J Crit Care 91 (2026) 155296

Contents lists available at ScienceDirect

Journal of Critical Care

journal homepage: www.journals.elsevier.com/journal-of-critical-care

Consensus statement on standards for neurocritical care units in low-income and middle-income countries (LMICs)

Gentle S. Shrestha [a,b,1,*], Hemanshu Prabhakar [c], Charu Mahajan [c], Indu Kapoor [c], Sarah L. Livesay [d], Venkatkrishna Rajajee [e], Kapil Zirpe [f], Walter Videtta [g], Susmita Hossain [h], Gisele Sampaio Silva [i], Andres M. Rubiano [j], Mohamed Samy Abdel Raheem [k], Yanet Pina [l], Jaya Wanchoo [m], Urvi Shukla [n], Swagata Tripathy [o], Vasudha Singhal [m], Ruth Evlin Margaretha [p], Samuel Tsan [q], Fasika Tesfaneh Yimer [r], Ritesh Lamsal [s], Halima Salisu-Kabara [t], Juan Luis Pinedo [u], Jo Ann R. Soliven [v], Konstantin Popugaev [w], Llewellyn C. Padayachy [x], Puvanendiran Shanmugam [y], Tanuwong Viarasilpa [z], Oguzhan Arun [aa], Tuan Van Bui [ab]

[a] Tribhuvan University Teaching Hospital, Institute of Medicine, Kathmandu, Nepal
[b] Australian and New Zealand Intensive Care Research Centre (ANZIC-RC), School of Public Health and Preventive Medicine, Monash University, Melbourne, Victoria, Australia
[c] All India Institute of Medical Sciences, New Delhi, India
[d] Rush University College of Nursing, Chicago, IL, USA
[e] Department of Neurology and Neurosurgery, 3552 Taubman Health Care Centre, University of Michigan, Ann Arbor, MI, USA
[f] Neurotrauma Intensive Care Unit, Grant Medical Foundation, Ruby Hall Clinic, Pune, India
[g] Department of Internal Care, Hospital Nacional Prof A Posadas, Buenos Aires, Argentina
[h] Department of Critical Care and Emergency Medicine, United Hospitals Limited, Dhaka, Bangladesh
[i] Department of Neurology and Neurosurgery, Universidade Federal de Paulo and Hospital Israelita Albert Einstein, Sao Paulo, Brazil
[j] Neuroscience Institute, Universidad El Bosque, Bogota, Colombia
[k] Department of Anesthesiology, Faculty of Medicine, Asyut University, Asyut, Egypt
[l] Department of Intensive Care Unit, Greater Accra Regional Hospital Ridge, Accra, Ghana
[m] Department of Neuroanaesthesia and Neurocritical Care, Medanta The Medicity Hospital, Gurugram, India
[n] Department of Critical Care, Symbiosis University Hospital and Research Centre, Symbiosis International University, Pune, India
[o] Department of Anesthesia and Intensive Care, All India Institute of Medical Sciences, Bhubaneswar, India
[p] Department of Anesthesiology and Intensive Therapy, Faculty of Medicine, Baiturrahmah University, Padang, Indonesia.
[q] Department of Anaesthesiology and Intensive Care, Faculty of Medicine and Health Sciences, University of Malaysia Sarawak, Kota Samarahan, Malaysia
[r] Department of Internal Medicine, University of Namibia, Windhoek, Namibia
[s] Department of Anaesthesiology, Tribhuvan University Teaching Hospital, Institute of Medicine, Kathmandu, Nepal
[t] Department of Anesthesiology and Intensive Care Unit, Aminu Kano Teaching Hospital, Kano, Nigeria
[u] Department of Emergency and Critical Care, Clinical AUNA, Chiclayo, Peru
[v] Institute of Neurological Sciences, The Medical City – Ortigas, Paaig City, Philippines
[w] Deputy Director of Science, National Medical Research Centre of Paediatrics, Moscow, Russia
[x] Department of Neurosurgery, University of Pretoria, Steve Biko Academic Hospital, Pretoria, South Africa
[y] Department of Neuroanesthesia and Intensive Care, National Hospital Kandy, Kandy, Sri Lanka
[z] Division of Critical Care, Department of Medicine, Siraj Hospital, Mahidol University, Bangkok, Thailand
[aa] Department of Anesthesiology and Reanimation, Selcuk University Faculty of Medicine, Konya, Turkey
[ab] Department of Neurosurgical ICU, Cho Ray Hospital, Ho Chi Minh, Vietnam

ARTICLE INFO

Keywords:
Quality indicator

ABSTRACT

The disease burden of severe neurological and neurosurgical illnesses in low-income and middle-income countries (LMICs) is high. Management of these patients by a dedicated neurocritical care team can improve outcome.

* Corresponding author at: Australian and New Zealand Intensive Care Research Centre (ANZIC-RC), School of Public Health and Preventive Medicine, Monash University, Melbourne, Victoria, Australia
E-mail addresses: gentlesunder@hotmail.com, gentle.shrestha@monash.edu (G.S. Shrestha).
[1] First and second author contributed equally.

https://doi.org/10.1016/j.jcrc.2025.155296

Available online 18 October 2025

Standards
Neurocritical care
Low-income countries
Middle-income countries
Resource limited settings

Globally, there is significant variation in organization, structure, and outcome of patients with neurocritical illnesses. This consensus statement aims to contextualize the standards for neurological critical care units (NCCUs) in LMICs. Recommendations were made about organization and infrastructure, personnel, logistics, training, education, and process for developing neurocritical care program appropriate for LMICs. Methods: The steering committee for the consensus statement was formed under the leadership of Society of Neurocritical Care (SNCC), India. With permission from Neurocritical Care Society (NCS) and the NCS guidelines committee, the previously published standards for NCCUs by NCS was used for a web-based survey. The Delphi method was used to gather consensus. A total of 28 experts from 21 nations, all from LMICs, participated in the Delphi. Responses were formally collated, reviewed, and incorporated into the final document. For Level 1 NCCUs, we found that LMIC experts have recommended few parameters that were considered optional by NCS. However, for Level 2 and 3 ICUs, many recommendations from NCS were suggested to be considered as optional by LMIC experts. We have made attempts to explain the variation in recommendations. The recommendations should be tested for feasibility at the local settings before implementing them.

1. Introduction

Critically ill neurological patients are best managed in a specialized ICU operated by a team of healthcare workers trained in managing such patients. The introduction of neurocritical care team, including a full-time neurointensivist is associated with significantly reduced in-hospital mortality and length of stay without changes in readmission rates or long-term mortality [1]. In a retrospective study of patients with aneurysmal subarachnoid hemorrhage admitted to Neuroscience ICU, patients treated after the introduction of multidisciplinary neurocritical care team were significantly more likely to receive definitive aneurysm treatment and were more likely to be discharged to home [2]. Also there is growing evidence supporting the use of performance measures in neurocritical care. Low-income and middle-income countries (LMICs) have a high disease burden of neurocritical illnesses. The difference in available infrastructure, patient demographics and healthcare system in LMICs limit the extrapolation of recommended standards for neurocritical care units, developed and aimed for developed countries. Conducting research on needs and best practice for brain-injured patients, developing systems for effective triage, education and training that is adapted to the requirements of LMICs, and supporting expansion of neurology workforce, is a need of the hour. This is best delivered by greater and more effective collaboration among the LMICs healthcare systems [3]. For the purpose of this consensus statement, we have categorized low, middle and high income nations as per the classification from World Bank.

In 2018, the Neurocritical Care Society (NCS) published Standards for Neurocritical Care Units (NCCUs) [4]. This statement for the health care professionals was prepared under the direction of NCS Executive Leadership. The writing group comprised members residing in the United States of America. These recommendations may not apply to the LMICs. In most LMICs, healthcare workers tend to adapt guidelines from high income countries. However, locally developed guidelines or the guidelines tailored to local context are more likely to be implemented succesfully, considering the variation in available resources, local expertise and local cultures [5]. Society of Neurocritical Care (SNCC), a Global Partner of the NCS, planned to reconsider these recommendations on the Standards for NCCU, and aimed to contextualize it for the resource limited settings.

This consensus statement aims to set standards for the NCCU in LMICs to recommend the structure, personnel and processes necessary to develop a NCCU and establish a comprehensive neurocritical care program.

2. Materials and methods

A steering committee (SC) was formed under the leadership of SNCC. With permission, we used the framework prepared for the statement on standards for the NCCU by experts from the NCS. Google Forms is a secure web application for building and managing online surveys and databases. The standard items were incorporated in form created on Google forms software and shared with experts from the LMICs. Experts from LMICs were selected based on their existing or past experience in neurocritical care. We also approached the NCS Guidelines Committee to help identify experts by contacting global partners. The members of the SC coordinated and communicated with these experts.

A Delphi method based on a web-based questionnaire developed with Google Forms on a secure server was used to seek the opinions of experts. The objective was to reduce the heterogeneity of different points of view, reach the highest possible degree of convergence, or attain stability. Experts sought opinions to classify standards for Level 1 to Level 3 NCCUs and provide their responses as Recommended, Optional, or Not Recommended. For the purpose of this Consensus Statement, we recognized three levels of NCCUs, as suggested in the original document from the NCS [4].

A total of 30 experts from 23 LMICs were approached for Delphi. Of them, 28 experts from 21 nations, participated in the first round (Fig. 1). In the final round, 27 experts from 20 nations were retained. One expert from Ethiopia participated in only round 1 and the expert is mentioned in the acknowledgment section. Consensus was considered to be achieved if 75 % or more of experts voted for a particular option (Recommended, Optional or Not Recommended). For each round, reminders were sent every week for a total of three times. Regarding stability, modifications to questionnaire were made upon reaching agreement and consensus during the rounds. Subsequent questionnaires were developed in rounds where no consensus was achieved in previous iterations. Stability was considered to be attained when less than 10 % of panelists suggested for changes.

2.1. Levels of neurocritical care units

Level I units receive patients with complex neurological emergencies requiring advanced interventions and providing the most comprehensive neurocritical care. These units should be equipped to provide definitive and expert care to a wide variety of neurocritical care disorders using an interdisciplinary approach. Level I units offer a full complement of advanced monitoring, surgical, and medical treatments and have the capability to provide physician fellowship and advanced practice professional training. They are often associated with academic training program. Level II units can stabilize acutely ill patients and safely manage stable neurocritical conditions while establishing relationships with Level I neurocritical care units. Level III units can provide emergent evaluation and stabilization of patients presenting with neurological emergencies and facilitate the transfer of these patients to Level I and Level II units as appropriate.

After each round of survey, we analyzed the responses. For statements where consensus was achieved, we removed them from subsequent rounds. Individual experts were approached when required to confirm a correct understanding of the question and asked whether they wanted to modify or retain their responses. Members were allowed to reconsider their responses and make desired changes. The intention was to reach a consensus.

3. Results

Responses were collected from all the experts, and results summated (Supplement - Table 1). The recommendations from LMIC experts were compared with the recommendations from NCS. All the differences in recommendations were tabulated and categorized for different levels of ICU in Table 1.

3.1. General organization and infrastructure

Neurocritical units (NCCUs) are the specialized areas taking care of neurocritically ill patients by specialized physicians, trained nurses, and a dedicated executive leadership. For the organizational setup in Level I, Level II, and Level III NCCUs, the opinion of the experts from the LMICs is in accordance with that of the experts from the healthcare professionals from NCS. (Supplement – Table 1) Regarding policies and guidelines related to admission and discharge, disease-specific protocols, patient monitoring and safety, quality and traffic control, and other items listed in Supplement - Table 1, the experts from the LMICs and healthcare professionals from NCS held similar recommendations for Level I and Level II NCCUs. However, the experts from the LMICs felt that Level III NCCUs should have disease specific protocols and, at the same time, policies related to equipment and procedures should be optional.

3.2. Personnel

Program Leadership: The experts from the LMICs (and healthcare professionals from NCS) recommended standing committee with interdisciplinary representation, a distinct administrative unit, and a NCC committee delineating the privileges of physicians and non-physicians for all the three Levels of NCCUs.

Medical Director: The experts recommended that the appointment of the medical director should be by the appropriate hospital authority at all Levels of NCCUs. In the absence of a medical director, a qualified physician should be identified to carry out the duties, and this should be communicated to the interdisciplinary team. There should be written documentation of all the responsibilities at all the Levels of NCCUs. The medical director should be a board-certified physician in the NCC speciality. He should be responsible for the implementation of policies, maintaining the database, budget preparation, education, and research at all the levels of NCCUs. The medical director should also supervise the quality improvement and assurance activities at all the Levels.

*Physician Staffing:*A certified neurointensivist should be available within 5 min 24 h a day and by telemedicine or telephone at all the Levels of NCCUs. Physicians' subspecialty training should be optional in Level II and Level III NCCUs. No consensus could be reached for in house availability for the intensivists at Level II NCCUs. The availability of neurointerventionalists, neurosurgeons, and radiologists in less than 30 min is recommended at Level I NCCUs. However, no consensus could be reached for the availability of the neurointerventionalist within 30 min at Level II. The availability of radiologist within 30 min should be optional for Level III. The specialists from other disciplines such as anesthesiologists, cardiologists, epileptologists, general surgeons, pathologists, and others listed in Supplement - Table 1, should be available for consultation as recommended by experts for Level I NCCUs. At Level II, the availability of endocrinologists, ethicists, gastroenterologists, oncologists, infectious disease, and palliative care experts may be optional. No consensus could be reached for the availability of psychologists. Anesthesiologists and general surgeons are also recommended at Level III. Rest of the consultations are optional.

Nursing: The nursing care plays a vital role in NCCUs in terms of the outcome of the patients. It is recommended that at Level I, the director of the nursing department should have experience in NCC. All nurses should have qualifications such as master's degree or subspecialty certification along with training in basic life support (BLS), advanced cardiac life support (ACLS), and emergency neurological life support (ENLS). There should be quality indicators for monitoring. At Level II, the specialty certification for the manager and nurses may be optional, whereas in Level III ENLS certification and NCC competencies are optional.

Advanced Practice Providers: Most of the LMICs do not have advanced practice providers (APP). As defined by the health care professionals from the NCS, APP encompasses the roles of nurse practitioners, clinical

Fig. 1. Representation of experts from the low – and middle – income countries who participated in the Delphi to establish Standards of Neurocritical Care.

Table 1
Key variations in recommendations on the Standards of Neurocritical Care Units between those from the experts in low – and middle – income countries (LMICs Standards) and those from NCS (NCS Standards). The differences are categorizes as per the recommendation for different levels of NCCU:

	LMICs Standards	NCS Standards
Level I Pharmacist		
1. Doctorate degree in pharmacy	O	R
Hospital facilities and services		
Emergency department		
1. Helipad	R	O
Continuous monitoring equipment		
1. Brain tissue oxygen monitoring	R	O
2. Cerebral blood flow	R	O
3. Esophageal pressure	O	R
Research and training		
Physician training		
1. Units/beds in facility with accredited neurology residency programme	R	O
2. Unit provides clinical rotation for neurocritical care	R	O
3. Fellowship programme in NCC	R	O
Level II. *Medical Director Qualifications*		
1. Neurocritical Care Subspeciality (Board) certified or eligible	NC	R
2. Coordinate research	R	O
Physician staff or licensed Independent Practitioners (LIP)		
Certified Neurointensivists or LIP or postgraduate year 2 above with NCC expertise and neurointensivist support		
1. Available –n-house 24 h a day	NC	O
2. Physicians should have subspeciality training in NCC	O	O
3. Neurointensivist on-site 24/7. May be delegated to another in-house provider (Trainee, advanced practice provider)	R	O
Available in less than 30 min		
1. Neurointerventionalist	NC	O
2. Neurosurgeon	R	O
Available for consultation		
1. Endocrinologist	O	R
2. Ethics	O	R
3. Gastroenterologist	O	R
4. Hematologist/oncologist	O	R
5. Infectious disease	O	R
6. Palliative care/supportive care medicine	O	R
7. Psychiatrist / psychologist	NC	O
Advanced Practice Provider (APP)		
1. Additional training in NCC completed and documented	O	R
2. Involved in rounding with NCC team	O	R
3. NCC Quality/education focused APP	O	R
Pharmacists		
1. Pharmacist with expertise in NCC	O	R
2. Doctorate degree in pharmacy	O	R
3. Attend in-hospital neurocritical care emergencies	O	R
4. Involved in hospital committees, quality improvement	NC	R
Respiratory therapy		
1. RT department supervise training	O	R
2. Therapist in-house 24 h day	O	R
3. Therapist in-house with NCC expertise	O	R
Other team members		
1. Occupational therapist (OT) with expertise in neurologic patient population	O	R
2. PT/OT/ Speech therapist (ST) available 7 days a week	O	R
3. PT/OT/ST with special expertise in NCC	O	R
4. Social worker and case manager with expertise in care of neurologic patient population	O	R
5. Spiritual care support	O	R
6. ST with expertise in neurologic patient population	O	R
Hospital facilities and services		
Emergency department		
1. Resuscitation area – capable of managing 2 patients at once	R	O
Radiology/diagnostic (perform/interpret)		
1. Angiography capabilities 24 h day	NC	R
2. Continuous EEG	O	R
3. Diagnostic and therapeutic endoscopy	O	R
4. Nuclear scanning	O	R
5. STAT EEG	O	R
6. Transcranial doppler	NC	R
7. Transesophageal echocardiogram	O	R
Laboratory		
1. Operating room		
a. Available within 30 min, 24 h day	R	O
b. Second OR available within 45 min, 24 h day	NC	O
Separate rooms		
1. Conference room	NC	R
2. Unit rooms, unit makeup	O	R
Portable equipment		
1. Automated bed scale	O	R
2. Bronchoscope	NC	R
Respiratory support equipment		
1. MRI compatible ventilator	O	O
Continuous monitoring equipment		
1. Esophageal pressure	O	R
Research and training		
Regional education		
1. Provide NCC educational outreach to public	O	R
Level III. Organization		
1. Distinct administrative unit	O	R
2. NCC Committee	O	R
3. Standing committee, interdisciplinary representation	O	R
Policies / Guidelines		
1. Disease specific protocols	R	O
2. Equipment and procedures related to NCC	O	R
Physician staff or licensed Independent Practitioners (LIP)		
Certified Neurointensivists or LIP or postgraduate year 2 above with NCC expertise and neurointensivist support		
1. Physicians should have subspeciality training in NCC	O	R
2. All medical staff undergo ongoing professional practice evaluation (OPPE) case review in NCC (or equivalent)	O	R
3. Additional privileges in NCC determined by organization	O	R
Available in less than 30 min		
1. Radiologist	O	R
Available for consultation		
1. Anesthesiologist	R	O
2. Ethics	O	R
3. General surgeon	R	O
4. Radiologist	O	R
Nursing staff		
1. ENLS certification or equivalent	O	R
2. Neurocritical care competencies (including ED staff)	O	R
Nursing skills		
1. Resuscitation, including ENLS certification or equivalent	NC	R
Pharmacists		
1. Doctorate degree in pharmacy	O	R
2. Attend in-hospital neurocritical care emergencies	O	R
3. Involved in hospital committees, quality improvement	O	R
Respiratory therapy		
1. Supervisor responsible for training RT staff, maintenance of equipment, and quality control/ review	O	R
2. RT department supervise training	O	R
3. Therapist in-house 24 h day	O	R
Other team members		
1. Biomedical technician	O	R

(*continued on next page*)

Table 1 (*continued*)

	LMICs Standards	NCS Standards
2. PT/OT/ST establish response time for new consultation	O	R
3. Radiology technician	O	R
4. Registered dietician or certified nutrition support clinician	O	R
5. Social worker and case manager with expertise in care of neurologic patient population	O	R
6. Spiritual care support	O	R
Hospital facilities and services		
Emergency department		
1. Staffed by physician 24 h day	R	O
2. Comprehensive blood bank, all components	O	R
Radiology/diagnostic (perform/interpret)		
1. Fluoroscopy	O	R
2. Transthoracic echocardiogram	O	R
Laboratory		
1. Available labs within 1 h		
a. CSF cell count	O	R
b. Platelet function test	O	R
2. Labs within 3 h		
a. Ammonia	O	R
b. Magnesium, phosphorus	O	R
c. Osmolality	O	R
d. Tox screen	O	R
3. Labs available 24 h day		
a. Culture and gram stain	O	R
5. Operating room		
a. Available within 60 min, 24 h day	NC	NC
Neurorehabilitation internal or affiliated		
Physical facility (unit)		
Separate rooms		
1. Conference room	O	R
2. Family counselling room	O	R
3. Leadership office space	O	R
4. Patients' personal effects storage (may be internal)	O	R
5. Staff lounge	O	R
6. Unit rooms, unit makeup	O	R
7. Computerized laboratory reporting or efficient equivalent	O	R
8. Isolation capacity	NC	R
9. Nourishment station	O	R
10. Two or more compressed air outlets/bed	O	R
11. Two vacuum outlets/bed	O	R
Portable equipment		
1. Blood warmer	O	R
2. Doppler ultrasonography	O	R
Respiratory support equipment		
1. Air-oxygen blenders	NC	R
Continuous monitoring equipment		
1. $ETCO_2$ monitor	NC	R
Research and training		
Physician training		
1. ENLS certification or equivalent	O	R
Unit personnel training		
1. ENLS certification or equivalent for nurses	O	R
2. Ongoing continuing education related to NCC	O	R
Regional education		
1. Provide regional / local NCC education	O	R
Quality assessment		
1. Discharge planning	R	O

R – Recommended.
O – Optional.
NA – Not applicable.
NC – No consensus.

nurse specialist or as defined by the state board of nursing and physician's assistant. The APP should have additional training in NCC, be involved in rounding with NCC team, and should remain focused on education and quality of NCC. However, the experts from the LMICs suggest that should such a post exists in their centers, they recommend for Level I NCCUs and optional in Level II and III NCCUs.

Nursing skills: Various roles for NCC nurses have been addressed by the experts, such as managing external ventricular drains (EVDs) and lumbar drains, managing advanced neurological monitoring, addressing psychological needs of the family and others listed in Supplement - Table 1. The experts from the LMICs recommended these roles at Level I and II NCCUs. No consensus could be reached for ENLS certification or equivalent for them at Level III NCCUs.

Pharmacy Services: It has been strongly recommended that the pharmacy be available to cater all requests 24 h a day. There should also be an urgent drug list at the bedside at all three Levels of NCCUs. The importance of the role of pharmacists in NCC can not be overemphasized. There is sufficient literature to support and suggest that the presence of a pharmacist reduces the rate of complications, morbidity, mortality and length of ICU and hospital stay [6-11]. It was recommended that a trained pharmacist should possess board certification or its equivalent at Level I but optional in Level II and Level III NCCUs. It is optional to have a doctorate degree in pharmacy in Level I NCCUs. For Level II and III NCCUs, experts suggest having a dedicated pharmacist in the NCCUs is optional. Their role in managing NCC emergencies and training other care givers is also optional in Level II and Level III NCCUs. While the pharmacist role in hospital committees for quality improvement was recommended at Level I and optional in Level III, no consensus could be reached for this role in Level II NCCUs.

Respiratory Therapy (RT) Services: Respiratory therapists play a vital role in caring for NCC patients, whether without or with mechanical ventilation. There should be a supervisor responsible for training the respiratory therapy staff, maintenance of equipment, and reviewing the quality of work at Level I and II NCCUs. The experts suggested the need for RT trained in NCC and available 24 h /day for Level I NCCUs. However, this was optional at Level II and Level III NCCUs.

Other Team Members: Several team members listed in Supplement - Table 1 have been recommended in Level I and suggested optional in Level III NCCUs. For Level II NCCUs, recommendations have been made for biomedical technician, radiology technician, dietician, physiotherapist and unit clerk.

3.3. Hospital services

Several recommendations related to the hospital facilities and services at various Levels of NCCUs have been suggested. At Level I, the experts from the LMICs recommended helipad, while the healthcare professionals from NCS made it optional. No consensus could be reached for the capabilities of angiography 24 h /day and the use of transcranial Doppler at Level II NCCUs. For Level III NCCUs, no consensus could be made for the availability of operation theatre within 60 min in a day.

3.4. Equipment

The availability of various equipments such as portable equipments, respiratory support equipments and continuous monitoring equipments (Supplement - Table 1) at all the three Levels of NCCUs was also discussed among the experts. The inclusion of esophageal pressure monitoring was suggested as optional at all three Levels of NCCUs. The other equipments that were considered optional for Level II NCCUs are an automated bed scale and an MRI-compatible ventilator. No consensus could be reached for including bronchoscope in the list of portable equipments in Level II NCCUs. The experts suggested that the inclusion of blood warmers and Doppler ultrasonography should be optional in Level III NCCUs. However, they recommend inclusion of point-of-care ultrasonography and emergency cut-down trays, even at Level III NCCUs. No consensus could be reached for the availability of air-oxygen blenders and end-tidal carbon dioxide monitors at this Level.

3.5. Training, continuing education and research

The education, training, research, and quality assessment are integral to NCCUs at all Levels. The experts from the LMICs recommend a

fellowship program in NCC, provision of clinical rotation, and facilities related to neurology residency programme should be available in Level I NCCUs. At Level II NCCUs the experts suggested that providing NCC educational outreach to the public should be optional. The same experts also consider ENLS certification or equivalent for physicians and nurses, along with optional provision for regional/local NCC education at Level III NCCUs. They support the concept of discharge planning at Level III NCCUs.

4. Discussion

This consensus statement, which is based on the opinion of neurocritical care experts from a broad range of low and middle-income nations, is the first to delineate standards for NCCUs in LMICs. These standards use the framework established by NCS in 2018. The framework was also based on The Joint Commission and Comprehensive Stroke Center requirements which largely emerged from the the persepective of United States. We used and retained the framework established by NCS so as to harmonize this consensus statement with the existing standards. The standards suggested by NCS may not be applicable to the resource limited settings of LMICs, thus triggering the need to define or explore standards of NCCUs that are relevant and applicable to the context of LMICs.

Notably, the diverse group of LMIC experts in our panel have recommended few parameters that were considered optional in the NCS 2018 level-1 NCCU standards. The panel, however, noted that many standards recommended in the 2018 NCS document should be considered optional for level 2 and 3 NCCUs in LMICs (Table 1). For the consensus statement, we identified LMICs as per the classification proposed by the World Bank. As the classification includes nation with a very wide range of income based on gross national income, we can expect representation of nations with varying availability of resources [12,13]. Though uncommon, apex referral centers do exist in many LMICs with organization, facilities, personnel, and equipment that equals or exceeds those of level-1 NCCUs in high-income nations. These centers may have routine access to facilities and equipment considered optional for level-1 NCCUs in the 2018 document, such as a helipad or cerebral microdialysis. Though the resource availability is limited in LMICs in general, there is wide variation in available resources between the nations, within a nation and even within a region. Most ICUs and resources are clustered in the major cities and in the large referral centers [14]. Most of the Delphi responders were practicing in Level 1 ICUs, similar to what we observed in the PRINCE study [15]. The practitioners in the larger centers are likely more active in research and collaboration and thus more visible and approachable. We have observed successful implementation of hub-and-spoke model integrated with telemedicine for effective stroke care in LMICs [16]. Such model would likely decrease cost in the spoke centers with some added cost in the hubs, being overall cost-effective [17]. From the perspective of policymakers, enhancing resources in the hubs can be a realistic and feasible approach [18]. Costly interventions in HICs may not necessarily be prohibitive in all LMICs as the cost-effectiveness and the needs can vary between HICs and LMICs [19]. There are evidences that presence of a full-time neurointensivist can be associated with improvement in quality metrics, patient outcome and can be cost effective [20,21]. Also, presence of neurointensivist can improve the process of care, and enhance eduation of the team. These together may translate into improved patient outcomes [22,23]. These factors combined may explain the consensus recommendation of the panel supporting higher level of care and facilities in Level 1 ICU, some being higher than recommended by NCS. Thus the recommendations can be considered as a reasonable target for most regions in LMICs, but needs to be guided by feasibility in local settings and cost-effectiveness analysis [24,25]. The expert panel is mindful that most LMIC NCCUs will face a broad range of challenges in achieving these standards [3]. The statements should be tested for feasibility in the local setting before adapting it.

The PRINCE study, an international multicenter cross-sectional neurocritical care survey, provides important insights into these challenges [15]. Cross-sectional data was obtained from 257 sites in 47 countries in a single week in 2014. While in a majority of centers (67 %) the delivery of neurocritical care occurred in dedicated NCCUs, trained neurointensivists staffed only 20 % of ICUs and NCC fellowship training (or the equivalent) was present in only 27 %. Neurointensivist staffing was lower in LMIC-predominant regions- Asia (20 %), the Middle East (20 %), Latin America (24 %), and Oceania (8 %). Neurocritical care fellowship training was uncommon in these regions- Asia (12 %), the Middle East (0 %), Latin America (16 %) and Oceania (14 %). These regions have likely seen growth in NCC in the intervening decade. However, pathways to formal subspecialty NCC training and board certification remain highly variable or non-existent across LMICs. While 24-h physician staffing was widely prevalent (>90 % of centers in these regions) in the PRINCE study, the availability of other disciplines was highly variable. However, majority of the enrolled sites were from the large cities providing service to a large number of population and were the academic centers, limiting generalizability of the findings. This may be the reason why there was no consensus about availability of in house intensivist in Level II NCCUs. While dedicated NCC pharmacists were more frequently present in the Middle East (67 %) and Oceania (86 %), fewer than half of centers in Asia (45 %) and Latin America (38 %) reported the presence of dedicated pharmacists, a requirement for level-1 NCCUs. Similarly, the majority of centers in the Middle East (85 %) and Latin America (84 %) reported the presence of dedicated respiratory therapists- another level-1 NCCU requirement- unlike centers in Asia (42 %) and Oceania (8 %). Advanced practice providers, also required for level-1 NCCUs, were uncommon in all regions except North America (74 %): Europe (12 %), Asia (18 %), Middle-East (0 %), Latin America (16 %) and Oceania (8 %). Data from an international multicenter study and anecdotal reports suggest that only a small minority of centers in some regions routinely perform invasive ICP monitoring [26]. Very few centers across these regions have access to advanced technology, such as continuous EEG and brain tissue oxygen monitoring. Based on the standards within this consensus statement, most units in LMICs will likely be eligible for a level-2 or level-3 designation.

While the challenges are obvious, the need for high-quality, standardized NCC services has never been greater. Over 80 % of all traumatic brain injuries worldwide occur in LMICs [27]. While 58 % of all strokes worldwide occur in LMICs, the risk of death is 50 % higher in LMICs compared to high-income nations [28]. Postoperative patients may, in particular, benefit from ICU care in low-income nations [29]. In this context, the absence of a dedicated NCCU was an independent predictor of mortality worldwide in the PRINCE study [30]. It is, therefore essential that attention and resources be dedicated to the development of NCCUs in these settings. Policymakers must balance competing demands in countries with many urgent healthcare needs. Recent developments in the field of NCC in LMICs have laid the groundwork for further development. Well over 500 Emergency Neurological Life Support (ENLS) courses have been conducted in over 33 countries worldwide [31], to help standardize the approach to neurological emergencies. Neurocritical care training programs and professional societies have seen growth worldwide. Research collaboration between academic centers in HICs and LMICs has helped establish the current state of NCC worldwide [15,30], and clarify the optimal approach to neuromonitoring of acute brain injury in these settings [26,32-34]. While these partnerships are invaluable, it is clear that local NCC experts will lead the determination of standards and development of NCCUs with the greatest knowledge of the available resources, challenges, feasibility and unmet needs in the local environment.

We suggest the use of these recommendations as a stepping stone for designing the setup, minimizing variations, and standardizing care in NCCUs of LMICs. Translating these recommendations into practice can be hinderd by multiple barriers and would not be devoid of challenges [35]. Adopting a range of implementation strategies, systematically

evaluating the effects of recommendations on clinical outcome, and conducting economic evaluations can reveal the barriers to effective implementation, help to explore feasibility of applying the standards, and the needs for adapting the recommendations considering the local context [36,37]. Combined, these startegies may enhance the outcome of patients in NCCUs of LMICs by facilitating the delivery of highest possible level and quality of care.

The consensus statement has several strengths. We embraced the opinion of neurocritical care experts from 21 LMICs, which can be considered as a decent consensus from LMICs. We adapted and retained the parameters recommended by NCS so as to maintain uniformity and for harmonization with the existing proposed standards.

There are several limitations. The parameters used in this consensus statement are derived from the standards recommended by NCS, which is targeted to the NCCUs of United States. Not all parameters would be suitable or applicable for NCCUs in LMICs. Considering the wide variablility in resources and capacity within the LMICs, the proposed recommendations need to be validated before implementing them. Among the 21 nations, some nations such as India are over-represented. As the Delphi consensus was the initiative of SNCC (India) and as India is one of the most heavily populated nation, such over-representation may be justifiable.

5. Conclusions

In conclusion, there is growing evidence that neurocritically ill patients managed in NCCUs involving dedicated neurocritical care team can improve outcomes. Considering the wide variation in neurocritical care practice and resources globally and considering the impact of unique challenges inherent to LMICs, this consensus statement was created involving the neurocritical care experts from LMICs in different regions. We recommend the use of this consensus statement so as to setup NCCUs, organize resources, minimize variations and improve outcomes in LMICs. Contextualizing the recommendations is expected to improve applicability of the consensus statement and would help with better adherence to the standards deemed feasible and achievable.

Funding disclosure

None.

CRediT authorship contribution statement

Gentle S. Shrestha: Writing – review & editing, Writing – original draft, Supervision, Conceptualization. **Hemanshu Prabhakar:** Writing – review & editing, Writing – original draft, Formal analysis, Data curation, Conceptualization. **Charu Mahajan:** Writing – review & editing, Writing – original draft, Conceptualization. **Indu Kapoor:** Writing – review & editing, Writing – original draft, Conceptualization. **Sarah L. Livesay:** Writing – review & editing, Supervision, Conceptualization. **Venkatkrishna Rajajee:** Writing – review & editing, Supervision, Conceptualization. **Kapil Zirpe:** Writing – review & editing, Supervision, Conceptualization. **Walter Videtta:** Writing – review & editing, Methodology. **Susmita Hossain:** Writing – review & editing, Methodology. **Gisele Sampaio Silva:** Writing – review & editing, Methodology. **Andres M. Rubiano:** Writing – review & editing, Methodology. **Mohamed Samy Abdel Raheem:** Writing – review & editing, Methodology. **Yanet Pina:** Writing – review & editing, Methodology. **Jaya Wanchoo:** Writing – review & editing, Methodology. **Urvi Shukla:** Writing – review & editing, Methodology. **Swagata Tripathy:** Writing – review & editing, Methodology. **Vasudha Singhal:** Writing – review & editing, Methodology. **Ruth Evlin Margaretha:** Writing – review & editing, Methodology. **Samuel Tsan:** Writing – review & editing, Methodology. **Fasika Tesfaneh Yimer:** Writing – review & editing, Methodology. **Ritesh Lamsal:** Writing – review & editing, Methodology. **Halima Salisu-Kabara:** Writing – review & editing, Methodology. **Juan Luis Pinedo:** Writing – review & editing, Methodology. **Jo Ann R. Soliven:** Writing – review & editing, Methodology. **Konstantin Popugaev:** Writing – review & editing, Methodology. **Llewellyn C. Padayachy:** Writing – review & editing, Methodology. **Puvanendiran Shanmugam:** Writing – review & editing, Methodology. **Tanuwong Viarasilpa:** Writing – review & editing, Methodology. **Oguzhan Arun:** Writing – review & editing, Methodology. **Tuan Van Bui:** Writing – review & editing, Methodology.

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.

Acknowledgements

We wish to acknowledge Dr. Yalew Hassen (Ethiopia) who partially contributed to the development of Consensus Statement.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jcrc.2025.155296.

References

[1] Suarez JI, Zaidat OO, Suri MF, Feen ES, Lynch G, Hickman J, et al. Length of stay and mortality in neurocritically ill patients: impact of a specialized neurocritical care team. Crit Care Med 2004;32(11):2311–7.
[2] Samuels O, Webb A, Culler S, Martin K, Barrow D. Impact of a dedicated neurocritical care team in treating patients with aneurysmal subarachnoid hemorrhage. Neurocrit Care 2011;14(3):334–40.
[3] Prust ML, Mbonde A, Rubinos C, Shrestha GS, Komolafe M, Saylor D, et al. Providing neurocritical care in resource-limited settings: challenges and opportunities. Neurocrit Care 2022;37(2):583–92.
[4] Moheet AM, Livesay SL, Abdelhak T, Bleck TP, Human T, Karanjia N, et al. Standards for neurologic critical care units: a statement for healthcare professionals from the Neurocritical care society. Neurocrit Care 2018;29(2):145–60.
[5] Olayemi E, Asare EV, Benneh-Akwasi Kuma AA. Guidelines in lower-middle income countries. Br J Haematol 2017;177(6):846–54.
[6] Kane SL, Weber RJ, Dasta JF. The impact of critical care pharmacists on enhancing patient outcomes. Intensive Care Med 2003;29(5):691–8.
[7] Leape LL, Cullen DJ, Clapp MD, Burdick E, Demonaco HJ, Erickson JI, et al. Pharmacist participation on physician rounds and adverse drug events in the intensive care unit. JAMA 1999;282(3):267–70.
[8] MacLaren R, Bond CA, Martin SJ, Fike D. Clinical and economic outcomes of involving pharmacists in the direct care of critically ill patients with infections. Crit Care Med 2008;36(12):3184–9.
[9] Marshall J, Finn CA, Theodore AC. Impact of a clinical pharmacist-enforced intensive care unit sedation protocol on duration of mechanical ventilation and hospital stay. Crit Care Med 2008;36(2):427–33.
[10] Rivkin A, Yin H. Evaluation of the role of the critical care pharmacist in identifying and avoiding or minimizing significant drug-drug interactions in medical intensive care patients. J Crit Care 2011;26(1):104.e1–6.
[11] Weant KA, Armitstead JA, Ladha AM, Sasaki-Adams D, Hadar EJ, Ewend MG. Cost effectiveness of a clinical pharmacist on a neurosurgical team. Neurosurgery 2009;65(5):946–50. discussion 50–1.
[12] Eric Metreau KEY. Shwetha Grace Eapen. World Bank country classifications by income level for 2024–2025. Available from: https://blogs.worldbank.org/en/opendata/world-bank-country-classifications-by-income-level-for-2024-2025.
[13] Lencucha R, Neupane S. The use, misuse and overuse of the 'low-income and middle-income countries' category. BMJ Glob Health 2022;7(6).
[14] Murthy S, Leligdowicz A, Adhikari NK. Intensive care unit capacity in low-income countries: a systematic review. PloS One 2015;10(1):e0116949.
[15] Suarez JI, Martin RH, Bauza C, Georgiadis A, Venkatasubba Rao CP, Calvillo E, et al. Worldwide Organization of Neurocritical Care: results from the PRINCE study part 1. Neurocrit Care 2020;32(1):172–9.
[16] Tan E, Gao L, Tran HN, Cadilhac D, Bladin C, Moodie M. Telestroke for acute ischaemic stroke: a systematic review of economic evaluations and a de novo cost-utility analysis for a middle income country. J Telemed Telecare 2024;30(1):18–30.
[17] Switzer JA, Demaerschalk BM, Xie J, Fan L, Villa KF, Wu EQ. Cost-effectiveness of hub-and-spoke telestroke networks for the management of acute ischemic stroke from the hospitals' perspectives. Circ Cardiovasc Qual Outcomes 2013;6(1):18–26.

[18] Pandian JD, Kalkonde Y, Sebastian IA, Felix C, Urimubenshi G, Bosch J. Stroke systems of care in low-income and middle-income countries: challenges and opportunities. Lancet 2020;396(10260):1443–51.
[19] Rajajee V. Can Neurocritical care guidelines developed in high-income countries be relevant to low- and middle-income countries? Neurocrit Care 2025.
[20] Ko MA, Lee JH, Kim JG, Jeong S, Kang DW, Lim CM, et al. Effects of appointing a full-time neurointensivist to run a closed-type neurological intensive care unit. J Clin Neurol 2019;15(3):360–8.
[21] Mirski MA, Chang CW, Cowan R. Impact of a neuroscience intensive care unit on neurosurgical patient outcomes and cost of care: evidence-based support for an intensivist-directed specialty ICU model of care. J Neurosurg Anesthesiol 2001;13 (2):83–92.
[22] Pham X, Ray J, Neto AS, Laing J, Perucca P, Kwan P, et al. Association of neurocritical care services with mortality and functional outcomes for adults with brain injury: a systematic review and meta-analysis. JAMA Neurol 2022;79(10): 1049–58.
[23] Prabhakar H, Shrestha GS, Kapoor I, Mahajan C, Singhal V, Luthra A, et al. Effectiveness of a Neurocritical care course with problem-based learning and discussion format in Asia. A A Pract 2025;19(1):e01903.
[24] Spencer SA, Adipa FE, Baker T, Crawford AM, Dark P, Dula D, et al. A health systems approach to critical care delivery in low-resource settings: a narrative review. Intensive Care Med 2023;49(7):772–84.
[25] Shrestha GS, Nepal G, Prabhakar H, Prust ML. Cost-effectiveness of neurocritical care in settings with limited resources. Lancet Glob. Health 2023;11(9):e1343.
[26] Robba C, Graziano F, Rebora P, Elli F, Giussani C, Oddo M, et al. Intracranial pressure monitoring in patients with acute brain injury in the intensive care unit (SYNAPSE-ICU): an international, prospective observational cohort study. Lancet Neurol 2021;20(7):548–58.
[27] Global, regional, and national burden of traumatic brain injury and spinal cord injury, 1990-2016: a systematic analysis for the global burden of disease study 2016. Lancet Neurol 2019;18(1):56–87.
[28] Global, regional, and national burden of stroke, 1990-2016: a systematic analysis for the global burden of disease study 2016. Lancet Neurol 2019;18(5):439–58.
[29] Towey RM, Ojara S. Intensive care in the developing world. Anaesthesia 2007;62 (Suppl. 1):32–7.
[30] Venkatasubba Rao CP, Suarez JI, Martin RH, Bauza C, Georgiadis A, Calvillo E, et al. Global survey of outcomes of Neurocritical care patients: analysis of the PRINCE study part 2. Neurocrit Care 2020;32(1):88–103.
[31] Venkatasubramanian C, Lopez GA, O'Phelan KH. Emergency neurological life support: fourth edition, updates in the approach to early Management of a Neurological Emergency. Neurocrit Care 2020;32(2):636–40.
[32] Agrawal D, Raghavendran K, Schaubel DE, Mishra MC, Rajajee V. A propensity score analysis of the impact of invasive intracranial pressure monitoring on outcomes after severe traumatic brain injury. J Neurotrauma 2016;33(9):853–8.
[33] Agrawal D, Raghavendran K, Zhao L, Rajajee V. A prospective study of optic nerve ultrasound for the detection of elevated intracranial pressure in severe traumatic brain injury. Crit Care Med 2020;48(12):e1278–85.
[34] Chesnut RM, Temkin N, Carney N, Dikmen S, Rondina C, Videtta W, et al. A trial of intracranial-pressure monitoring in traumatic brain injury. N Engl J Med 2012;367 (26):2471–81.
[35] Kalassian KG, Dremsizov T, Angus DC. Translating research evidence into clinical practice: new challenges for critical care. Crit Care 2002;6(1):11–4.
[36] Eisman AB, Kilbourne AM, Dopp AR, Saldana L, Eisenberg D. Economic evaluation in implementation science: making the business case for implementation strategies. Psychiatry Res 2020;283:112433.
[37] McNett M, O'Mathúna D, Tucker S, Roberts H, Mion LC, Balas MC. A scoping review of implementation science in adult critical care settings. Crit Care Explor 2020;2(12):e0301.