

Consensus Statement on Standards for Neurocritical Care Units in Low-Income and Middle-Income Countries (LMICs).

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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. 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 SNCC. With permission from 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 30 experts from 21 regions, all from LMICs, participated in the survey. Feedback was formally collated, reviewed, and incorporated into the final document.

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]. Low-income and middle-income countries (LMICs) have a high disease burden of neurocritical illnesses. The difference in available infrastructure, patient demographics and healthcare ecosystem 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 LMICs requirements, and support expanding 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].

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. 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 places.

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.

Methods

A Steering committee (SC) was formed under the leadership of SNCC. With permission, we planned using 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 survey 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].

Levels of Neurocritical Care Units

Level I units receive centers for 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. As such, they are often associated with an academic program. Level II units can stabilize acutely ill patients and safely manage stable neurocritical disease processes 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 when 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.

A majority (more than 75% votes) went into generating the final decision as Recommended, Optional or Not Recommended. For the present document, five rounds of Delphi were conducted to finalise our

recommendations.

Results

Responses were collected from all the experts, and results summated. (Table 1)

General organisation 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. (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 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.

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 minutes 24 hours 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 minutes is recommended at Level I NCCUs. However, no consensus could be reached for the availability of the neurointerventionalist within 30 minutes at Level II. The availability of radiologist within 30 minutes should be optional for Level III. The specialists from other disciplines such as anesthesiologists, cardiologists, epileptologists, general surgeons, pathologists, and others listed in 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 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 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 hours 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 [5–10]. 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 hours /day for Level I NCCUs. However, this was optional at Level II and Level III NCCUs.

Other Team Members

Several team members listed in 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.

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 hours /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 minutes in a day.

Equipment

The availability of various equipments such as portable equipments, respiratory support equipments and continuous monitoring equipments (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.

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.

Discussion

This consensus statement, which was 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 perspective of United States. In contrary, many LMICs lack these mandatory standards, thus triggering the need to define or explore standards of NCCUs that are relevant and applicable to the context of LMICs. Notably, the diverse experts in our panel largely endorsed the NCS 2018 level-1 NCCU standards as appropriate for LMICs. 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. The endorsement of the advanced requirements for level-1 NCCUs in LMICs should be considered aspirational. Apex referral centers 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. Such centers are the exception, however. The expert panel is mindful that most LMIC NCCUs will face a broad range of challenges in achieving these standards [3].

The PRINCE study, an international multicenter cross-sectional neurocritical care survey, provides important insights into these challenges [11]. 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) occurred 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-hour 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 [12]. 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 [13]. While 58% of all strokes worldwide occur in LMICs, the risk of death is 50% higher in LMICs compared to high-income nations [14]. Postoperative patients may, in particular, benefit from ICU care in low-income nations [15]. In this context, the absence of a dedicated NCCU was an independent predictor of mortality worldwide in the PRINCE study [16]. 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 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 [17], 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 [11, 16], and clarify the optimal approach to neuromonitoring of acute brain injury in these settings [12, 18–20]. 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, and unmet needs in the local environment.

Conclusion

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. Contextualizing the recommendations would likely improve applicability of the consensus statement and would help with better adherence to the standards deemed feasible and achievable.

Declarations

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We the authors, Confirm that

1) Manuscript complies with all instructions to authors

2) Confirm that authorship requirements have been met and the final manuscript was approved by all authors

3) Authors contribution -

Gentle S Shrestha – Conceived the plan of the study and helped in drafting and critical revision of manuscript.

Hemanshu Prabhakar – Conceived the plan of the study, conducted the survey, analyzed data and helped in finalizing the draft of manuscript.

Charu Mahajan – Conceived the plan of the study and helped in drafting and critical revision of manuscript.

Indu Kapoor – Conceived the plan of the study and helped in drafting and critical revision of manuscript.

Sarah Livesay – Reviewed the manuscript and gave necessary inputs for the final version of the manuscript.

Venkatakrishna Rajajee - Reviewed the manuscript and gave necessary inputs for the final version of the manuscript.

Kapil Zirpe – Conceived the plan of the study and helped in drafting and critical revision of manuscript.

Remaining Co-authors

All collaborators contributed for all rounds of Delphi and for critical revision of manuscript.

4) Confirm that this manuscript has not been published elsewhere and is not under consideration by another journal

5) Confirm adherence to ethical guidelines and indicate ethical approvals (IRB).

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Table

Table 1. Recommendations on the Standards of Neurocritical Care Units from the experts in low – and middle – income countries

Organization	Level I	Level II	Level III
1. Neurocritical care (NCC) service oversight by physician, nursing, and hospital executive leadership	R	R	R
2. Delineation of physician and non-physician privileges	R	R	R
3. Distinct administrative unit	R	R	O
4. Leadership meet regularly to evaluate service needs	R	R	R
5. NCC Committee	R	R	O
6. Standing committee, interdisciplinary representation	R	R	O
Policies / Guidelines			
1. Admit/Discharge	R	R	R
2. Determination of death by neurologic criteria	R	R	R
3. Disease specific protocols	R	R	R
4. Equipment and procedures related to NCC	R	R	O
5. Equipment maintenance	R	R	R
6. Essential equipment list	R	R	R
7. Nosocomial infection	R	R	R
8. Patient isolation	R	R	R
9. Patient monitoring	R	R	R
10. Periodic review of morbidity / mortality	R	R	R
11. Quality	R	R	R
12. Safety	R	R	R
13. System record keeping	R	R	R
14. Traffic control	R	R	R
15. Transfer	R	R	R
16. Visitation and family/surrogate – integrated care	R	R	R
Medical Director			
1. Appointment by appropriate hospital authority	R	R	R
2. Acknowledge in writing	R	R	R

Organization	Level I	Level II	Level III
3. Name qualified physician to fulfil duties when unavailable, communicated to interdisciplinary team	R	R	R
4. Written documentation of responsibilities	R	R	R
<i>Medical Director Qualifications</i>			
1. Neurocritical Care Subspecialty (Board) certified or eligible	R	NC	O
2. Assure policy implementation	R	R	R
3. Coordinate research	R	R	O
4. Ensure staff education	R	R	R
5. Maintain database or vital statistics	R	R	R
6. Participate in budget preparation	R	R	R
7. Participate in development, review and implementation of policies	R	R	R
8. Quality oversight of any NCC patient	R	R	R
9. Supervise quality improvement (QI) and quality assurance (QA) activities	R	R	R
10. Supervise resuscitation techniques	R	R	R
Physician staff or licensed Independent Practitioners (LIP)			
<i>Certified Neurointensivists or LIP or postgraduate year 2 above with NCC expertise and neurointensivist support</i>			
1. Available –in-house 24 h a day	R	NC	O
2. Available at bedside within 5 min 24 h a day	R	R	O
3. Available by telemedicine or telephone	R	R	R
4. All physicians should have subspecialty certification in NCC	R	O	O
5. Physicians should have subspecialty training in NCC	R	O	O
6. All medical staff undergo ongoing professional practice evaluation (OPPE) case review in NCC (or equivalent)	R	R	O
7. Additional privileges in NCC determined by organization	R	R	O
8. Neurointensivist on-site 24/7. May be delegated to another in-house provider (Trainee, advanced practice provider)	R	R	O
9. When off-site, neurointensivist must return calls within 5 min, at bedside within 5 min	R	R	O

Organization	Level I	Level II	Level III
<i>Available in less than 30 minutes</i>			
1. Neurointerventionalist	R	NC	O
2. Neurosurgeon	R	R	O
3. Radiologist	R	R	O
<i>Available in less than an hour</i>			
1. Neurointerventionalist	R	R	O
2. Neurosurgeon	R	R	O
<i>Available for consultation</i>			
1. Anesthesiologist	R	R	R
2. Cardiologist	R	R	O
3. Cardiothoracic and vascular surgeon	R	R	O
4. Endocrinologist	R	O	O
5. Epileptologist	R	O	O
6. Ethics	R	O	O
7. Gastroenterologist	R	O	O
8. General surgeon	R	R	R
9. Hematologist/oncologist	R	O	O
10. Infectious disease	R	O	O
11. Nephrologist	R	R	O
12. Palliative care/supportive care medicine	R	O	O
13. Pathologist	R	O	O
14. Psychiatrist / psychologist	R	NC	O
15. Pulmonologist	R	R	O
16. Radiologist	R	R	O
Nursing staff			
1. Director/Manager with NCC experience	R	R	N/A
2. Nurse to patient ratio 2:1, criteria for 1:1	R	R	N/A

Organization	Level I	Level II	Level III
3. % Nurses with speciality certification	R	O	O
4. All nurses offered initial orientation, ongoing education, annual performance evaluation, ongoing competency assessment	R	R	R
5. BLS, ACLS for all nurses	R	R	R
6. ENLS certification or equivalent	R	R	O
7. Knowledge and education should reflect general critical care and neurocritical care concepts	R	R	R
8. Manager has master's degree or higher or subspecialty certification	R	O	O
9. Neurocritical care competencies (including ED staff)	R	R	O
10. Nurse-sensitive quality indicators should be monitored	R	R	R
11. Nursing policies and procedure	R	R	R
12. Orientation to ICU, NCC	R	R	N/A
Advanced Practice Provider (APP)			
1. Additional training in NCC completed and documented	R	O	O
2. Involved in rounding with NCC team	R	O	O
3. NCC Quality/education focused APP	R	O	O
Nursing skills			
1. Management of external ventricular drains and lumbar drains	R	R	R
2. Address psychological needs of family	R	R	R
3. Administer drugs	R	R	R
4. Administer fluids	R	R	R
5. Management of available advanced neurological monitoring	R	R	O
6. Management, troubleshooting patient monitors	R	R	R
7. Recognize, interpret, record physiologic parameters	R	R	R
8. Respiratory care techniques (including mechanical ventilation)	R	R	R
9. Resuscitation, including ENLS certification or equivalent	R	R	NC
10. Wound care of cranial and spinal postoperative patients	R	R	R
Pharmacists			

Organization	Level I	Level II	Level III
1. Pharmacist dedicated to NCC unit/team	R	O	O
2. Pharmacist with expertise in NCC	R	O	O
3. Pharmacist with residency training or equivalent in high-acuity area	R	O	O
4. Doctorate degree in pharmacy	O	O	O
5. Board certified critical care pharmacists (BCCCP) (preferred) or board certified pharmacotherapy specialist (BCPS) certification	R	O	O
6. Attend in-hospital neurocritical care emergencies	R	O	O
7. Engaged in clinical rounding with team, daily medication review	R	R	O
8. Involved in hospital committees, quality improvement	R	NC	O
9. Provide neuropharmacology training to other caregivers	R	O	O
Respiratory therapy			
1. Supervisor responsible for training RT staff, maintenance of equipment, and quality control/review	R	R	O
2. RT department supervise training	R	O	O
3. Therapist in-house 24 h day	R	O	O
4. Therapist in-house with NCC expertise	R	O	O
Other team members			
1. Biomedical technician	R	R	O
2. Occupational therapist (OT) with expertise in neurologic patient population	R	O	O
3. Physical therapist (PT) with expertise in neurologic patient population	R	R	O
4. PT/OT/ Speech therapist (ST) available 7 days a week	R	O	O
5. PT/OT/ST establish response time for new consultation	R	R	O
6. PT/OT/ST with special expertise in NCC	R	O	O
7. Radiology technician	R	R	O
8. Registered dietician or certified nutrition support clinician	R	R	O
9. Social worker and case manager with expertise in care of neurologic patient population	R	O	O
10. Spiritual care support	R	O	O

Organization	Level I	Level II	Level III
11. ST with expertise in neurologic patient population	R	O	O
12. Unit clerk	R	R	O
Hospital facilities and services			
<i>Emergency department</i>			
1. Staffed by physician 24 h day	R	R	R
2. Helipad	R	O	O
3. Resuscitation area – capable of managing 2 patients at once	R	R	O
4. Resuscitation area – capable of managing at least 1 patient	R	R	R
5. Comprehensive blood bank, all components	R	R	O
6. Type and screen, cross match within 1 h	R	R	R
<i>Radiology/diagnostic (perform/interpret)</i>			
1. Angiography capabilities 24 h day	R	NC	O
2. Continuous EEG	R	O	O
3. CT scan available 24 h day	R	R	R
4. ECG	R	R	R
5. Fluoroscopy	R	R	O
6. Diagnostic and therapeutic endoscopy	R	O	O
7. MRI available 24 h day	R	R	O
8. Nuclear scanning	R	O	O
9. Portable radiograph	R	R	R
10. Radiation therapy	R	O	O
11. STAT EEG	R	O	O
12. Transcranial doppler	R	NC	O
13. Transesophageal echocardiogram	R	O	O
14. Transthoracic echocardiogram	R	R	O
15. Ultrasonography	R	R	R
Laboratory			

Organization	Level I	Level II	Level III
1. ABG available within 15 minutes	R	R	R
2. Available labs within 1 h			
a. CBC, platelets, differential count	R	R	R
b. Chemistry	R	R	R
c. Clotting studies	R	R	R
d. CSF cell count	R	R	O
e. Platelet function test	R	R	O
f. UA	R	R	R
3. Labs within 3 h			
a. Ammonia	R	R	O
b. Magnesium, phosphorus	R	R	O
c. Osmolality	R	R	O
d. Tox screen	R	R	O
4. Labs available 24 h day			
a. Culture and gram stain	R	R	O
5. Operating room			
a. Available within 30 min, 24 h day	R	R	O
b. Available within 60 min, 24 h day	R	R	NC
c. Second OR available within 45 min, 24 h day	R	NC	O
d. Renal replacement therapy including intermittent hemodialysis and continuous renal replacement therapy	R	R	O
Pharmacy			
1. 24 h day for all requests	R	R	R
2. Bedside urgent drug list	R	R	R
Neurorehabilitation internal or affiliated			
Physical facility (unit)			
1. Dedicated beds	R	R	O
Separate rooms			

Organization	Level I	Level II	Level III
1. Conference room	R	NC	O
2. Family counselling room	R	R	O
3. Leadership office space	R	R	O
4. On call room	R	R	R
5. Patients' personal effects storage (may be internal)	R	R	O
6. Staff locker room	R	R	R
7. Staff lounge	R	R	O
8. Unit rooms, unit makeup	R	O	O
9. Clean utility room	R	R	R
10. Clocks	R	R	R
11. Computerized laboratory reporting or efficient equivalent	R	R	O
12. Counter, cabinet space	R	R	R
13. Easy, rapid access to head of bed	R	R	R
14. Emergency equipment storage	R	R	R
15. Handwashing facility	R	R	R
16. Isolation capacity	R	R	NC
17. Medication station with drug refrigerator and locked narcotics cabinet	R	R	R
18. Nourishment station	R	R	O
19. Patient privacy provision	R	R	R
20. Patient toilet	R	R	R
21. Soiled utility room	R	R	R
22. Staff toilet	R	R	R
23. Television, radios	R	R	O
24. Two or more compressed air outlets/bed	R	R	O
25. Two oxygen outlets/bed	R	R	R
26. Two vacuum outlets/bed	R	R	O
27. Building code or federal code conforming			

Organization	Level I	Level II	Level III
a. Heating, ventilation, air conditioning	R	R	R
b. Fire safety	R	R	R
c. Electrical safety	R	R	R
d. Plumbing	R	R	R
e. Illumination	R	R	R
Portable equipment			
1. Automated bed scale	R	O	O
2. Automated blood pressure and monitoring technology	R	R	R
3. Blood warmer	R	R	O
4. Defibrillator/Cardioverter	R	R	R
5. Difficult airway management equipment	R	R	R
6. Doppler ultrasonography	R	R	O
7. ECG machine	R	R	R
8. EEG machine	R	R	O
9. Emergency cart	R	R	R
10. Emergency surgical airway equipment	R	R	R
11. Endotracheal intubation equipment	R	R	R
12. Equipment from intracranial access, external ventricular drain placement and intraparenchymal pressure monitoring	R	R	O
13. Heating/cooling blankets	R	R	R
14. Infusion pumps	R	R	R
15. Intraosseous access and/or emergency cut down trays	R	R	R
16. Isolation cart	R	R	R
17. Oral/nasal airways	R	R	R
18. Oto-ophthalmoscope	R	R	R
19. Point-of-care ultrasonography	R	R	R
20. Procedure lamp (if adequate in room lighting not available)	R	R	R
21. Suction machine (in addition to bedside)	R	R	R

Organization	Level I	Level II	Level III
22. Thermometers	R	R	R
23. Transport monitors	R	R	R
24. Vascular access equipment	R	R	R
25. Bronchoscope	R	NC	O
26. Emergency drugs	R	R	R
Respiratory support equipment			
1. Air compressor	R	R	R
2. Air-oxygen blenders	R	R	NC
3. Bag-valve-mask resuscitation devices	R	R	R
4. Chest physiotherapy and suctioning	R	R	R
5. Continuous oxygen analyzers with alarms	R	R	R
6. Mechanical ventilator	R	R	R
7. MRI compatible ventilator	R	O	O
8. Non-invasive mechanical ventilator	R	R	R
9. Oxygen tanks	R	R	R
10. Respired gas humidifiers	R	R	R
11. Spirometers	R	R	R
Continuous monitoring equipment			
1. ECG, heart rate	R	R	R
2. Advanced hemodynamics: invasive or non-invasive including cardiac output	R	R	O
3. Arrhythmia detection/alarm	R	R	R
4. Brain tissue oxygen monitoring	R	O	O
5. Cerebral blood flow	R	O	O
6. Esophageal pressure	O	O	O
7. ETCO ₂ monitor	R	R	NC
8. Intracranial pressure	R	R	O
9. Microdialysis	O	O	O

Organization	Level I	Level II	Level III
10. O ₂ monitors	R	R	R
11. Respirators	R	R	R
12. Systemic arterial pressure	R	R	R
13. Temperature	R	R	R
Research and training			
<i>Physician training</i>			
1. Units/beds in facility with accredited neurology residency programme	R	O	N/A
2. Unit provides clinical rotation for neurocritical care	R	O	N/A
3. Fellowship programme in NCC	R	O	N/A
4. BLS/ACLS certification or equivalent	R	R	R
5. Programme participates in regional / national meetings related to NCC	R	R	O
6. ENLS certification or equivalent	R	R	O
<i>Unit personnel training</i>			
1. BLS training for nurses, respiratory therapists	R	R	R
2. ENLS certification or equivalent for nurses	R	R	O
3. Ongoing continuing education related to NCC	R	R	O
<i>Regional education</i>			
1. Provide regional / local NCC education	R	R	O
2. Provide NCC educational outreach to public	R	O	O
<i>Prehospital care and interfacility transport</i>			
1. Educational programmes in stabilization and transportation for EMS personnel	R	R	R
2. Integration / communication with EMS	R	R	R
3. Periodic review of EMS/transport protocols for NCC diseases	R	R	R
4. Transfer arrangement with level 1 NCC unit	N/A	R	R
5. Transfer arrangements with referral hospitals	R	R	R
Quality assessment			
1. Discharge planning	R	R	R

Organization	Level I	Level II	Level III
2. Monitor quality metrics	R	R	R
3. Morbidity / mortality review	R	R	R
4. Safety review	R	R	R
5. Utilization review	R	R	R

R – Recommended

O – Optional

NA – Not applicable

NC – No consensus

Figures



Figure 1

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