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REVIEW

Acute Stroke Units Nested within Broader Neurology: Care Bundles for Nursing to Enhance Competence and Interdisciplinary Coordination

Marianne Elisabeth Klinke[1,2] · **Bjorn Logi Thorarinsson**[2] · **Ólafur Árni Sveinsson**[2,3]

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Abstract

Purpose of Review The benefits of acute stroke unit care, with nurses as central figures, are well-documented. As care bundles gain traction to enhance evidence-based nursing care, this review explores their development and adaptation in a setting where stroke care is integrated into general neurology. It also highlights key elements for reinforcing competence and interdisciplinary support.

Recent Findings Most evidenced based acute stroke unit recommendations focus on hyperacute medical management. In comparison, the literature on decision-making for selecting and evaluating key components of nursing surveillance to support specialized stroke care in geographically smaller settings is sparse although the benefits of nursing care bundles is emerging.

Summary Well-structured care bundles, grounded in robust evidence and supported by thorough documentation and effective implementation strategies, provide a clear framework for nursing care, facilitate continuous monitoring, and are useful for enhancing practices especially in smaller stroke units that lack the resources of more comprehensive state-of-the-art units. Tailoring stroke nursing care bundles to local contexts requires an adaptable approach.

Keywords Stroke · Care bundles · Stroke unit · Nursing care · Documentation · Implementation

Introduction

Stroke, a devastating condition, results in high mortality and significant, long-term disability, and represents a growing global health burden [1–3]. An interdisciplinary team-based approach, led and coordinated by nursing professionals, plays an important role in optimizing acute stroke treatment, preventing patient deterioration, and enhancing rehabilitation potential and outcomes [4–6]. When stroke patients are admitted, a stroke activation protocol initiates immediate organized medical investigations and should also, by default, set in motion standardized nursing care pathways to ascertain implementation of important clinical bedside observations and interventions [7–9].

This review critically examines key considerations in translating evidence-based care and acute stroke surveillance into interdisciplinary practice, with a focus on nursing in smaller stroke units embedded in general neurological settings. It initially provides a broad introduction to the role of nurses in acute stroke care, gives an overview of the usability of care bundles to optimize bedside care, and finally presents a case study illustrating how acute stroke care can be adapted to maintain high standards when nested within general neurology settings. Additionally, in light of current evidence, we reflect on elements to enhance interdisciplinary support during implementation to ensure consistent, or even rising, standards of care.

✉ Marianne Elisabeth Klinke
marianne@hi.is

Bjorn Logi Thorarinsson
bjornlth@landspitali.is

Ólafur Árni Sveinsson
olafursv@landspitali.is

[1] Faculty of Nursing and Midwifery, School of Health Sciences, University of Iceland Eiriksgata, Reykjavik 34 107, Iceland

[2] Department of Neurology, Landspitali University Hospital of Iceland, Reykjavik, Iceland

[3] Faculty of Medicine, School of Health Sciences, University of Iceland, Reykjavik, Iceland

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Nurses' Role in Acute Stroke Care

The role of nurses in stroke care is well-established, and their prominence within the stroke team is expected to grow with the increasing complexity of treatments and the emergence of new therapies [10]. Stroke guidelines consistently emphasize that standardized nursing activities improve care across all stroke types, facilitate early detection of complications, and ultimately enhance patient outcomes [7, 8, 11–14]. Nurses provide a holistic perspective, taking on essential roles such as care coordinators, ensuring continuity and supporting patients and families [9, 15, 16]. Moreover, their responsibilities at the bedside include delivering effective fundamental care, preventing complications, facilitating early rehabilitation, and, throughout the patient's stroke unit stay, applying systematic, multicomponent monitoring to identify and respond swiftly to clinical deterioration [10, 16–18].

Care Pathways and Unique Contributions of Acute Stroke Nursing

Care pathways, such as those developed to ensure timely delivery of thrombolysis and thrombectomy for ischemic stroke and rapid blood pressure management for acute hemorrhagic stroke, are key to achieving successful outcomes and are now standard practice [4, 19, 20]. Regardless of eligibility for reperfusion therapy, comprehensive nursing care remains vital [10, 21, 22]. However, many guidelines fail to address the specifics of what nursing care exactly entails, such as the frequency and content of neuro checks, methods of assessing different stroke types, and best systems for auditing and feedback [23, 24]. Furthermore, there is limited guidance on aligning and integrating nursing priorities within interdisciplinary activities, leaving significant gaps for the practical applicability of standardized nursing protocols [10, 25, 26].

Acute stroke nursing distinguishes itself from medical interventions through its broad applicability. It can be provided in virtually *any* hospital setting for *any* stroke patient, including those who are elderly, have severe strokes, or face multiple comorbidities [18, 27–29]. In contrast, medical interventions such as reperfusion therapies, though highly effective, are often limited by strict eligibility criteria [30, 31].

Stroke Units – Need to Maximize Local Use of Evidence-Based Guidelines

Stroke units, equipped with non-invasive monitoring and emphasizing an interdisciplinary approach to bedside care, have demonstrated remarkable, consistent effectiveness in improving patient outcomes over the past 25 years [32, 33]. The most recent landmark meta-analysis revealed that stroke unit care reduces mortality by saving two additional lives per 100 patients treated compared to general medical wards. Additionally, six more patients return home instead of being transferred to a nursing facility, and a further six achieve independent living [27]. The size and structure of stroke services within a hospital are shaped by factors such as population density and available resources [34, 35]. Notably, even smaller stroke units, managing as few as 100 admissions annually, have demonstrated significant benefits of stroke unit care [35].

To fully leverage the benefits of stroke unit care, it is necessary to implement locally adapted guidelines to ensure coordinated care that prioritizes safety and minimizes complications [24, 36, 37]. However, recommendations often overlook the resources required for implementation [19]. Comprehensive education and training of stroke nurses empowers evidence-based decision-making and high-quality care, but educational strategies often remain inconsistent [38–41]. Along these lines, a recent review underscores the importance of organizational support in developing effective knowledge enhancement solutions [6].

Care Bundles – From Knowledge to Bedside Use

Effectively translating and integrating new stroke care approaches into clinical practice calls for strong communication within the interdisciplinary team [21, 41]. Denny et al. [42] recently outlined strategies to foster alignment toward interdisciplinary shared goals. Key strategies include equipping hospital staff with the knowledge and resources to follow guidelines, engaging them in the implementation process, and resolving specific patient care challenges proactively. Feasible guideline adaptations are crucial, as overly ambitious objectives can hinder compliance [43].

Integrating clinical recommendations into care bundles promotes their clinical adoption and creates a direct link between evidence and clinical practice [38, 44, 45]. In recent years, care bundles have gained momentum, often replacing comprehensive guidelines due to their practicality and capacity to enhance interdisciplinary collaboration [46, 47]. Care bundles consist of succinct, evidence-based sets of interventions tailored to specific patient populations and care settings. They typically consist of three to five components. When implemented as a cohesive set, these interventions yield better outcomes than they do when applied individually [48]. Notably, care bundles have proved effective in stroke management and even in settings that deviate from traditional stroke unit structures, further highlighting their practicality and versatility [26, 47, 49–52].

Designing effective stroke care bundles involves a diverse range of healthcare professionals, including nursing staff, stroke physicians, dietitians, speech-language therapists, physiotherapists, and occupational therapists [23, 53]. These professionals must collaborate in composing care bundles and ascertain sufficient flexibility to address the unique needs of patients [54]. Other key factors influencing the design include the availability of technology and equipment for surveillance, the physical layout of the stroke unit, staff training and competency levels, and the alignment with existing care pathways [23, 24, 55–57]. Effective communication among healthcare providers cultivates a collaborative, multicomponent approach that prioritizes accurate documentation. By connecting evaluation systems to provide feedback on care bundle fidelity, teams can enhance the consistency and long-term sustainability of quality care provision [5, 24].

Acute Stroke Nursing Care Bundles – Description of Setting, Development, and Critical Reflections

Setting – a Small Stroke Unit Nested Within a General Neurological Department

Landspítali, the National University Hospital (LUH) in Reykjavik, serves as Iceland's leading stroke center. It offers thrombolysis and is the sole facility in the country capable of performing mechanical thrombectomy. The hospital primarily serves Reykjavik and surrounding area, with a catchment population of 239,000 in 2022, or approximately 65% of the country's total population. Moreover, LUH also receives patients requiring advanced stroke treatment from across Iceland, with a total population of 376,000 in 2022 (www.statice.is).

In 2022, LUH had 408 stroke admissions, comprising 337 ischemic and 71 hemorrhagic cases [58]. For decades, LUH has functioned as Iceland's centralized hub for stroke care, streamlining treatment pathways and promoting standardized practices nationwide. Approximately 82% of all stroke patients in Iceland are admitted to LUH, either as the first hospital of arrival or by secondary referral from other hospitals in the Icelandic stroke network. Advanced stroke services are available according to definitions of Mead et al. [19] in the form of interdisciplinary stroke expertise, access to advanced imaging, and comprehensive therapies.

A surveillance room with a capacity of four patients was established within an acute 22-bed neurological department. This dedicated stroke area provides non-invasive cardiac monitoring at each bed (without arterial lines) where beds are separated by curtains to maintain patient privacy. The staffing model features a nurse-to-patient ratio of 1:4, complemented by a specially trained licensed practical nurse (LPN) on every shift, resulting in an overall nursing staff ratio of 1:2. In Iceland, LPNs complete a three-year vocational education program. To qualify to work in the acute stroke unit they must pass the National Institute of Health Stroke Scale (NIHSS) training module and alongside nurses, participate in annual "stroke courses" and clinical case discussions to maintain their competencies. The staffing level aligns closely with the European Stroke Organization's recommendations, which advocate for an optimal nurse-to-patient ratio of 1:2 in acute stroke care [59]. Patients initially admitted to the stroke unit can transition to step-down stroke care in the adjacent neurological unit, where nurse-to-patient ratios range from 1:4 to 1:6, plus LPNs, apart from during the night shifts when the ratio is lower.

Nursing education in Iceland maintains high standards, requiring a bachelor's degree after four years of university-level training. Collaboration between the Faculty of Nursing and clinical specialties ensures updates, like advancements in stroke care, are swiftly integrated into the curriculum. Third-year students receive current lectures, equipping about 200 graduates annually with updated stroke care knowledge. Teaching is led by clinical nurse specialists and academic chairs, who also oversee hospital education programs. This ensures bidirectional integration of academic and clinical training.

Despite this structure, significant challenges persist in delivering specialized stroke care. Key issues include staffing shortages, high nurse turnover rates, the lack of dedicated clinical specialization programs, and difficulties in care documentation and auditing. Since the stroke unit is integrated within broader neurology, nursing staff do not work exclusively with stroke patients, making it challenging to maintain clinical stroke competency.

Developing Care Bundles: Bridging Knowledge and Practice

In preparation for the launch of the dedicated stroke unit within our neurological department, we organized a collaborative forum inviting input from key stakeholders from the local stroke team. This interdisciplinary group included representatives from dietetics, neurology, nursing, occupational therapy, physiotherapy, and speech-language therapy. Each participant provided valuable insights, helping to identify priorities for developing effective nursing care bundles. A core team of nurses and physicians worked together to reach consensus on critical issues, ensuring clarity and creating a strategy to enhance adherence to the care bundle elements. Intended as both clinical tools and educational resources, the care bundles encompass elements to enhance nurse-neurologist collaboration.

Using Borgerts et al.'s [60] method, we systematically reviewed guidelines and up-to-date evidence to identify

key elements for the care bundles. A structured, two-tiered approach was implemented for staff involvement. The first tier engaged key stakeholders within the stroke nursing team, including the head nurse of the neurological department, clinical nurse specialists, clinical staff nurses serving as opinion leaders, and the academic chair in neurological nursing. The second tier involved gathering feedback and fostering discussion with the broader interdisciplinary stroke team. This collaborative effort ensured smooth integration into the interdisciplinary pathway.

We identified a need for four distinct care bundles that, while sharing many common care components, differed in important aspects; see Table 1. These pathways included: (1) thrombolysis and endovascular treatment, (2) ischemic stroke (without recanalization therapy within the last 24 h), (3) risk of malignant edema and suspected elevated intracranial pressure, and (4) intracerebral hemorrhage. Each care bundle comprised four to five essential components, with overlapping elements across all pathways. Common components included position and mobility, fever, sugar, swallowing (FeSS), nutritional intake, neurostatus, and vital signs. Additionally, the thrombolysis and endovascular treatment bundle emphasized a critical focus on bleeding risk management. To ensure a prompt response to patient deterioration, we identified critical red flags necessitating immediate notification of the stroke physician.

Key measures for preventing complications align with established guidelines, focusing on the timely recognition and management of issues such as neurological deterioration, immobility-related problems, swallowing and nutritional challenges, signs of increased intracranial pressure, cerebral edema, fever, hyperglycemia, pneumonia, and other infections [11, 26, 61]. Beyond these standard measures, we identified issues in nursing care that required targeted attention and optimization. These included blood pressure fluctuations in hemorrhagic stroke, ensuring proper oral hygiene, and supporting paralyzed arms – all these issues are evidence-based but often considered "common sense" and thus not explicitly stated in local guidelines. To enhance care delivery, we introduced clear documentation guidelines and developed user-friendly nursing diagnoses tailored to the unique needs of the stroke unit. Additionally, the care bundles were designed to enable integration of the rapidly evolving evidence in stroke research while also being responsive to needs identified by stroke unit staff [62, 63].

The Structure Surrounding Implementation of the Care Bundles

The core stroke team established clear goals to improve nursing care coordination, staff training, and evidence-based knowledge. Tools were developed to support bedside practices and ensure compliance with the care bundles. Particular emphasis was placed on streamlining documentation processes to address variability in nursing records and incorporate neurological scales into patients' electronic health records, a deficiency highlighted by both nurses and neurologists as needing a resolution. To achieve this, nursing documentation was standardized, and structured neurological assessments were embedded into routine practice through close collaboration with neurologists. These advancements were reinforced by continuous training, clearly defined routines, and the development of a robust infrastructure designed to ensure sustained improvements [23, 39, 64].

To support a patient-centered approach, several meetings focused on mapping the acute stroke care pathway, incorporating discussions of real patient journeys. Clinical nursing staff provided valuable input by identifying day-to-day challenges and suggesting practical solutions in relation to patient care, its implementation, and how staff knowledge could be increased. Additionally, the Icelandic Stroke Survivors Association, Heilaheill, was consulted to provide their perspective. For details of key considerations, see Table 2.

Ongoing feedback on care bundle adherence is essential to address gaps in implementation [23, 24]. To exemplify, monitoring and managing elevated body temperature and blood glucose levels, as well as screening for dysphagia, are fundamental practices for all stroke patients [7, 8, 10]. However, significant adherence gaps remain despite clear evidence and intervention guidelines. For instance, the 2019 Australian Stroke Foundation's national stroke audit revealed that only 48% of patients with fever received acetaminophen/paracetamol within the recommended one-hour window, and just 30% of those needing insulin were treated within the same timeframe. Even more concerning, only half of acute stroke patients underwent a swallow screen before consuming food or drink—a lapse that poses significant risk to patient safety [26]. Similar deficiencies have been observed in other settings, often attributed to nursing oversights [26, 65]. These findings underscore the need for clear surveillance of benchmarks. Examples of benchmarks for adherence and organizational factors, such as staffing levels, matching our care bundles are outlined in Table 2.

Interdisciplinary Reinforcement of the Care Bundle Use

Patients admitted to the stroke unit arrive from various points, including the emergency department, Intensive care unit (post-thrombectomy or intensive care), imaging suites (CT/MRI), or other institutions. Transitions between hospital locations, such as moving patients from the emergency room to the stroke unit, are inherently vulnerable moments, but offer prime opportunities to improve care quality [14,

Table 1 Care bundles for acute stroke nursing surveillance

Care bundles				
Items	Thrombolysis and Endovascular Treatment in Ischemic Stroke (first 24 h)	Ischemic Stroke (not receiving recanalization therapy within the last 24 h)	Risk of Malignant Brain Edema and Suspected Elevation in Intracranial Pressure	Intracerebral Hemorrhage
Positioning and Mobility	Bedrest at least 4 h after thrombectomy, see recommendation from interventionist Bathroom with assistance/supervision > 2 h after thrombolytic treatment, if condition allows Elevate head 15–30° (aid breathing, prevent aspiration) Morse and Braden assessment Support paralyzed shoulder/arm	Record mobility: Mobility status, required assistance, helping aids, turning schedule If mobility is impaired, consult a physiotherapist Elevate head 15–30° (aid breathing, prevent aspiration) Morse and Braden assessment Support paralyzed shoulder/arm Assess pain with VAS or NRS Assess risk of thrombosis (DVT, PE). High risk: history of DVT/PE, lower limb immobility, malignancy, dehydration. Prevent with movement/ repositioning	Minimal movement Program of passive movements by a physiotherapist Prevent ↑ICP by: ▪Elevate head 30°, prevent compression of jugular veins ▪Head in a neutral position, not tilted to the side ▪Hip flexion < 90° Morse and Braden assessment Support paralyzed shoulder/arm Assess pain with VAS or NRS Assess risk of thrombosis (DVT, PE). High risk: history of DVT/PE, lower limb immobility, malignancy, dehydration. Prevent with movement/ repositioning	Record mobility: Mobility status, required assistance, helping aids, turning schedule) If mobility is impaired, consult a physiotherapist Prevent ↑ICP by: ▪Elevate head 30°, prevent compression of jugular veins ▪Head in a neutral position, not tilted to the side ▪Hip flexion < 90° Morse and Braden assessment Support paralyzed shoulder/arm Assess pain with VAS or NRS Assess risk of thrombosis (DVT, PE). High risk: history of DVT/PE, lower limb immobility, malignancy, dehydration. Prevent with movement/ repositioning. Foot pump, i.e., intermittent pneumatic compression, upon admission, and reassess daily
Fever, Sugar, Swallowing (FeSS), and Nutritional Intake	Monitor temperature x 4. If > 37.5 °C antipyretics, consider infection (PI, UTI) Nil by mouth until completed swallowing screen If passes swallowing screen with facial paralysis or dysarthria, order "safe diet" Swallow screen before each meal High Fowler position during meals and 30 min. after Oral care before/after meals, or at least x2 per shift if facial paralysis, dysarthria, or altered consciousness Consider safe medication administration routes (i.e., oral route – whole or crushed) BG x4. Keep BG < 10 mmol/L. Record fluid/nutritional intake at the end of each shift IV fluid administration (avoid glucose)	Monitor temperature x 4 for 72 h. If > 37.5 °C antipyretics, consider infection (PI, UTI) Nil by mouth until completed swallowing screen If passes swallowing with facial paralysis or dysarthria, order "safe diet" Swallow screen before each meal Refer to SLT and dietician if swallowing difficulties High Fowler position during meals and 30 min. after Oral care before/after meals, or at least x2 per shift if facial paralysis, dysarthria, or altered consciousness Consider safe medication administration routes (i.e., oral route – whole or crushed) BG x4 for 48 h. Keep BG < 10 mmol/L. If no treatment is needed, discontinue measurements Nutritional screening according to protocol	Monitor temperature x 4 for 72 h. If > 37.5 °C antipyretics, consider infection (PI, UTI) Nil by mouth until completed swallowing screen If passes swallowing screen with facial paralysis or dysarthria, order "safe diet" Swallow screen before each meal Refer to SLT and dietician if swallowing difficulties High Fowler position during meals and 0 min. after Oral care before/after meals, or at least x2 per shift if facial paralysis, dysarthria, or altered consciousness Consider safe medication administration routes (i.e., oral route – whole or crushed) BG x4 for 48 h. Keep BG < 10 mmol/L. If no treatment is needed, discontinue measurements Nutritional screening according to protocol	Monitor temperature x 4 for 72 h. If > 37.5 °C antipyretics, consider infection (PI, UTI) Nil by mouth until completed swallowing screen If passes swallowing screen with facial paralysis or dysarthria, order "safe diet" Swallow screen before each meal Refer to SLT and dietician if swallowing difficulties High Fowler position during meals and 30 min. after Oral care before/after meals, or at least x2 per shift if facial paralysis, dysarthria, or altered consciousness Consider safe medication administration routes (i.e., oral route – whole or crushed) BG x4 for 48 h. Keep BG < 10 mmol/L. If no treatment is needed, discontinue measurements Nutritional screening according to protocol

Table 1 (continued)

Care bundles				
Neuro- Status	GCS x1per shift under "measurements and assessments" in PHR and response to stimuli described in nursing notes. Pupils: size, shape, symmetry, light x1 per shift Headache, nausea, vomiting, dizziness x2 per shift NIHSS screening alongside vital sign monitoring If symptoms fall outside NIHSS (e.g., posterior or non-dominant stroke), a more targeted assessment is determined Record abnormal behavior such as pulling tubes, restlessness, aggression, and confusion Standardized NIHSS upon arrival to stroke unit Document neurological examination upon arrival and deviation from baseline assessment on later shifts in the nursing diagnosis "Risk of ineffective cerebral tissue perfusion" (NANDA00201)	Frequency of neurological examination determined upon admission and reassessed daily GCS x1 per shift under "measurements and assessments" in PHR and response to stimuli described in nursing notes. Pupils: size, shape, symmetry, light x1 per shift NIHSS screening alongside vital sign monitoring If symptoms fall outside NIHSS (e.g., posterior or non-dominant stroke), a more targeted assessment is determined Record abnormal behavior such as pulling tubes, restlessness, aggression, and confusion Standardized NIHSS upon arrival and x1 day on morning shift Document neurological examination on each morning shift in nursing diagnosis "Risk for ineffective cerebral tissue perfusion" (NANDA00201) and deviation from this baseline assessment on later shifts	Frequency of neurological examination determined upon admission and reassessed daily GCS x1 per hour under "measurements and assessments" in PHR and response to stimuli described in nursing notes. Other clinical signs of ↑ICP/herniation: Headache, nausea, vomiting, dizziness x 1 per hour Pupils: size, shape, symmetry, light x 1 per hour NIHSS screening alongside vital sign monitoring If symptoms fall outside of NIHSS (e.g., posterior or non-dominant stroke), a more targeted assessment is determined Record abnormal behavior such as pulling tubes, restlessness, aggression, and confusion Standardized NIHSS upon arrival and x1 day on morning shift Document neurological examination on each morning shift in nursing diagnosis "Risk for ineffective cerebral tissue perfusion" (NANDA00201) and deviation from this baseline assessment on later shifts *Important clinical considerations*: *Excess stimulation/activity/noise can ↑ICP. Complete rest and reduced stimuli may be required, avoid Valsalva's maneuver, consider CAD*	Frequency of neurological examination determined upon admission and reassessed daily GCS x1 per hour under "measurements and assessments" in PHR and response to stimuli described in nursing notes Headache, nausea, vomiting, dizziness x1 per hour Pupils: size, shape, symmetry, light x per hour NIHSS screening alongside vital sign monitoring If symptoms fall outside NIHSS (e.g., posterior or non-dominant stroke), a more targeted assessment is determined Record abnormal behavior such as pulling tubes, restlessness, aggression, and confusion Standardized NIHSS upon arrival and x1 day on morning shift Document neurological examination on each morning shift in nursing diagnosis "Risk for ineffective cerebral tissue perfusion" (NANDA00201) and deviation from this baseline assessment on later shifts *Important clinical considerations*: *Excess stimulation/activity/noise can ↑ICP. Complete rest and reduced stimuli may be required, avoid Valsalva's maneuver, consider CAD*

Table 1 (continued)

Care bundles				
Vital Signs	Cardiac monitoring: track heart/arrhythmias Frequency of vital sign measurements after IVT: ▪ Every 15 min for the first 2 h ▪ Every 30 min for the next 6 h ▪ Every hour for the next 16 h Keep patient within the following thresholds: ▪ Blood pressure < 180/105 mmHg ▪ Pulse 50–120 per minute ▪ Respiratory Frequency < 24 ▪ Oxygen saturation 94–98%, and 88–92% for COPD Risk of cerebral hypoperfusion: Hypotension < 120/70 mmHg: ▪ Alert physician ▪ Consider IV fluids ▪ Review blood pressure medication	Cardiac monitoring: track heart/arrhythmias, for minimum 24 h Vital sign measurements min x2 per shift. Frequency of measurements reassessed at daily rounds. The goal is to stay within the following thresholds: ▪ Blood pressure < 220/120 mmHg ▪ Pulse 50–120 per minute ▪ Respiratory Frequency < 24 ▪ Oxygen saturation 94–98%, and 88–92% for COPD Risk of cerebral hypoperfusion: Hypotension < 120/70 mmHg: ▪ Alert physician ▪ Consider IV fluids ▪ Review blood pressure medication *Important clinical considerations*: Manage hypertension with caution. Hypertension is usually not treated in the acute phase unless > 220/120 mmHg or if it causes clinical symptoms.	Cardiac monitoring: track heart/arrhythmias, generally for 5–7 days Vital sign measurements x 1per hour. Frequency of measurements reassessed at daily rounds. The goal is to stay within the following thresholds: ▪ Blood pressure < 220/120 mmHg ▪ Pulse 50–120 per minute ▪ Respiratory Frequency < 24 ▪ Oxygen saturation 94–98%, or 88–92% for COPD Risk of cerebral hypoperfusion: Hypotension < 120/70 mmHg: ▪ Alert physician ▪ Consider IV fluids ▪ Review blood pressure medication *Important clinical considerations*: Manage hypertension with caution. Hypertension is usually not treated in the acute phase unless > 220/120 mmHg or if it causes clinical symptoms.	Cardiac monitoring: track heart/arrhythmias, generally for 48–72 h Frequency of vital sign measurements • Every 30 min. for the first 6 h after stroke onset • Every hour for the next 16 h Frequency of measurements reassessed at daily rounds. The goal is to stay within the following thresholds: ▪ Systolic blood pressure 120–140 ▪ Pulse 50–120 per minute ▪ Respiratory Frequency < 24 ▪ Oxygen saturation 94–98%, or 88–92% for COPD Hypotension, if blood pressure < 110/70 mmHg: ▪ Alert physician ▪ Consider IV fluids ▪ Review blood pressure medication *Important clinical considerations*: *When administering blood pressure lowering treatment, avoid spikes and significant fluctuation in systolic blood pressure. The goal is to lower systolic blood pressure from 140–220 mmHg to < 140 mmHg and maintain it at 120–140 mmHg. A higher systolic target of < 160 mmHg can be chosen if presenting systolic blood pressure > 220 mmHg or if symptoms of ↑ICP*

Table 1 (continued)

Care bundles		
Bleeding Risk	Risk of bleeding/hemorrhage – monitoring and preventive measures If suspicion of ICH, immediately stop thrombolysis, alert physician. Monitor for bleeding in other sites: ▪ From insertion site of iv. needles ▪ In the groin after thrombectomy ▪ In the urine ▪ Under the blood pressure cuff Avoid placement of nasogastric tubes and iv lines < 24 h after thrombolysis Avoid catheterization < 60 min. after thrombolysis, preferably wait at least 3–4 h. If residual urine > 700 ml or if the patient shows clinical symptoms, catheterization should proceed under the best conditions, with the physician's approval	Red flags in all care bundles – alert physician immediatly if: Decreased level of consciousness or increasing confusion, restlessness and/or agitation GCS ≤ 10 or a drop of > 2 in GCS within 24 h, or worsening neurological symptoms ≥4 points of NIHSS within 24 h Unequal pupil size (anisocoria), change in light response Sudden headache, nausea and/or vomiting Seizures If you have a "bad feeling" about the patient Signs of Cushing's response (increased blood pressure, irregular breathing, decreased pulse) BG: blood glucose; DVT: deep vein thrombosis; GCS: Glascow Coma Scale; ICH: intracerebral hemorrhage; ICP: intracranial pressure; NIHSS: National Institute of Health Stroke Scale; NRS: Numeric Pain Rating Scale; PE: pulmonary embolism; SLT: speech-language therapist; UTI: urinary tract infection; VAS: Visual Analogue Scale

Table 2 Reflections on implementing care bundles to optimize their use and evaluate adherence

Organizational/administrational issues related to care bundle implementation			
	Clinical contemplations and discussions	**Practical solutions / use**	**Evaluations/indicators**
Physical surroundings: a four-bed unit nested within the larger neurological department	Integrating the stroke unit within the neurological unit makes it harder for others to distinguish stroke unit staff, leading to interruptions during breaks or supply runs. Staff address this by wearing clearly marked uniforms. While proximity to neurological nurses provides support, busy periods can leave stroke unit staff feeling isolated. Additionally, the four-bed "open space" often becomes crowded and noisy, complicating visits from relatives.	To ensure smooth workflow, stroke unit staff must be easily identifiable. Each shift assigns a nurse and LPN nurse to cover breaks, ensuring continuous coverage. A designated waiting area supports family members, and visiting guidelines, emphasizing quietness, should be shared via pamphlets, the hospital website, and during admission conversations.	Consensus discussions and assessing stroke admissions and working routines "what are staff needs during the day?" and "What are patients and relatives' needs during the day?" Annual formal assessment of physical surroundings (observation, focus groups) to identify and address improvement opportunities.
Staffing on stroke unit	Staffing constraints prevent meeting the recommended 1:2 nurse-to-patient ratio in acute stroke care. However, one nurse and one LPN are always present, both meeting essential qualifications: NIHSS certification, completion of Stroke Course I, and dysphagia screening training.	Standard staffing ratio. 1:2 staffing • One nurse per four patients • One LPN per four patients. High-Care Load Adjustment: In cases of extremely high care demands or patient acuity, an additional nurse will be assigned to ensure patient safety and quality care.	▪ Indicator: Percentages of shifts with qualified staff in the stroke unit Target ≥ 80%
Strengthening of a structured stroke leadership team	The stroke team includes: the head physician and nurse of the neurological/stroke unit, a CNS or research-trained stroke nurse, at least two clinical stroke nurses (opinion leaders), one LPN, a physiotherapist, occupational therapist, a dietitian, and speech-language therapists.	The stroke team holds a monthly one-hour meeting to review stroke unit updates and discuss complex clinical cases with the broader team. Additionally, 20-minute weekly meetings on Fridays (including physician, nurse, dietitian, SLT, and occupational therapists) ensure continuity of care over the weekend.	▪ Indicator: Number of documented discussions in the stroke team Target ≥ 10 documented meetings per year
Core Stroke Leaders Academic chairs, stroke, CNS, neurologists	▪ Work with the stroke team to ensure that care bundles, along with process and structural components, align with the standards required for international stroke unit certification. ▪ Gap analysis: identify care gaps through ongoing evaluation against benchmarks, driving targeted improvements and practice optimization. ▪ Policy development: update evidence-based policies with interdisciplinary input for cohesive, patient-centered care. ▪ Education: advance nursing education by contributing to curricula and establishing accredited university courses. ▪ Documentation: create methods to document and evaluate care bundle adherence for consistency and accountability.	▪ Host biannual stroke education days in the simulation center using rotational training to cover Stroke Programs I and II. ▪ Integrate "Stroke Care I" into the curricula of both national nursing faculties. ▪ Establish a stroke competency program offering ongoing growth opportunities, complemented by annual reviews for stroke unit nurses. ▪ Conduct annual meetings with organizational leaders to present achievements, set goals, and address concerns. ▪ Provide quarterly updates to ward staff on key achievements and progress.	▪ Indicator: Number of educational days effectuated Target ≥ 2 documented education days per year

Table 2 (continued)

Layout of care bundles	The design, developed with the LUH graphic designer, features an attractive, user-friendly layout in a worksheet format for simplicity**. Initially, evidence levels accompanied each recommendation, but clinical nurse feedback revealed this discouraged adherence to items with lower evidence levels and led to dismissing "clinical practice points". To address this, we emphasized that care bundles are cohesive packages where all components, including documentation, hold equal importance.	The care bundle provides a framework for doctor's rounds: ▪ Care Bundle: Evaluate current bundle or step-down needs. ▪ Surveillance: Assess need for acute monitoring. ▪ Mobility: Review status and thrombosis prevention. ▪ Swallowing: Update assessments and medication routes. ▪ Nutrition/Hydration: Plan intake and fluids for 24 h. ▪ Blood Glucose: Monitor and manage levels. ▪ Neuro Status: Check changes, baseline, and red flags. ▪ Blood Pressure: Set 24-hour targets. ▪ Interdisciplinary Input: Consult dietitian, SLT, physiotherapist, or ▪ OT as needed.	Consensus discussions and assessing ease of use "what do staff think about the content and look of the care bundles?", and "How can nurses and physicians use the care bundles to ascertain continuity in patient care and reinforce their use by interdisciplinary collaboration?" Yearly formal assessment of user friendliness – focus group interview in the context of stroke education. Care bundles will be dynamically updated with new evidence and reviewed every six months during stroke team meetings.
Advanced training for nurses caring for patients with acute complex stroke	Content of training sessions ▪ NIHSS certification ▪ Neurological management: basic assessments, ICP control, and GCS. ▪ Cardiac monitoring and blood pressure management – brain-heart connection. ▪ Blood glucose, thermoregulation, and swallowing training (FeSS protocols). ▪ Medications commonly used in acute stroke. ▪ Stroke pathway: overview of the local stroke care process. ▪ Care bundles: detailed sessions on bundles I–IV. ▪ Nursing management: Two two-hour sessions covering: • Acute care and complication prevention, incl, secondary prevention and risk factors. • Family care, risk assessment, and interdisciplinary approaches. • Risk management, clinical benchmarking and documentation, and neuro-palliative care. • Mobilization, positioning, nutrition, hydration, and refeeding syndrome prevention.	Stroke training and development for nurses ▪ Stroke portfolio Each nurse and LPN will maintain a stroke portfolio to document completed training sessions. Nursing staff must complete a total of 16 h of stroke-related training annually. ▪ Mandatory training components for working in the stroke unit: NIHSS certification; dysphagia screening; completion of Nursing Management of Stroke Patients I. ▪ Teaching modalities: A variety of educational formats will be offered to accommodate different learning styles: computerized learning modules; face-to-face lectures, recorded lectures and podcasts, journal club sessions to discuss relevant literature, and protocol and guideline reviews with discussions tailored to the local context. ▪ Professional development: Nurses who work more than 40% of their shifts in the stroke unit are encouraged to attend an international stroke conference every two years	▪ Indicator: Number of nurses and licensed practical nurses with NIHSS certification Target ≥ 80% ▪ Indicator: Total hours of educational modules offered per year (within the different teaching modalities) Target ≥ 24 h. ▪ Number of staff employed in >40% who have their stroke portfolio updated and have received a 20-minute conversation with CNS, academic chair, or head nurse Target ≥ x1 per year

Table 2 (continued)

Clinical issues related to care bundle implementation		
	Key discussion points included	**Evaluation/indicators**
Positioning and mobility in the care bundles	Head elevation and positioning: while evidence on optimal head positioning remains inconclusive, a consensus recommends a 15–30° elevation in ischemic stroke patients to reduce aspiration risk and support breathing. For cases with elevated ICP, care bundles specify a 30° elevation in line with guidelines, particularly for "Risk of Malignant Edema" and "Intracerebral Hemorrhages". Paralyzed arm: clinical staff, including physiotherapists, highlighted insufficient support for paralyzed arms/shoulders. Enhanced education on proper handling and positioning is necessary. Thrombosis risk and prevention: pneumatic compression is strongly emphasized for hemorrhagic stroke patients to reduce thrombosis risk without increasing bleeding complications.	▪ Indicator: Number of patients with documented head elevation within 15–30° at least x 1 day/72 hours (all patients) (according to care bundle, exclude patient with flat head ordination) ▪ Indicator: Number of patients with a documented intervention for shoulder/arm support (patients with paralysis affecting the shoulder/arm). ▪ Indicator: Number of patients assessed for thrombosis risk (DVT/PE) within 24 h of admission (all patients unable to ambulate/move independently) Target≥80%
*Fever, sugar swallowing and nutritional intake	Oral Care: clinical staff emphasized the importance of oral care, noting it is often underprioritized despite posing safety risks. Based on consensus and literature, the protocol recommends oral care before/after meals or at least twice per shift for patients with facial paralysis, dysarthria, or altered consciousness. Swallowing: nurses must screen swallowing before each meal, even if SLT has cleared the patient for oral intake, to detect neurological deterioration. Default enteral nutrition plans are available for suspected dysphagia during weekends or holidays when SLTs and dietitians are unavailable.	▪ Indicator Percentage of patients with temperature monitored four times daily for the first 72 h after admission. ▪ Indicator: Percentage of patients with a temperature > 37.5 °C receiving antipyretics and assessed for possible infection (e.g., PI, UTI). ▪ Indicator: Number of stroke patients with recorded blood glucose levels according to care bundles ▪ Indicator: Number of patients receiving treatment with insulin when BG > 10 mmol/L ▪ Indicator: Percentage of patients who remain nil by mouth until a swallowing screen is completed. ▪ Indicator: Percentage of patients with facial paralysis or dysarthria who passed the swallowing screen and had a "safe diet" order implemented. ▪ Indicator: Percentage of patients with swallowing difficulties referred to an SLT and dietician. ▪ Indicator: Number of patients with documented fluid intake on day 1, day 2, and day 3 ▪ Indicator: Percentage of patients with facial paralysis, dysarthria, or altered consciousness receiving oral care at least twice per shift. Target≥80%

Table 2 (continued)

Neuro status	For detailed discussions, refer to the neuro-checks section in the article. Staff expressed a need for clearer routines in performing basic neurological assessments. Key discussions centered on: frequency and content of neuro checks and criteria for physician notification, balancing patient safety achieved by close surveillance with their need to rest and nursing workloads which was difficult due to limited evidence. Consensus requires: • Clear interdisciplinary definitions of significant neurological deterioration. • Shared understanding of the need for interdisciplinary assessment in ambiguous cases.	▪ Indicator: Number of patients with neurological examination frequency determined on admission. ▪ Indicator: Number of patients with "full neuro check" on morning shifts during stroke unit admission (documented in Risk for ineffective cerebral tissue perfusion (NANDA00201). ▪ Indicator: Number of patients with "full NIHSS" x 1/day ▪ Indicator: Timeliness of targeted assessments for non-standard stroke presentations (e.g., posterior strokes). Target ≥ 80%
Vital signs	Vital signs are automatically transferred to the PHR in real time, ensuring continuous monitoring. Staff must act promptly when reading exceeds the established limits. Key discussions centered on: • Measurement frequency and thresholds for normal and abnormal values. • Protocolized responses to deviations. Balancing patient safety with manageable workloads for nursing staff remains critical. Interdisciplinary collaboration is essential to address the lack of evidence-based guidance, reach consensus on measurement protocols, and ensure timely responses, particularly in ambiguous cases.	▪ Indicator: Number of patients with established blood pressure targets each day ▪ Indicator: Number of patients with temperature > 37.5 ▪ Indicator: Number of patients with temperature > 37.5 who receive paracetamol within an hour Target ≥ 80%
Bleeding risks	Bleeding risks have not been documented in a structured way after thrombolysis and thrombectomy. Need for including structured documentation.	▪ Indicator: Number of patients with structured documentation of signs of bleeding in urine, from IV needles, ICH in conjunction with thrombolysis and thrombectomy). Target ≥ 80%

*The focus on the indicators center on nutrition, swallowing, oral care, and positioning, guided by input from the stroke team and interdisciplinary opinion leaders alongside basic organizational/administrative indicators ensuring, for instance adequate education of nursing staff. Many indicators originate from the FeSS protocol

**Available by request to the first author

CNS: Clinical nurse specialist; FeSS: Fever, Sugar, Swallowing protocol; GCS: Glasgow Coma Scale; LPN: licensed practical nurse; ICH: intracerebral hemorrhage; ICP: intracranial pressure; LUH: Landspitali University Hospital; NIHSS: National Institutes of Health Stroke Scale; NANDA: North American Nursing Diagnosis Association; PHR: patient health record; PI: pulmonary infection; SLT: speech-language therapist; UTI: urinary tract infection

66]. Similar risks arise during handoffs between shifts within the stroke unit. To address these vulnerabilities, care bundles—structured as worksheets—ensure systematic attention to essential tasks and comprehensive documentation in patients' electronic health records. This protocolized approach strengthens weaker points in the care pathway, promoting continuity and fostering high-quality practices. It ensures that all interdisciplinary team members, both across and within professional roles, consistently reinforce the use of care bundles. Figure 1 illustrates how acute stroke nursing care is integrated and supported by the wider interdisciplinary team, from admission until discharge from the stroke unit.

In practice, the care bundle assigned to each patient is reassessed daily during doctors' rounds and promptly adjusted to the patient's clinical status. For instance, a patient may initially follow care bundle I (thrombolysis and endovascular treatment) and then transition to care bundle II (ischemic stroke) after 24 h. Similarly, a patient on the ischemic stroke pathway may later require care bundle III (risk of malignant edema and suspected elevated intracranial pressure). The overarching goal is to provide individualized, high quality stroke care for all admitted patients. This includes close monitoring of heart function (e.g., arrhythmias), symptom progression, and complications, for at least 24 h, guided by one of the four care bundles. Physicians, in collaboration with nurses, select the most suitable care bundle, while tailoring specific components, such as blood pressure thresholds or the frequency of neurological assessments, to meet the unique needs of each patient. This carefully calibrated approach promotes alignment between nursing staff and neurologists, ensuring consistency in care delivery, effective communication, and clear prioritization of tasks. Overall, this dynamic, team-based synergy enhances responsiveness and individualization of stroke care.

The following section highlights the thorough interdisciplinary discussions that informed the incorporation of care bundle items. Neuro checks serve as a focal example, as they posed the greatest challenges due to ambiguities in the existing evidence, necessitating in-depth deliberation to devise practical and effective solutions.

Critical Reflections Related to Neuro Checks

Approximately 10–25% of ischemic stroke patients [67, 68] and one-third of hemorrhagic stroke patients [69, 70] experience early neurological deterioration within the first 24–48 h after stroke, underscoring the need for vigilant monitoring [22, 71]. Nurses, often the first to recognize signs of clinical deterioration, must be well-trained and use effective clinical tools to ensure timely detection and response to changes [14, 39, 72].

The NIHSS is widely regarded as fundamental for assessing stroke severity and detecting neurological deterioration in a quantifiable way both in clinical practice and research [10, 73, 74]. It is the most commonly used clinical tool among nurses and neurologists in acute stroke care [75]. At a minimum, a certified healthcare professional should conduct a full NIHSS upon arrival, at 24 h post-admission, and either before discharge or on the seventh day after stroke [10, 22, 76, 77], both in ischemic and hemorrhagic stroke [78, 79]. However, the absence of definitive guidelines for ongoing frequency has resulted in variability of practice and gaps in detecting neurological deterioration [80]. For example, one study found that 29% of 231 patients who experienced deterioration within the first 72 h had their symptoms go unnoticed [72].

The NIHSS evaluates key domains such as consciousness, sensory impairment, visual field abnormalities, eye movements, motor strength (legs and arms), speech, cognition, inattention, and ataxia [10]. Scores range from 0 to 42, although the practical maximum is 39 due to mutually exclusive items (e.g., ataxia cannot be present in patients with total hemiparesis) [73]. Higher scores in the NIHSS correspond to greater stroke severity. With sufficient training and standardized use, the NIHSS demonstrates excellent validity and reliability among both nurses and physicians [81–83]. Accurate and reproducible scoring, however, relies on assessing observed patient performance rather than making assumptions about their capabilities [73].

Incorporating the NIHSS into nursing practice is both practical and beneficial, as it complements its use by physicians and aligns with recommendations in leading stroke guidelines [10, 14, 31, 84]. The tool further enhances communication across disciplines, facilitates tracking of symptom progression, and informs necessary interventions [85]. However, its limitations must be considered. For example, the NIHSS tends to underestimate deficits from right (non-dominant) hemisphere strokes and poorly captures symptoms associated with posterior circulation stroke [10, 86–88].

Recognizing these limitations, nurses and physicians must identify specific areas for focused monitoring to effectively track symptom progression. Neurologists specify additional symptoms to monitor during neuro checks beyond those captured by the NIHSS, such as following the progression of hand or finger paralysis and dizziness [10, 14]. By combining structured tools like the NIHSS with customized monitoring strategies, acute stroke surveillance becomes more precise and individualized.

The development of our local care bundles involved extensive discussions surrounding documentation practices and the frequency and depth of neurological checks, including by whom, how, and when a standardized NIHSS

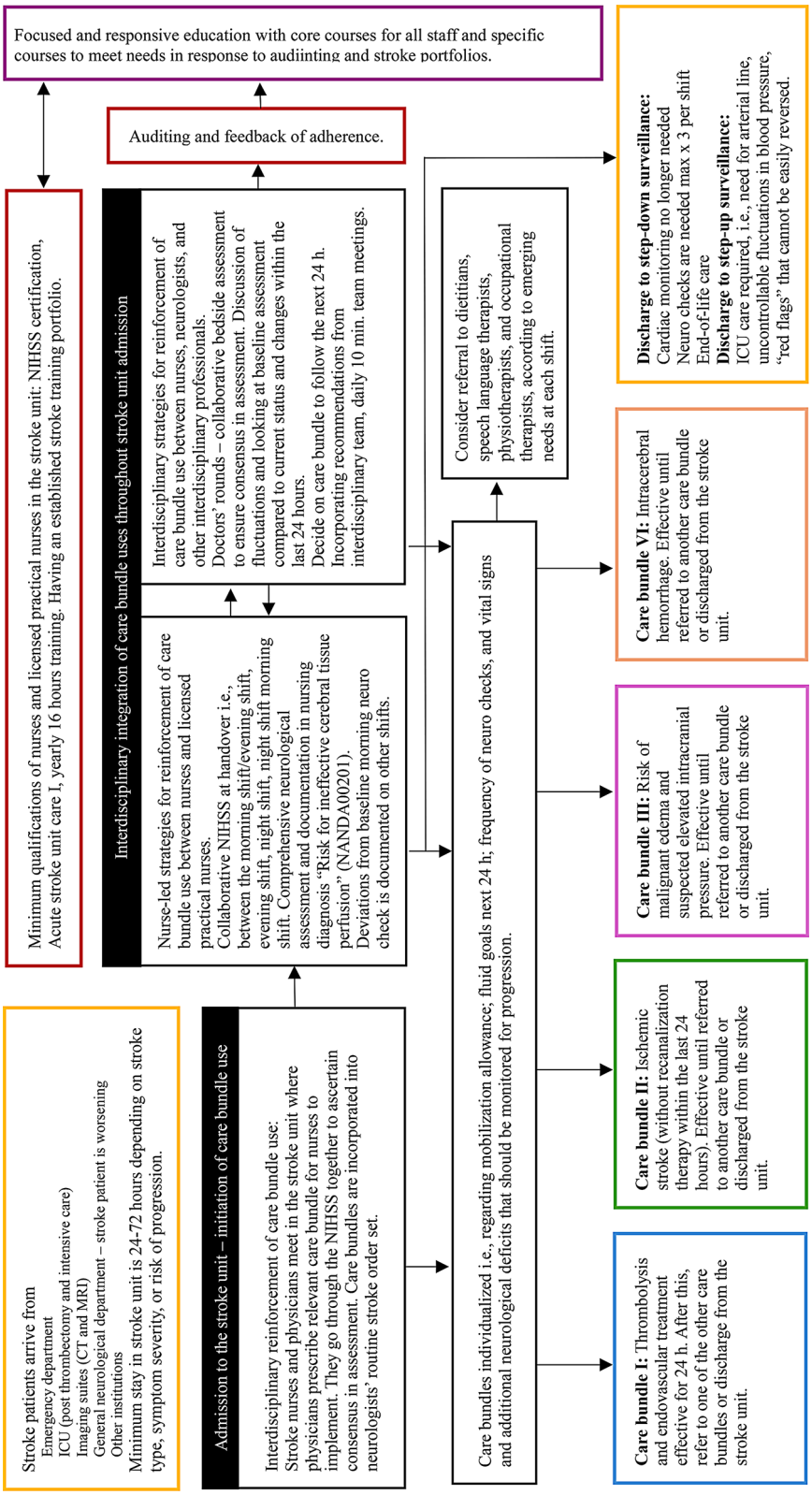

Fig. 1 Integrated Acute Stroke Nursing Care Within the Interdisciplinary Team.
ICU: Intensive care unit; NANDA: North American Nursing Diagnosis Association; NIHSS: National Institute of Health Stroke Scale

assessment should be conducted. At our clinical site, the NIHSS serves two distinct purposes: (1) to screen clinically for neurological deterioration or improvement, and (2) to provide reliable stroke severity data for global comparability. Advocates for the NIHSS emphasize the importance of clearly differentiating between these applications in documentation [73]. To ensure consistency in assessment, all nursing staff are required to complete the online NIHSS certification [77], renewing it every one to two years, depending on their certification level. As an incentive, staff members are credited with eight hours of work time upon (re)certification.

The standardized NIHSS, scored strictly according to the certification protocol, is performed by nurses upon the patient's admission to the stroke unit and repeated daily in conjunction with a comprehensive neurological examination. In contrast, the simplified version includes the same items but serves as a rapid screening tool throughout the day to detect neurological changes. For example, nurses may screen for persistent aphasia by prompting patients to answer questions instead of using the pictures from the standardized protocol. This simplified approach addresses nurses' concerns that the full standardized version is impractical for frequent serial measurements, leading clinicians to make non-standardized adjustments, that may compromise scale validity [85, 88, 89]. Importantly, the use of all NIHSS items complies with recent nursing guidelines [7, 10]. When neurological deterioration is suspected—commonly defined as an increase of ≥4 points on the NIHSS within 24 h [12, 80, 90, 91]—the standardized version of the NIHSS is performed, and the physician notified [83]. To ensure clarity in documentation, nurses and physicians indicate the type of NIHSS assessment used by selecting either a "standardized" or "screening" checkbox in patients' electronic health records. A prospective analysis of this dual-use documentation may yield valuable insights into optimizing neuro checks, addressing a highly recommended but yet often under documented practice.

As part of the handoff process between shifts, nurses and LPNs collaboratively conduct the initial NIHSS assessment at the start of each shift. This promotes a culture of debriefing, enhances continuity, and reduces variability in NIHSS scoring by promoting discussions to reconcile differing interpretations of patient responses. Establishing a consistent neurological baseline for each shift helps reduce assessment discrepancies and resolve disagreements in scale usage [85]. This is particularly valuable for NIHSS items with low inter-rater agreement, such as visual fields, ataxia, language, and hemi-inattention [92, 93]. Calibration during assessment is especially important in smaller stroke units embedded within larger neurological departments, where staff may not exclusively work in the stroke unit during all shifts, increasing the risk of inconsistency in patient evaluations. Frequent NIHSS use is essential for maintaining clinical proficiency, and certification has been shown to enhance nursing practice. Certified nurses not only demonstrate higher scores on stroke knowledge assessments but also seem to benefit more covertly by staying current with best practices [94]. To support accurate and consistent NIHSS assessments, practical tools such as pocket cards in the local language are provided, further aiding in the effective application of the scale.

The Glasgow Coma Scale (GCS) is primarily recommended for patients with hemorrhagic stroke [11, 84] and is not typically included in standard ischemic stroke guidelines [7, 10, 12, 14, 31]. Despite this, we chose to routinely monitor all stroke patients using the GCS regardless of etiology. Incorporating the GCS across all cases allows for consistent comparison of neurological assessments between hemorrhagic and ischemic strokes. To complement the use of the NIHSS and GCS, a comprehensive neurological assessment is systematically conducted during morning shifts and documented within the framework of the nursing diagnosis. This practice facilitates greater individualization of neurological examinations.

All issues in the care bundles were approached in a similar manner to this neuro check example to optimize practical relevance and fidelity of the care bundles.

Conclusion

Practices employed in larger stroke units cannot be directly translated to smaller settings, where staff must balance limited resources between general neurology and specialized stroke care. We summarized the current evidence around optimizing nurse contribution emphasizing the benefits of acute stroke care bundles. Our case study further demonstrates how acute stroke nursing care bundles can be tailored to reinforce effective implementation within interdisciplinary teams—which is a perspective often overlooked. Moreover, it also provides insights into the rationale behind selecting care bundle elements.

When applied within a structured framework, care bundles can leverage staff competencies, strengthen interdisciplinary coherence, and improve care quality. Informal teaching moments, such as shift handoffs and joint nurse-neurologist assessments, can strategically enhance learning and ensure consistent care bundle application. Successful implementation, however, requires thorough documentation and regular evaluation of key performance measures to achieve optimal results.

Every stroke patient deserves the highest quality care. Metrics capturing nursing care must take a central role in

international stroke policy, standing shoulder-to-shoulder with acute medical benchmarks and recognized as equally important to optimize patient outcomes.

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Illustrate a system for continuously updating stroke guidelines in response to new evidence.

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Declarations

Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

Competing Interests The authors declare no competing interests.

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