems are vital for identifying gaps, prioritizing research in surgery, obstetrics, and anesthesia, and for establishing actionable targets.

NSOAP strategies promote strengthening national research capacity through targeted investments in training, institutional collaborations, and sustainable funding for local scholarship. Regular updates of surgical indicators and national health metrics enable tracking of progress over time, allowing for iterative policy changes and ongoing quality improvements. Ultimately, integrating information management and research within NSOAP ensures reforms remain data-driven, contextually appropriate, and responsive to changing population health needs.

For neuroanesthesia, data collection should incorporate neurosurgical and anesthetic outcome indicators—such as perioperative mortality, postoperative neurological deficits, anesthetic risk class (e.g., ASA grade), mean arterial pressure variations, ICP trends, and other postoperative morbidities into national databases. This approach enables benchmarking and continuous quality improvement.

19.3.6 Leadership and governance

Strong governance ensures coordination and accountability in NSOAP implementation. Ministries of Health at the national level, followed by Departments of Health at the provincial or district levels, are responsible for leading SOA service delivery and establishing coordination mechanisms through national committees. Regular stakeholder meetings should review progress toward service integration and system harmonization.

Incorporating neuroanesthesiologists into NSOAP leadership committees is vital to developing essential clinical protocols and ensuring representation of neurosurgical and neurocritical care needs. Legal and regulatory frameworks should be strengthened by developing national protocols and operating standards, for example, for emergency management of raised ICP, aneurysm rupture, and perioperative management of traumatic brain injury.

19.3.7 Global Neurosurgery Initiative

The Global Neurosurgery Initiative, established by the Program in Global Surgery and Social Change at Harvard Medical School in 2018, is another global advocacy effort in advancing neurosurgical care. It is dedicated to advancing research, policy, and advocacy within global neurosurgery ([Blavatnik Institute Harvard Medical School, n.d.](#)). The Initiative's policy work has led to the development of two comprehensive frameworks: "Comprehensive Policy Recommendations for Head and Spine Injury Care in Low- and Middle-Income Countries" and "Comprehensive Policy Recommendations for the Management of Spina Bifida & Hydrocephalus in Low- and Middle-Income Countries" ([Corley et al., 2019](#); [Park et al., 2021](#)).

The recommendations for head and spine injury care were systematically developed using the best available evidence and expert consensus. These policy guidelines were designed to help policymakers in designing contextualized national plans aimed at reducing mortality and morbidity from road traffic accidents. The recommendations used a policy-oriented methodology derived from the NSOAP framework and, at the same time, integrated established trauma guidelines to ensure a holistic approach to the development of neurotrauma systems. Beyond the six foundational NSOAP building blocks, the Initiative's framework delineated five essential domains within each block: surveillance, prevention, prehospital care, surgical system, and rehabilitation ([Corley et al., 2019](#)).

Similarly, the "Comprehensive Policy Recommendations for the Management of Spina Bifida & Hydrocephalus in Low- and Middle-Income Countries" provided a guide for healthcare personnel, hospitals, ministries of health, and governments to develop robust management frameworks for spina bifida and hydrocephalus. These policy recommendations adopted the NSOAP health systems model and are organized into six key sections. Of specific relevance to neuroanesthesia was the endorsement of telemedicine, which was recommended for pretransfer consultation and perioperative anesthesia planning. The timely surgical closure of open spina bifida remains a challenge for most LMICs. However, the initiative stressed that immediate medical care, such as antibiotic coverage and protection of the exposed placode, enables preoperative evaluation for concurrent congenital anomalies, which is critical for anesthesia assessment and planning. Furthermore, the guidelines highlighted hydrocephalus shunt failure as a neurosurgical emergency and advocated for the strategic placement of district-level hydrocephalus treatment centers so that 80% of the population resides within two hours of care. This approach necessitates the availability of neuroanesthesia services to support timely and safe surgical intervention.

These comprehensive, system-level policy recommendations provide actionable frameworks for governments and healthcare practitioners in LMICs to strengthen neurotrauma and pediatric neurosurgical care. Incorporating neuroanesthesia into these policy guidelines as a fundamental part of multidisciplinary service delivery and policy development is a key advocacy strategy for neuroanesthesia. These examples of global advocacy efforts are worth replicating and can be expanded upon to improve neuroanesthesia care in LMICs.

19.4 Advocacy through education initiatives

To address the escalating demand for neuroanesthesia services, LMICs must prioritize the development and retention of a skilled anesthesia workforce, specifically within the neuroanesthesia subspecialty. However, in many LMICs, neuroanesthesia residency and fellowship programs have evolved in a nonuniform manner due to the absence of

standardized guidelines or regulatory oversight. Program lengths are variable, commonly lasting 1–3 years, but most include clinical apprenticeship, formal didactics, and introduction to research methods (Khandelwal et al., 2021). Therefore, to improve the quality of neuroanesthesia services in LMICs, advocacy and global initiatives should be carried out to improve the education and training of specialist neuroanesthesiologists.

19.4.1 Neuroanesthesia fellowship initiatives

The World Federation of Societies of Anaesthesiologists (WFSA) supports global fellowship opportunities, including dedicated neuroanesthesia fellowship, for early-career anesthesiologists from LMICs. An example is the WFSA and the Royal College of Anesthesiologists of Thailand collaboration for neuroanesthesia fellowship, called the *Bangkok Anesthesia Regional Training Centre: Neuroanesthesia Fellowship*. Successful applicants will receive financial support from the WFSA to complete this fellowship (World Federation of Societies of Anaesthesiologists, 2025). These initiatives offer a complete clinical experience in high-volume academic centers. Fellows benefit from direct supervision in neuroanesthesia, neurocritical care, and neurophysiological monitoring, alongside exposure to research mentorship and academic activities. There is also evidence that the alumni of these fellowship programs reported increased clinical confidence and improved decision-making upon fellowship completion, with the ability to bring improvement in service delivery, research, and teaching to their home country (Bould et al., 2024).

19.4.2 Standardization of neuroanesthesia training

Another aspect of improving neuroanesthesia care from an educational perspective is through the standardization of neuroanesthesia training. Standardized accreditation of neuroanesthesia training, based on a globally recognized curriculum, allows consistent trainee competencies, safe, and high-quality patient care in LMICs. On the other hand, a curriculum that is too rigid may limit the flexibility required for local adaptation or a more specialized subspecialty focus. Hence, training models should include mechanisms that allow adaptation to specific institutional strengths and the diverse educational or research interests of fellows (Rajan et al., 2021).

The need for an international body to establish standards of specialty training in the field of perioperative neuroscience led to the formation of the International Council for Perioperative Neuroscience Training (ICPNT), which is administratively managed by the Society of Neuroscience in Anesthesia and Critical Care (SNACC). The ICPNT was established to support regional differences in training culture and regulations while maintaining a minimum required curriculum and clinical experience for a neuroanesthesia fellowship program. The main difference between the ICPNT accreditation system and traditional accreditation systems is the collaborative framework of accredited neuroanesthesia fellowship programs with the ICPNT. This collaborative framework enables clinical and research networking among the programs (Rajan et al., 2021). In the ICPNT accreditation system, the “three pillars of neuroanesthesiology,” first introduced by Dr. George Mashour, are incorporated. The three pillars are as follows:

- The first pillar is clinical management of neurosurgical patients, involving the disciplines of neuroanesthesia, neurocritical care, and neuromonitoring.
- The second pillar is the foundational neuroscience relevant to anesthesiology, which is how anesthesia drugs target the brain, along with research on the central nervous system.
- The third pillar is the neurological outcomes of nonneurosurgical interventions, for example, anesthetic neurotoxicity, cognitive dysfunction, perioperative brain health, and stroke.

Many neuroanesthesia fellowship programs primarily focus on the first pillar, namely, perioperative care for neurosurgical and neuroradiological procedures. On the other hand, the ICPNT curriculum recommends that comprehensive neuroanesthesia programs should integrate both foundational neurosciences (for example, nervous system networks, memory, neuromuscular, and autonomic systems) and emerging neurological outcomes domains such as postoperative cognitive outcomes, delirium, and perioperative brain health (Rajan et al., 2021).

By standardizing neuroanesthesia fellowship programs, aspiring neuroanesthesiologists in LMICs will be comprehensively trained, empowering them to deliver effective, safe neuroanesthesia care in their home countries.

19.4.3 National neuroanesthesia societies and international collaborations

Regional and national neuroanesthesia societies serve as focal points for advocacy of neuroanesthesia in LMICs. The creation of these societies can spearhead the improvement of neuroanesthesia care in their respective countries by providing a platform for education in perioperative neurosciences. Examples include the Indian Society of

Neuroanesthesiology and Critical Care, the Malaysian Society of Neuroanesthesiology and Neurocritical Care (MSNACC), the Thai Society for Neuroanesthesia, and many more. Each of these societies organizes numerous educational initiatives, including symposia, workshops, tutorials, and short courses, bringing immense benefit not only to the societies' members but also to the whole anesthesia fraternity in their own countries.

In Asia, regional collaborations involving national neuroanesthesia societies led to the formation of the Asian Society for Neuroanaesthesia and Critical Care (ASNACC). The ASNACC was founded by Japan, South Korea, India, Indonesia, China, and Singapore and was subsequently joined by the Philippines, Malaysia, Thailand, and Myanmar. The formation of ASNACC became a platform for the exchange of ideas among the regional neuroanesthesia societies, with the objective of improving neuroanesthesia and neurocritical care services in Asian countries. In addition, the ASNACC also allowed research and training networks to be established among member countries. The member countries of ASNACC take turns to organize the biennial ASNACC Congress, with eight congresses held so far, and the ninth congress scheduled for May 2027 in Malaysia ([Asian Society for Neuroanesthesia and Critical Care. ASNACC, 2025](#)). This regional model of collaboration among national neuroanesthesia societies is an example of an advocacy measure to improve neuroanesthesia care in LMICs through education initiatives.

Globally, collaboration with neuroanesthesia societies from high-income countries such as the SNACC and the Neuroanesthesia and Critical Care Society (NACCS) based in the United Kingdom will also allow the exchange of ideas and knowledge, thereby advancing neuroanesthesia care in LMICs. An example is the MSNACC, which jointly organized the 7th Neuroanesthesia Symposium 2025 in Malaysia with SNACC and NACCS UK. This collaboration enabled anesthesiology doctors in Malaysia to gain knowledge and insights into neuroanesthesia care in high-income countries, which will help improve neuroanesthetic care in Malaysia ([Yeap, 2025](#)).

19.5 Advocacy through technology and telemedicine

19.5.1 Telemedicine and technological innovations in neuroanesthesia

Over the past decade, telemedicine has undergone rapid development, a process notably accelerated by the COVID-19 pandemic. It now represents a revolutionary approach to tackling significant challenges faced by neuroanesthesia in LMICs, such as workforce shortages, delayed access to specialists, and high costs. The earliest use of telemedicine in anesthesiology was documented in a 2004 case series that described preoperative assessments conducted via remote videoconferencing platforms ([Wong et al., 2004](#)). Benefits included reduced travel and waiting times, greater convenience, expanded rural outreach, and significant cost savings. Importantly, surgical cancellation rates were not negatively impacted ([Kamdar et al., 2020](#)). However, the successful implementation of telemedicine is still hindered by infrastructural barriers, technical issues, and the need for substantial initial investments.

In the context of LMICs, integrating telemedicine into neuroanesthesia care offers significant opportunities to improve patient outcomes, especially in underserved, remote, and resource-limited settings. Despite challenges such as unreliable internet, cultural resistance, regulatory hurdles, and limited funding, ongoing collaborative initiatives continue to demonstrate that scalable and sustainable solutions are achievable.

19.5.2 Preoperative phase: teleconsultation

Teleconsultations during the preoperative phase have achieved high satisfaction rates among both patients and providers, considerably reduced travel and waiting times, and resulted in surgical cancellation rates similar to face-to-face consultations ([Kamdar et al., 2020](#)). Although remote consultations naturally limit the ability to conduct certain physical assessments (for example, airway evaluation and auscultation), hybrid models that combine targeted in-person examinations based on clinical and procedural risk have demonstrated feasibility and high satisfaction among patients.

19.5.3 Intraoperative phase: telemedicine for remote guidance and monitoring

During surgery, telemedicine can improve care delivery through remote expert guidance in rural areas and real-time monitoring of multiple operating theaters. The safety and reliability of these systems depend heavily on continuous data transmission and strong communications. Initiatives such as remote vital sign monitoring and using telecommunication tools to extend anesthetic expertise to underserved regions can be highly effective. For example, in the Ecuadorian Amazon, vital signs and intraoperative video were transmitted from a remote theater to enable specialist supervision and guidance, demonstrating how high-quality care advice can reach remote anesthetic teams ([Cone et al., 2004](#)).

Telemedicine also supports remote intraoperative training, as shown by video-guided real-time ultrasound instruction, promoting capacity building and skills transfer (Miyashita et al., 2014).

19.5.4 Postoperative phase: telehealth for ongoing care

Telehealth platforms have been effectively utilized for postoperative follow-up of surgical patients. For those in rural areas or at substantial distance from tertiary centers, telehealth reduces the follow-up burden and ensures ongoing specialty oversight. There is evidence from an observational study that telehealth neurosurgical follow-up of patients after brain tumor surgeries is safe (Morell et al., 2023). Although at the moment there is no report of telemedicine anesthetic follow-up, digital platforms have the potential to enable postoperative neuroanesthesia and neurocritical care follow-up, for example, monitoring for pain, recovery, or neurologic complications in rural care settings.

19.5.5 Provider readiness and research gaps

Despite many successes, significant challenges still exist in the widespread use of telemedicine in neuroanesthesia within LMICs. A survey of anesthesiologists in Northwest Ethiopia found that only 48.25% of respondents were aware of telemonitoring technologies. In the same study, over 90% of respondents in the same study expressed a strong willingness to adopt these platforms if given proper infrastructure and training (Endeshaw et al., 2025). There is a notable lack of neuroanesthesia-specific telemedicine data from LMICs, emphasizing a critical need and opportunity for research in areas such as remote telemetry of advanced perioperative monitoring, remote mentorship, and outcome-focused studies (for example, perioperative brain swelling, ICU stay, postoperative complications).

19.5.6 Emerging technologies: artificial intelligence and precision medicine

Recent advances in artificial intelligence (AI), machine learning, and big data analytics further expand the potential for telemedicine in perioperative neuroscience. AI-enabled telemedicine systems show promise for improving preoperative risk assessment, intraoperative support, and postoperative recovery monitoring. As these technologies develop, they may enable precision medicine approaches and enhance safety and efficiency in neuroanesthesia, especially in resource-limited settings.

19.5.7 Advocacy and the way forward

The accumulated evidence and illustrative case studies in digital and telemedicine innovation provide compelling advocacy tools for neuroanesthesia in resource-limited settings. For policymakers in LMICs, demonstrated clinical effectiveness, cost-efficiency, and integration into existing health systems are convincing. Leadership from neuroanesthesiologists and professional societies will be essential, both in launching and sharing pilot projects, developing evidence-based guidelines for remote anesthesia and neurocritical care, and ensuring telemedicine reaches rural and marginalized populations.

19.6 Conclusion

It is essential to improve neuroanesthetic care in resource-limited countries to improve surgical outcomes, reduce morbidity and mortality, and enhance the quality of life for patients with neurological disorders. Achieving this requires coordinated, cross-sectoral investment in training, infrastructure, policy integration, research, and digital innovation. A list of future directions and recommendations for neuroanesthesia advocacy in LMICs is summarized in Table 19.1. Regional leadership, global partnerships, and robust advocacy networks must collaborate to develop equitable and sustainable systems of care in neuroanesthesia. Empowering neuroanesthesiologists in LMICs to lead this transformation will be vital in addressing current disparities in access and outcomes.

AI disclosure

During the preparation of this work, the author(s) used Grammarly to correct grammatical errors and improve sentence clarity. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the publication.

TABLE 19.1 Future directions and recommendations for neuroanesthesia advocacy in resource-limited countries.

Workforce	Strategic investment in both training infrastructure and long-term career development to strengthen local capacity, by: Expanding national training programs in neuroanesthesia and neurocritical care Creating structured mentorship pathways, in collaboration with international societies (e.g., fellowship programs under WFSA or ICPNT) Ensuring sustained mentorship postfellowship, with collaboration in teaching and research
	Address workforce attrition by mitigating both “push” and “pull” factors—strategies include protected time for teaching and research, recognition of neuroanesthesia as a distinct subspecialty, and equitable remuneration.
	Integrate policy making and advocacy into training programs, by: Embedding training in health systems, policy and advocacy into anesthesia and neuroanesthesia curricula, to empower neuroanesthesiologists to lead advocacy efforts Encouraging early-career neuroanesthesiologists to participate in national policy development platforms, surgical planning committees, and international conferences
Governance	Neuroanesthesia must be recognized within national health plans: Align budgeting with neurosurgical caseload projections, ensuring adequate investment in neuroanesthesia infrastructure, including equipment and human resources. Integrate neuroanesthesia into workforce development strategies, formally acknowledging it as a high-complexity, high-risk subspecialty that requires dedicated training pathways. Prioritize procurement of essential equipment, for example, for neuromonitoring (EEG, BIS, ICP monitors)
Professional collaborations	Collaboration with global and regional professional societies (WFSA, SNACC, ASNACC, etc.) to develop advocacy tools for LMICs, including training guides and implementation support.
Technology and digital health	Pilot telemedicine applications for neuroanesthetic consultations, intraoperative support, and postoperative follow-up, especially in remote and underserved areas. Integrate digital education tools, including telementoring, virtual simulations, and interactive case-based learning to improve training Invest in digital infrastructure, including reliable internet connectivity, hardware, cybersecurity measures, and IT support, particularly at secondary and tertiary referral centers
Research	Incorporate research training, covering methodology, data analysis, and scientific writing into neuroanesthesia fellowships programs. Establish neuroanesthesia-specific registries and databases to systematically capture patient outcomes, complications, and healthcare utilization trends in LMICs Facilitate international research network and partnerships, particularly focused on areas such as perioperative brain injury, neuromonitoring practices, and postoperative neurocognitive outcomes. These collaborations can elevate research capacity while addressing critical knowledge gaps in LMIC settings.
Abbreviations: ASNACC, Asian Society for Neuroanesthesia and Critical Care; BIS, bispectral index; EEG, electroencephalography; ICP, intracranial pressure; ICPNT, International Council for Perioperative Neuroscience Training; IT, information technology; LMICs, low- and middle-income countries; SNACC, Society for Neuroscience in Anesthesiology and Critical Care; WFSA, World Federation of Societies of Anaesthesiologists.	

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Practice of Neuroanesthesia in Resource Limited Countries reviews the critical challenges and innovative solutions in delivering neuroanesthesia care within low- and middle-income countries (LMICs). As these regions grapple with a high prevalence of neurological disorders and limited resources, this book examines the core principles of neuroanesthesia, emphasizing safety, efficacy, and essential monitoring techniques.

This book addresses the availability of equipment and medications, offering practical alternatives tailored to resource constraints. Special considerations for pediatric populations, trauma management in emergencies, and regional anesthesia techniques are thoroughly examined. This book emphasizes the importance of postoperative care and neurocritical support, highlighting strategies for effective recovery in resource-limited settings. Furthermore, it advocates for building local capacity through training, education, and collaborative efforts, underscoring the role of simulation and remote learning.

With contributions from authors across various LMICs, this comprehensive resource aims to enhance the practice of neuroanesthesia and improve patient outcomes in regions where healthcare systems face significant challenges.

Key Features

- Explores innovative solutions for neuroanesthesia in resource-limited settings
- Addresses the challenges faced by healthcare professionals in LMICs
- Highlights strategies for effective postoperative and neurocritical care
- Leverages simulation and remote learning for enhanced training

About the Editors

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