



Advancing Surgical and Medical Education: Insights and Lessons from Neurosurgery in Pakistan

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Asian J Neurosurg

Abstract

In this article, we have summarized the current landscape of neurosurgical education in Pakistan, highlighting key gaps in training, mentorship, and academic resources. In this narrative review, we explore original articles and reviews that discussed the factors affecting the surgical and medical education in Pakistan, published between January 2000 and July 2025. At the undergraduate level, exposure to surgical subspecialties like neurosurgery is often limited and inconsistent, which may affect students' interest in pursuing such fields. Postgraduate training programs also exhibit significant variation in the quality of mentorship, academic activities, and access to modern teaching resources like simulation-based learning.

Based on the latest assessment of medical education pertaining to neurosurgery in Pakistan, recommendations for the way forward are provided in this article.

Keywords

- ▶ clinical curriculum
- ▶ developing country
- ▶ medical education
- ▶ Pakistan
- ▶ surgical education

Introduction

Clinical training is one of the components of medical education integrated in clerkships at undergraduate levels and during postgraduate programs, enabling students and graduates to become competent health care providers capable of delivering optimal patient care. Hands-on experience under the mentorship of clinical and surgical professionals strengthens their knowledge and skills.¹ However, there is a notable lack of literature on clinical teaching and postgraduate training for surgical specialties, particularly in Pakistan.

Undergraduate clinical curriculum varies widely, which could hinder students' learning. For a variety of reasons,

medical schools arrange their curriculum differently. These factors include the duration of the rotations, the kind of hospital service that the students rotate within, the academic program year in which the rotations can be completed, and whether or not the rotations are required. Similarly, postgraduate programs have considerable heterogeneity in terms of teaching environment, research output, quality of mentorship, hands-on exposure, and experiential learning opportunities.

Neurosurgery, in particular, is a highly specialized field that requires comprehensive training and surgical expertise to achieve optimum patient outcomes. In alignment with global efforts to improve access to surgical services, initiatives in low- and middle-income countries (LMICs) have

DOI <https://doi.org/10.1055/s-0045-1812294>.
ISSN 2248-9614.

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Thieme Medical and Scientific Publishers Pvt. Ltd., A-12, 2nd Floor, Sector 2, Noida-201301 UP, India

aimed to expand neurosurgical care coverage.² While improved infrastructure and equipment will enhance surgical care in the short term, the most cost-effective and sustainable measure is improving medical education and training to build a proficient network of surgical professionals.²

Although there has been a substantial growth of the field in Pakistan over the last few years, the current neurosurgical workforce density of 0.28 per 100,000 lags behind the international requirement of 0.5 neurosurgeons per 100,000 people.⁴ This gap must be addressed by robust training programs, high-quality medical curriculum, as well as an understanding of the diverse influences that govern medical student and trainee decisions. To evaluate whether the current educational landscape is conducive to the development of surgical specialties in Pakistan, in this article learners in neurosurgery are evaluated at every level of the educational hierarchy, from undergraduate students, interns, and medical officers to residents, instructors, and fellows to learn about their perspectives and experiences.

Methodology

In this narrative review, we explored and selected original articles and reviews that discussed the factors affecting the surgical and medical education in Pakistan, focusing particularly the field of neurosurgery. Relevant studies were identified by using a combination of keywords and Medical Subject Headings terms including LMIC, medical education, surgical education, and neurosurgery. These terms were queried in the PubMed databases for articles published in English between January 2000 and July 2025. Further articles were used from the bibliography of the articles selected, if relevant.

Main Text

There is a growing debate over the relevance of surgical specialty training at the undergraduate level. The exposure of medical students to a certain specialty often dictates their interest in pursuing the specialty. A qualitative study among junior doctors in Colombia found that rotation in surgical subspecialties helped reinforce clinical concepts related to primary care, build professional profiles, and influence career decisions.⁵ Note that 64.8% of students in Pakistan have a clerkship of neurosurgery, depicting a lack of uniformity in the medical curriculum.⁶

Whether exposure to neurosurgery as a clinical rotation definitively impacts career choice is unclear; in Shakir et al's study, around 39% of participants had rotated in neurosurgery and they were less likely to opt for it.⁶ On the contrary, 38.9% of participants from Chan et al's study had rotated which was positively associated with the decision to pursue neurosurgery.⁷ Hence, any intervention aimed at enhancing exposure may affect career preferences differently, but it may promote a deeper understanding of the specialty and facilitate realistic decision-making.

The differences in curriculum and students' clerkship experiences lead to mixed perceptions and academic outcomes in surgical specialties. Facilitating medical students

through modern learning strategies, mentorship, and interest groups may help improve these aspects.

At the postgraduate level, neurosurgery training programs are offered at 40 centers across Pakistan.⁸ Multiple studies conducted over the last decade provide a sequential picture of how the training outlook has evolved over the years, each analyzing specific aspects of neurosurgical education.⁹⁻¹² Although these centers are accredited by the College of Physicians and Surgeons of Pakistan (CPSP), it is evident that there is great variation between the educational practices at different programs and consequently among graduates from each institution.¹² Neurosurgery residency is offered as a 5-year Master of Surgery (MS) program by universities or a 5-year Fellowship (FCPS) by the CPSP, with rotations in neurosurgery, general surgery, and other specialties.¹³ The educational exposure in MS programs is often dictated by the mentor or trainer rather than any established curriculum.

Academic Activities

There is a lack of local literature evaluating neurosurgical knowledge and teaching methodologies at the medical school level. A study from Pakistan revealed that only a minority (36.3%) of students found neurosurgical teaching to be sufficient, suggesting the need for improvement in surgical specialty education.¹⁴

With changing pedagogies in medical education, it is essential for surgical specialty education to take the leap. The flipped classroom (FCR) approach when implemented in neurosurgery has profound results with students showing better academic results and rating it positively due to its stimulating nature.¹⁵ In addition, a crucial component of learning is to be able to make connections and case-based learning (CBL) and problem-based learning methods have been found to enhance clinical capabilities.¹⁶

Academic sessions at postgraduate training programs include morbidity meetings, journal clubs, and educational sessions, which promote sharing of clinical knowledge and critical thinking. A survey among 22 training programs in Pakistan found that morbidity and mortality meetings were attended by 84.2% of residents by 2024.¹¹ This reflects a positive trend, since the meetings are mandated by the Accreditation Council for Graduate Medical Education (ACGME) and have a favorable impact on residents' learning.¹⁷ Neuroradiology sessions were available to 76.7% residents in 2024, and in Ali et al's study of 22 programs in 2021, the majority of the participants were comfortable in their interpretation of computed tomography scans, magnetic resonance imaging, and X-rays.¹¹ However, journal clubs were only attended by 66.7% of participants, suggesting more steps are needed to cultivate an interest in medical literature and discourse.¹²

Learning Resources and Methodologies

Clinical knowledge is a fundamental component of specialty education. Previous studies from 13 and 11 centers in Pakistan

have identified textbooks such as Youman's Textbook of Neurosurgery and Greenberg's Handbook of Neurosurgery as popular choices among residents.^{9,10} A survey across LMICs found that while library textbooks and electronic books remain preferred resources, there is an increasing reliance on Web sites and online journals, underscoring the importance of staying updated with new developments.¹⁸

For LMICs like Pakistan, where the standard of learning at many programs might be less than adequate, electronic learning (eLearning) tools such as online libraries, webinars, virtual classrooms, and courses offer a cost-effective alternative.² Adopting modern methods for delivering didactic knowledge is essential. For instance, a FCR curriculum combined with CBL, as part of the ACGME in the United States, was associated with more positive educational outcomes compared with the traditional lecture-based format.¹⁸

In addition to academic development, hands-on teaching is an essential part of any training program. While live surgery workshops were available to half of the participants in Shakir et al's study, cadaver workshops and modern learning simulations (including virtual reality) were accessible to a minority.¹² These facilities are necessary to supplement technical skills and teach novel surgical procedures, but the high cost makes them inaccessible for most institutions in developing countries like Pakistan. The lack of experiential learning modalities may affect learners' competence in complex surgical techniques.

In a developing country, institutes must venture into low-cost and sustainable methods of training. One such method is to encourage neurosurgery bootcamps where learners can practice hands-on skills and immediate feedback over the course of the camp was given to the learners.¹⁹ These locally created simulators are a useful teaching tool that raises students' confidence, abilities, and knowledge levels. They can be adjusted for different levels of difficulty. Another recent innovation is the noncadaveric low-cost brain tumor surgery laboratory piloted at a tertiary care hospital in Pakistan to teach residents psychomotor skills and surgical techniques.²⁰

International collaborations are also helpful, such as the cadaver-free courses using advanced cranial simulators conducted in 11 LMICs (including Pakistan) by a nonprofit initiative.²¹ These were well received by participants and increased their confidence at handling neurosurgical instruments, supporting the application of simulation-based learning in routine training. In Pakistan, the Syndicate of Pakistani International Neurosurgeons (SPIN) Workshop was also organized, which facilitated neurosurgeons from all around the world to conduct practical skills workshops at the Aga Khan University for all learners.

Interest Groups

The role of medical student interest groups in promoting research, mentorship opportunities, and specialty-specific education has been well-documented.²² In Pakistan, Shakir et al's study identified that only 24.2% of medical students had access to neuroscience or neurosurgery interest groups.⁶

Although they do not necessarily correlate with ambition for neurosurgery, international literature suggests that they increase students' success at pursuing the field.²² Interest groups providing students with patient interactions have reportedly played role in creating compassion among them.²³ Even though the structure of student interest groups in Pakistan is not organized under a formally affiliated body, they have the potential to provide students with avenues for networking, career guidance, and professional development especially for surgical specialties not explored during routine clerkships.

Mentorship

It is difficult to integrate and train medical students appropriately, especially in highly subspecialized professions that are exceedingly demanding for residents. This especially applies to the specialty of neurosurgery. Only 24.1% of students in Pakistan viewed mentorship opportunities for neurosurgery as adequate.¹⁴ An initiative that could be taken to overcome this is one-on-one mentoring, which a study from Germany showed has positive outcomes.²⁴

Mentorship is a core component of medical education, more so in surgical specialties, which require transfer of technical skills at the postgraduate level. In Pakistan, more than half of the neurosurgery residents were satisfied with the available mentorship despite the lack of formal mentorship programs.¹² This is in contrast to a study from Saudi Arabia where a majority of residents were dissatisfied.²⁵ This is an interesting result considering it is ingrained in Pakistani society to praise and exalt superiors to an unnatural degree.²⁶ A strong relationship between a mentor and a trainee necessitates respect enough to listen to the voice of experience and candor enough to allow for questions from the student.²⁷ However, a significant difference was found in mentorship opportunities between public and private sector institutes in Pakistan. Note that 38.3% of respondents from private institutes in comparison to 29.5% from public institutes agreed to have sufficient mentorship available for them in support to their future in neurosurgery.²⁸

The benefits of mentorship are profound at every level, from helping medical students navigate career choices to promoting research excellence, neurosurgical knowledge, and competency at both the undergraduate and postgraduate level. Well-established mentorship programs in the United States correlate with positive ACGME outcomes,²⁹ supporting the idea that initiation of formal programs in Pakistan and other LMICs will be beneficial for residents' education.

Research

Research is an integral part of postgraduate training and even an ACGME requirement.³⁰ It promotes critical thinking and is an introduction to the lifelong learning essential to medicine. Furthermore, studies have shown that residents involved in research while training have greater application and appreciation of evidence-based medicine.^{31,32}

A national study covering 12 institutes from Pakistan found that although the majority of residents had received research training, there was a strong belief that it was challenging to participate in it while training.³³ This is reflected by the unsatisfactory research output from neurosurgical trainees in Pakistan identified across multiple surveys.^{11,34} To boost postgraduate trainees' research productivity, better research mentorship and methods that allow for protected time and institutional access to data are required.

International and local research conferences may foster research interest and help trainees stay updated on recent advances in neurosurgery. It is encouraging to note that around 81.7% of residents in Pakistan reported that their program conducted neurosurgical conferences,¹² whereas 53% in another study indicated attending international conferences.³⁵ Comparable trends are seen in other developing countries; a study from Africa found that 55.4% of trainees and residents had never attended a conference endorsed by the World Federation of Neurosurgical Societies.³⁶ Participation in international conferences can provide valuable exposure to global best practices, networking opportunities, and latest research developments. Pakistan Society of Neuro-Oncology (PASNO) and Pakistan Society of Basic and Applied Neuroscience (PASBAN) have held several of these conferences over the years, which has led to increased research collaborations. Other LMICs should also follow similar models. Hence, sponsorship opportunities should be provided to boost trainees' engagement on such platforms.

Gender Equality

Underrepresentation of women in competitive surgical specialties has been a global concern, with females comprising only 19.07% of total neurosurgical residents in the United States.³⁷ In Pakistan, one-third of neurosurgical residents are women, but considering that females constitute 85% of medical students nationally, it shows that a small percentage of female doctors progress to neurosurgical specialization.³⁸ This discrepancy is particularly interesting since a study on medical students' career choices in Pakistan revealed that a greater percentage of women (58.9%) compared with men (41.1%) were interested in neurosurgery as a career, suggesting that certain barriers prevent women from pursuing their preferred specialty. A study found that 40.3% of female medical students strongly perceived a potential gender bias in neurosurgery, compared with just 17.3% of their male counterparts, hence a possible discouraging factor.³⁹

Gender disparity is also observed in the research output internationally, with female authorships ranging between 13.3 and 19.9%, although this has not been the case in Pakistan where publication numbers are generally low.⁴⁰ With regards to neurosurgical specialty education, a survey of 22 programs found that more men reported quality surgical exposure, and a higher percentage of females reported concerns regarding gender equality during training.³⁸ Further in-depth qualitative studies are required in Pakistan to explore the reasons behind these results and identify the specific barriers women encounter. Nonetheless,

it is clear from the present data that there is a need to establish a gender inclusive environment in all educational measures to enhance surgical training.

Perceived Barriers

The choice of specialty is often a multifaceted decision, and it has been found that medical students in Pakistan are often influenced by personal interest, finances, and job security.⁴¹ For surgical specialties in particular, the gratification obtained from direct patient care, nature of clinical problem-solving, and level of consideration given to stress were found to have an association.⁴²

Common deterrents to pursuing neurosurgery as a career in Pakistan include unsatisfactory work-life balance and the perceived need for strong surgical skills.^{6,43,44} Similar themes have been reflected in internationally published literature, with studies from Turkey and the Philippines demonstrating only 14.4 and 18.7% of students desire to pursue neurosurgery, citing intense work hours, lack of manual dexterity, and high work-related stress as demotivating factors.^{7,46} While aspects like working hours are lifestyle choices, there is evidence that students may not be able to accurately self-evaluate their surgical skills in medical school.⁴⁷ Therefore, interventions in the medical curriculum can be aimed to improve early surgical technique and guide students better regarding their aptitude for a surgical career.

Undergraduate students in neurosurgery face several challenges, including limited exposure due to the absence of dedicated clinical rotations, the persistence of conventional teaching methods that restrict interactive learning, and lack of an integrated curriculum. At the postgraduate level, the issues extend to reduced access for simulated hands-on training, less opportunities to explore unique surgical cases and complex techniques, and lower research output. A national survey indicated that 64.1% of the neurosurgical trainees intended to migrate abroad for further supervised practice, and one of the factors suggested were insufficient clinical training opportunities in Pakistan.⁴⁸ Both undergraduate and postgraduate learners experience gender disparities and a lack of effective mentorship, further hindering growth and development in the field.

Recommendations

Enhancing simulation training is crucial; investing in state-of-the-art simulation technologies allows learners to practice surgical techniques and manage emergencies in a controlled, risk-free environment, which builds confidence and skill. LMICs can adapt to this by inculcating research on newer methods of hands-on teaching and using proven techniques such as wet laboratories to develop their simulation training modules.

Structured mentorship programs should be established, where experienced surgeons provide guidance, share clinical insights, and offer regular feedback, fostering a supportive learning environment.

An integrated curriculum that combines surgical skills with theoretical knowledge such as anatomy, pathology, and patient management ensures a well-rounded understanding of the surgical field. Encouraging interdisciplinary collaboration is also essential, as it helps students and residents appreciate the role of surgery within the broader context of health care and understand how different specialties interact. Regular formative assessments and constructive feedback are important for tracking progress and addressing learning gaps, enabling continuous improvement.

Exposure to a diverse range of surgical cases, including complex and rare conditions, equips learners with a comprehensive skill set and prepares them for various clinical scenarios. For settings where complex cases are not available, institutes can attempt learner exchange programs with other hospitals.

Finally, promoting involvement in surgical research and innovation is vital to keep pace with advancements in the field and foster critical thinking. By integrating these strategies, such as advanced simulations, mentorship, a comprehensive curriculum, interdisciplinary learning, regular assessments, diverse case exposure, and research engagement, surgical education can be significantly enhanced, leading to more proficient and adaptable future surgeons.

Outlook

This article has evaluated local evidence on neurosurgical medical education in Pakistan, identifying key gaps and proposing practical, cost-effective interventions. Addressing these gaps will require institutional prioritization, adequate funding, and collaboration between local institutions and international partners. While the focus is on neurosurgical training, these findings are likely relevant to other surgical specialties in Pakistan, where original research and data remain limited. Optimizing surgical education through integrating innovative teaching methods such as simulation-based learning, mentorship programs, and research opportunities can improve the quality of surgical services, develop a highly skilled workforce, and ultimately increase access to specialized surgical care in resource-constrained environments like Pakistan. To assess the effectiveness of these modern learning approaches, qualitative insights and interventional studies are required. Such research will assess their applicability across different surgical fields and ensure that they are not only effective but also sustainable in resource-constrained environments.

Authors' Contributions

H.A.I. conceptualized the topic; E.A., T.S., and H.A.I. prepared and reviewed the manuscript; D.A. edited the manuscript; H.A.I., M.S., and S.A.E. supervised the manuscript; all authors approved the final version.

Conflict of Interest

None declared.

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