ScientificScholar®
Knowledge is power
Publisher of Scientific Journals

www.surgicalneurologyint.com

Surgical Neurology International

**Editor-in-Chief:** Nancy E. Epstein, MD, Professor of Clinical Neurosurgery, School of Medicine, State U. of NY at Stony Brook.

*SNI: Computational*

**Editor**
Pieter L. Kubben, MD, PhD
Maastricht University Medical Center, Maastricht, The Netherlands

SNI
Open Access

*Editorial*

# The implementation of simulators in neurosurgery training. The application of the simulator program in Peru

Luis Fernando Aguilar-Zegarra, Diego Alonso Quiroz-Marcelo, Fanny Shuyi Ou-Li, Milagros Fernanda Nombera-Aznarán

School of Medicine, Universidad Peruana Cayetano Heredia, Lima, Perú.

E-mail: Luis Fernando Aguilar-Zegarra - luis.aguilar.z@upch.pe; *Diego Alonso Quiroz-Marcelo - diego.quiroz@upch.pe; Fanny Shuyi Ou-Li - fanny.ou@upch.pe; Milagros Fernanda Nombera-Aznarán - milagros.nombera@upch.pe

***Corresponding author:**
Diego Alonso Quiroz-Marcelo, Universidad Peruana Cayetano Heredia, Lima, Peru.

diego.quiroz@upch.pe

Received: 12 September 2023
Accepted: 13 September 2023
Published: 06 October 2023

**DOI**
10.25259/SNI_755_2023

**Quick Response Code:**

## INTRODUCTION

The neurosurgery residency is one of the most demanding programs internationally. Peru must implement simulation spaces within its neurosurgery residency programs to face this competition. In addition, the implementation of the latest technologies in simulation programs will provide outstanding support to improve performance in neurosurgical training and address the challenge of current technologies.

## NEUROSURGERY RESIDENCY IN LATIN AMERICA

In Latin America, the neurosurgery specialty faces a technological disadvantage compared to its international competitors during specialty training. For example, a study conducted by Murguia-Fuentes *et al.* presents that 40% of residents from Latin American countries members of the Latin American Federation of Neurosurgical Societies (FLANC) do not achieve optimal academic performance during their training. This situation is connected to the level of support provided by their residency program, including participation in conferences, international rotations, and mental health meeting attendance, among others.[10] Therefore, to train proficient specialists, we require access to a higher quality environment in comprehensive neurosurgical training that can compete with other residency programs in developed countries.

## NEUROSURGERY RESIDENCY IN PERU

In Peru, the National Medical Residency system is regulated by the National Council of Medical Residency (CONAREME). In this regard, there are "Minimum Training Standards for the Second Specialization Program in Neurosurgery" regulations that govern professional training in acquiring skills to tackle challenges in the field of neurosurgery.[3] At present, in response to the demand for simulation spaces, the Department of Neurosurgery at the Luis N. Sáenz Central Hospital of the Police has implemented the first neuro-microsurgery and 3D printing laboratory, aiming for a more three-dimensional approach.[12] Based on this, we can discuss the importance of introducing surgical simulation within the training methodology for acquiring procedural competencies.

## IMPLEMENTATION OF SIMULATION ENVIRONMENTS FOR NEUROSURGICAL TRAINING

One branch of neurosurgery that greatly benefits from the use of the simulated practice is microneurosurgery. This involves the use of specific instruments to access complex and delicate areas, such as the brain or the base of the skull, through microsurgical techniques, supported by the magnification of an operating microscope. Due to these requirements, the development of advanced skills is needed, including hand-eye coordination, extensive microanatomical knowledge, fine surgical precision, and even control over physiological tremors. However, all of this represents a significant obstacle for young Peruvian neurosurgeons as they require equipped learning spaces and have fewer training opportunities during the early stages of their specialization. As demonstrated in the study by Lefevre *et al*., where the learning curve is influenced by both the duration of the training and technical errors,[9] the importance of creating an adequate learning space must be recognized. Taking this into account, microsurgery simulation programs play an essential role in neurosurgical practice during residency by utilizing simulated models and laboratories that facilitate experiential learning.

## BENEFITS OF SIMULATION IMPLEMENTATION IN PHYSICIAN AND PATIENT SAFETY

The implementation of simulation provides a safe and risk-free practice environment for residents. In addition, it allows them to train in rare or highly demanding clinical scenarios. The physician can identify their weaknesses early on and reduce the margin of error, which is crucial to ensuring the safety and integrity of patient health. Furthermore, simulation facilitates the acquisition of clinical skills before actual patient contact and corrects deficiencies in coordination with the professional team.[15] This simulated practice not only enables neurosurgeons to acquire technical competence but also provides them with the necessary confidence to successfully face the challenges encountered in daily clinical practice. An example is a study conducted by Thiong'o and Kulkarni, in 2022, where they assessed the confidence of 11 residents before and after performing a hemispherectomy on a simulator using a 10-item questionnaire.[14] The results showed that all participants experienced a significant increase in their confidence to perform the procedure after completing the simulation, indicating that it can positively influence decision-making and performance during surgical procedures. In this regard, it has been observed that those with earlier training using simulators demonstrate an improvement in their surgical technical performance.[6] Therefore, simulation programs should be implemented within the curriculum of residency programs to enhance neurosurgical training.

## NEW SIMULATION TECHNOLOGIES IN NEUROSURGERY RESIDENCY

To support simulation models, technological resources such as virtual reality and augmented reality are currently being used, which provide better spatial orientation for the surgical training of young residents. Kennedy *et al*. demonstrated that the group of students trained with virtual reality-assisted simulators had 40% fewer errors than the control group, which only trained with the traditional method.[7] On the other hand, Petrone *et al*. incorporated hybrid simulators, which combined virtual reality with anatomical models created by 3D printers, avoiding the use of animal models. They reported an improvement in the competence and technical skills of residents by 85.8% and 84.7%, respectively.[11] Bruening *et al*. also observed the usefulness of 3D and 360° virtual reality videos, including annotations and narration during neurosurgical training, in procedures such as aneurysm clipping and metastasis resection. They obtained a positive response (91%) from residents as it is a tool that allows for improved procedural orientation.[2] Therefore, by complementing simulation spaces with more immersive technologies, better learning outcomes can be achieved during neurosurgery residency.

## ARTIFICIAL INTELLIGENCE SUPPORT IN SIMULATOR DEVELOPMENT

Artificial intelligence applied to virtual simulators offers the possibility to personalize the learning experience of users. A study conducted with 50 participants, including neurosurgeons, neurosurgery residents, and medical students, evaluated the development of surgical skills in subpial tumor resection using metrics selected by artificial intelligence. This allowed for detailed tracking of the evolution of their learning curve after repeated practice.[8] In addition, Fazlollahi *et al*. demonstrated that the group of students who received feedback from an artificial intelligence-based tutoring system showed superior performance in the use of neurosurgical simulators compared to those who received feedback from an expert.[5] However, despite the benefits of artificial intelligence, it also has its limitations such as restricted accessibility due to its high cost.

## THE FINANCIAL CHALLENGE OF IMPLEMENTATION OF SIMULATION LABORATORIES' EQUIPMENT

At present, there are few examples of the implementation of simulation in the medical residency program for neurosurgery in Peru. One of these examples is Cayetano Heredia Peruvian University, which has completed the implementation of the first neurosurgery residency program that includes a simulation center as part of the residents' training in neurosurgery in 2023.[4] The inclusion varies

considerably depending on the availability of simulation centers, which is related to economic limitations. It is essential to highlight that the simulation equipment for neurosurgery is modern, advanced, and sophisticated, making it an expensive investment ranging from $200,000 to $1.6 million, in addition to an annual maintenance cost of $15,000.[13] However, institutions may be able to obtain funds through government grants or sponsorships from healthcare or educational companies, as was the case with the Boston Medical Center, which was primarily sponsored by the three families Solomont, Dempsey and Belkin.[1] In this sense, in a developing country like Peru, there are greater difficulties in implementing simulation spaces in neurosurgery residency programs.

## CONCLUSION

To promote future Peruvian neurosurgeons having international competencies focused on new technologies, it is crucial to encourage the creation of simulation spaces in surgical technical preparation.

## REFERENCES


1. Boston University. Three families give $7.5 million to BMC BU today Boston University. Boston University. Available from: https://www.bu.edu/articles/2006/three-families-give-7-5-million-to-bmc [Last accessed on 2023 Jun 17].
2. Bruening DM, Truckenmueller P, Stein C, Fuellhase J, Vajkoczy P, Picht T, *et al*. 360° 3D virtual reality operative video for the training of residents in neurosurgery. Neurosurg Focus 2022;53:E4.
3. Comité Nacional del Residentado Médico (CONAREME). Estándares mínimos de formación para el programa de segunda especialización en neurocirugía. Available from: https://www.conareme.org.pe/web/documentos/estandares%20minimos/grupo%20iiia/neurocirugia.pdf [Last accessed on 2023 Jun 05].
4. Facultad de Medicina. Residentes médicos en Neurocirugía realizan entrenamiento con equipos de última generación en el Centro de Simulación de la Facultad de Medicina. Available from: https://medicina.cayetano.edu.pe/noticias/residentes-medicos-en-neurocirugia-realizan-entrenamiento-con-equipos-de-ultima-generacion-en-el-centro-de-simulacion-de-la-facultad-de-medicina [Last accessed on 2023 Jun 10].
5. Fazlollahi AM, Bakhaidar M, Alsayegh A, Yilmaz R, Winkler-Schwartz A, Mirchi N, *et al*. Effect of artificial intelligence tutoring vs expert instruction on learning simulated surgical skills among medical students. JAMA Netw Open 2022;5:e2149008.
6. Ferreira CD, Filho JL, Elbabaa SK, Brandão MF, de Almeida Holanda MM, de Souza MS, *et al*. The role of a new anatomical simulator for meningomyelocele in the training of neurosurgeons. Childs Nerv Syst 2023;39:2433-8.
7. Kennedy GA, Pedram S, Sanzone S. Improving safety outcomes through medical error reduction via virtual reality-based clinical skills training. Saf Sci 2023;165:106200.
8. Ledwos N, Mirchi N, Yilmaz R, Winkler-Schwartz A, Sawni A, Fazlollahi AM, *et al*. Assessment of learning curves on a simulated neurosurgical task using metrics selected by artificial intelligence. J Neurosurg 2022;137:1160-71.
9. Lefevre E, Ganau M, Zaed I, de Macedo Machado-Filho G, Scibilia A, Mallereau CH, *et al*. Learning curve and influencing factors of performing microsurgical anastomosis: A laboratory prospective study. Neurosurg Rev 2022;45:3271-80.
10. Murguia-Fuentes R, Husein N, Vega A, Rangel-Castilla L, Rotta JM, Quinones-Hinojosa A, *et al*. Neurosurgical residency training in Latin America: Current status, challenges, and future opportunities. World Neurosurg 2018;120:e1079-97.
11. Petrone S, Cofano F, Nicolosi F, Spena G, Moschino M, Di Perna G, *et al*. Virtual-augmented reality and life-like neurosurgical simulator for training: First evaluation of a hands-on experience for residents. Front Surg 2022;9:862948.
12. Salazar-Campos CE. Road to global neurosurgery: "The new Covid-19 generation: Neuro-microsurgery and 3d printing". Rev Cuerpo Med HNAAA 2022;15:151-2.
13. Simulation Center Finances: Calculating fees and costs. Available from: https://www.wolterskluwer.com/en/expert-insights/simulation-center-finances-calculating-fees-and-costs [Last accessed on 2023 Jun 10].
14. Thiong'o GM, Kulkarni A, Drake JM. Moderate procedural confidence improvement following hands-on practice using the hemispherectomy simulator. Childs Nerv Syst 2022;38:1777-82.
15. Villca S. Clinical simulation and patients security in medical education. Rev Cien Technol Innov 2018;16:75-88.


**How to cite this article:** Aguilar-Zegarra LF, Quiroz-Marcelo DA, Ou-Li FS, Nombera-Aznarán MF. The implementation of simulators in neurosurgery training. The application of the simulator program in Peru. Surg Neurol Int 2023;14:356.