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Review Article

Nursing neurological assessment in the intensive care unit: A scoping review

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ABSTRACT

Objective: To describe the scope and nature of research examining nurse-performed neurological assessments in adult intensive care unit (ICU) settings and identify gaps for prioritisation in future research.
Design & Registration: Scoping review conducted according to a prospectively registered protocol.
Methods: Systematic searches of CINAHL, MEDLINE and PsycINFO were conducted in June 2025. Studies published from 2014 were eligible if focusing on nursing neurological assessments in adult ICUs. Independent screening and selection were undertaken by at least two reviewers. Data extraction using a customised form was duplicated for 20% of studies. An inductive content analysis approach was used to identify predominant research themes.
Results: Thirty-one studies were included, with the majority involving only patients with neurological conditions. Four research themes were identified: assessment of consciousness, pupil inspection, electroencephalography (EEG) monitoring, and clinical utility of hourly neurological assessments (neurochecks). Each theme was characterised by substantial clinical and methodological heterogeneity, limiting meaningful synthesis of study findings. Nevertheless, several broader findings emerged, each representing priority areas for future research. First, the reliability and validity of ICU nurses' assessment of consciousness and pupils remain uncertain. Second, nurse-led EEG monitoring appears technically feasible in expediting electrographic seizure detection and optimising therapeutic burst suppression. Finally, the clinical utility of sustained hourly neurochecks appears limited, given low diagnostic yield and potential risks.
Conclusions: Evidence regarding nurse-performed neurological assessment in ICU settings is low in volume, methodologically heterogeneous, and concentrated within neurocritical populations. This evidence lacks the coherence and empirical maturity required to substantiate the reliability, validity, and clinical significance of current practices. Progress in this field requires rigorous research to address the identified priority areas.
Implications for clinical practice: Without robust evidence, nursing neurological assessment practices remain convention-driven rather than outcome-oriented. Uncertainty surrounding the reliability and validity of neurological assessment practices raises questions regarding their utility in informing safe, high-quality care for critically ill adults in ICU settings.

Introduction

Neurological dysfunction remains a common manifestation of critical illness [1,2]. While primary neurocritical conditions represent 15–30% of intensive care unit (ICU) admissions internationally [3–5], life-threatening neurological complications, including stroke, seizures, and encephalopathies, occur frequently amongst critically ill adults [1,6,7]. The recognition, monitoring, and management of these conditions are guided by neurological assessments or examinations [2,8], most of which are performed by ICU nurses [9,10]. Accordingly, regular neurological assessments remain a cornerstone of surveillance in ICU settings [1,2,8,11], and a core responsibility of ICU nurses, irrespective of subspecialty or primary diagnosis [9,10].

Neurological assessment in the ICU is operationalised in two distinct

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ways: first, as a surveillance-oriented practice, it evaluates the functional integrity of the nervous system for diagnostic and prognostic significance, with the aim of detecting acute neurological change or deterioration [2]. Second, as a management-oriented practice, it involves monitoring that directly guides management strategies to address symptoms and reduce complications due to pain, agitation/sedation, delirium, immobility and sleep optimisation (PADIS) [2,12]. Both operationalisations are essential in optimising patient safety and improving clinical outcomes, and while they often intersect in practice, their underlying clinical purposes differ. To maintain conceptual clarity and coherence, this review is grounded in the surveillance-oriented conceptualisation of neurological assessment outlined above.

Within the multidisciplinary ICU context, surveillance is most closely aligned with the nursing role due to their continuous bedside presence [13,14]. This sustained proximity enables the ongoing acquisition, interpretation, and synthesis of patient data that characterises nursing surveillance [13,14]. Neurological assessment therefore constitutes a focused application of this broader surveillance process, concerned specifically with recognising and responding to changes in neurological function. A conventional neurological assessment typically evaluates consciousness, cognition, cranial nerves, motor function, and sensory perception [15]. Notably, comprehensive assessment of higher cortical and sensorimotor functions require active patient participation [8,15], which is often limited in critically ill patients due to impaired consciousness or medical instability [2,8]. Moreover, conventional neurological assessments are invariably confounded by patient factors ubiquitous in ICU settings, including intubation, sedation, and physiological extremis [2,8,11]. Therefore, neurological assessment of critically ill adults demands advanced clinical judgement and represents one of the most challenging responsibilities of ICU clinicians [8].

These challenges contribute to substantial conceptual and operational ambiguity, as there is no consistent understanding of what nurse-performed neurological assessment should involve in ICU settings. While the 2014 European Society of Intensive Care Medicine expert consensus report [2] provides a robust, generalisable framework for neurological examination in both general and neuroscience ICUs, these recommendations do not provide nursing-specific operational detail and are based on now dated evidence. Current evidence relevant to nursing neurological assessment in ICU settings appears dispersed across various research foci, methodologies, and clinical contexts, often embedded within broader studies not specific to nursing practice or ICU settings. The fragmented nature of existing evidence has likely precluded the development of evidence-based ICU nursing–specific guidance. Furthermore, the validity and clinical utility of both conventional and emerging assessment techniques remain unclear in the context of ICU nursing practice.

Given the conceptual breadth and heterogeneous nature of relevant literature, a rigorous scoping review is needed to systematically map the available evidence and summarise current knowledge regarding this core nursing responsibility. Such mapping is needed to provide early insights into the feasibility of developing nursing–specific guidance, and to identify research priorities that must be addressed to ensure current practice is evidence-based. Accordingly, the aim of this scoping review was to describe the scope and nature of published research that explicitly examines neurological assessment when performed by nurses across adult ICU settings and identify knowledge gaps for prioritisation in future research.

Methods

An a priori protocol was developed in alignment with internationally recognised guidelines for scoping reviews [16–20] and registered on the Open Science Framework (https://doi.org/10.17605/OSF.IO/JFCNG). This review is reported according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews [21].

Selection criteria

In alignment with the exploratory purpose of scoping reviews, inclusion criteria were deliberately expansive across assessment domains, ICU populations, and methodological approaches. Publications were eligible for inclusion if they explored neurological assessments that were performed by nurses in an adult ICU setting, either broadly or with a focus on specific components (e.g., assessment of consciousness, cranial nerve function, or motor responses); as shown in the full selection criteria in Table 1. Importantly, studies must have reported ICU nurse-specific results separately from results from other clinicians or settings. Any study meeting this expansive inclusion criteria and no exclusion criteria, were included for review. As aforementioned, the surveillance-oriented operationalisation of neurological assessment was the focus of this review; therefore, studies focusing exclusively on management-oriented domains such as pain, agitation, sedation, immobility or delirium were excluded. These domains are conceptualised together within dedicated clinical frameworks and guidelines distinct from surveillance-oriented examination practices [12,22–24], and fall outside the conceptual scope of this review. Grey literature would not address the review aims and was not sought.

Search strategy and source selection

A systematic search of CINAHL, Medline Complete, and PsycINFO was conducted in June 2025 (Supplementary Table 1). Given the breadth of the topic, search strategies were developed to maximise specificity without compromising sensitivity and were reviewed by specialist librarians. The search was limited to studies published from January 2014 to ensure relevance to contemporary practice and

Table 1
Selection Criteria and Population Concept and Context Concepts.

Domain	Inclusion	Exclusion
Participants	Nurses caring for critically ill adults	• Non-nurse clinicians/ assessors. • Mixed assessor/clinician groups: nurse-specific findings not reported separately.
Concept	Neurological assessment – relevant practices, processes, antecedents or implications, including: • Techniques or tools used & respective measurement properties • Knowledge, confidence & competence • Timing, clinical utility/ significance for either neurological assessment broadly, or any of the core domains, including but not limited to: • Consciousness • Brainstem and cranial nerve functions • Motor responses or movement	Studies exclusively reporting practices related to assessment of: • Delirium or cognitive impairment • Pain • Sedation • Agitation • ICU-acquired muscle weakness or immobility • Sleep optimisation
Context	Any adult intensive care unit	• Non-ICU settings • Paediatric or neonatal patients. • Mixed settings: ICU-specific findings not reported separately
Sources	Peer-reviewed original research, and: • Full text available in English • Published from January 2014 onwards.	• Non-peer reviewed or non-English reports • Conference proceedings/ abstracts • Editorials, commentaries or opinion pieces • Grey literature

concluded following reference list screening and citation searches in Scopus. Results were exported to EndNote, where retracted articles were detected and removed, then imported to Covidence for de-duplication, screening, and selection.

Title/abstract screening and full-text review were conducted by at least two reviewers independently. Papers clearly meeting exclusion criteria were removed during title and abstract screening. Remaining papers proceeded to full-text review for comparison against the full selection criteria. Meetings amongst the review team were held regularly to resolve any disagreements. Corresponding authors were contacted when clarification was required to determine eligibility.

Data extraction, analysis and reporting

Data were extracted from each paper using a customised form, with duplicate independent extraction conducted for 20% of studies to ensure consistency [20]. The primary reviewer (JES) extracted data for remaining papers, including citation details, ICU setting and population, aims, methods, and key findings [19,20]. Critical appraisal was not performed, as it is not routinely indicated for scoping reviews and would not address review aims [16–20].

Extracted data were analysed using an inductive content analysis approach to categorise studies by primary empirical focus [25,26]. Identification of specific research foci from each study's aims and outcome measures were used to generate subthemes, which were synthesised into overarching themes to facilitate comparisons across studies and provide a framework for reporting [26]. Characteristics and key findings of each included study are summarised in a Summary of Findings table, while the overall direction of findings for each theme or subtheme are described in the accompanying narrative syntheses. Statistical results were interpreted using established descriptive thresholds [27–30]. For studies investigating multiple themes across mixed clinician groups or settings, only nurse- and/or ICU-relevant data were mapped to ensure alignment with review aims and selection criteria, and to preserve coherence in reporting. Identified gaps in evidence and recommendations for future research are summarised at the end of the discussion.

Results

The search yielded 4,014 sources: after de-duplication, 3,091 were screened, leaving 116 papers for full-text review. Thirty-one papers [9,31–60] met selection criteria and were included, as shown in Fig. 1. All 31 papers were reports of primary studies, for which study characteristics are summarised in Table 2. Studies were predominantly quantitative with observational designs. Nearly half were conducted in the United States (USA; n = 14, 45%), with limited representation from other high-income countries. Sixteen studies (51.6%) were conducted in neuroscience ICUs, followed by general ICUs (n = 11, 35.5%), and mixed ICU sub-settings (n = 4, 12.9%). Of the 23 studies recruiting patients, 19 (82.6%) included individuals with neurological conditions; only one study focused exclusively on patients with non-neurological

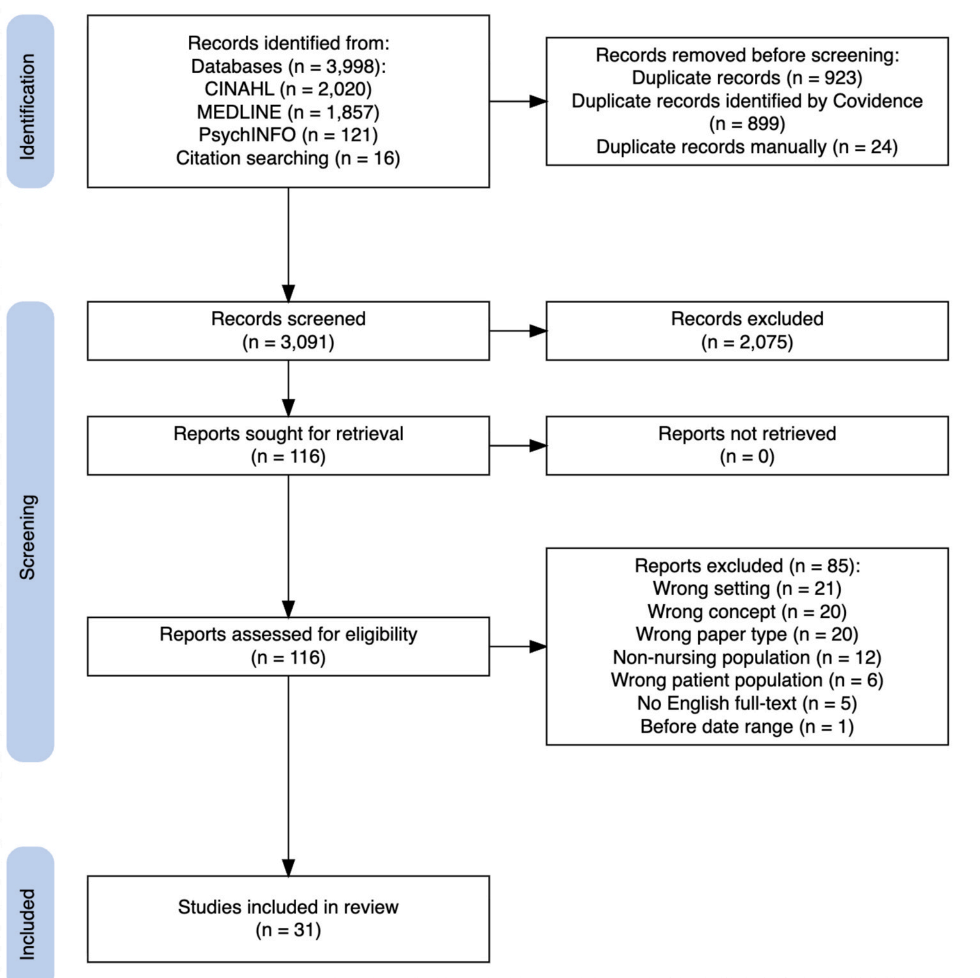

Fig. 1. PRISMA Flow Diagram.

Table 2
Study Characteristics.

Characteristic	n (31)	%
Design		
Observational	27	87.1
Prospective	23	74.2
Retrospective	4	12.9
Quasi-experimental	3	9.7
Qualitative	1	3.2
Country		
USA	14	45.2
Turkey	4	12.9
Iran	3	9.7
Australia	1	3.2
China	1	3.2
Denmark	1	3.2
Egypt	1	3.2
Ethiopia	1	3.2
Finland	1	3.2
France	1	3.2
Jordan	1	3.2
Korea	1	3.2
Taiwan	1	3.2
Year of Publication	n	Mean/year
Overall (2014–June 2025)	31	2.7
2014–2016	9	3.0
2017–2019	8	2.7
2020–2022	11	3.7
2023–June 2025	3	1.2

conditions. Studies involving only nurse-participants (n = 9, 22.6%) predominantly addressed practice in neuroscience ICUs or in relation to patients with neurological conditions (n = 7, 77.8%).

Four primary research themes were identified across included studies: nurses' assessment of consciousness (n = 13, 42%), assessment of pupils (n = 6, 19%), monitoring of electroencephalography (EEG; n = 6, 19%), and the clinical utility of hourly neurological assessment (n = 5, 16%). Detailed summaries of each study are presented in Table 3. One study [53] investigated more than one theme, and the foci of two studies [9,42] (6%) did not directly align with the other identified themes. The distribution of studies by theme and clinical context is shown in Fig. 2.

Research Theme 1: Nurse-Assessed Level of Consciousness in ICU Settings

Studies exploring ICU nurses' assessment of consciousness using the Glasgow Coma Scale (GCS) or Full Outline of UnResponsiveness (FOUR) score formed the largest research theme. This theme comprised 13 studies [31,32,38,41,43,46,50–55,57] across two subthemes: the psychometric performance of consciousness assessment tools when used by ICU nurses, and ICU nurses' knowledge of the GCS.

Subtheme 1: The Psychometric Performance of Nurse-Assessed Level of Consciousness Tools in ICU Settings

Nine single-centre studies, predominantly from low- and middle-income countries (LMICs; n = 6, 66.7%), investigated psychometric properties of nurse-assessed GCS and/or FOUR score. While most studies were conducted in general ICUs (n = 6; 66.7%), only one study [54] included patients with non-neurological conditions. Notably, all eight studies investigating reliability or predictive validity involved only patients with acute brain injury [43,46,50–53,55,57]. Most studies excluded sedated or 'heavily' sedated patients (n = 4 [50,54,55,57]; n = 3 [43,46,51], respectively). Assessor numbers were small, with seven studies (77.8%) observing five nurses or fewer. Nurse-assessors received instruction on GCS and FOUR score assessment immediately before data collection in six studies [43,50,53–55,57]. Only one study [46] evaluated the interrater reliability (IRR) of the GCS without providing prior instruction.

Six studies compared psychometric performance for both GCS and FOUR score assessed by nurses in adults with acute brain injury: four studies [43,51,53,57] evaluated predictive validity, and two [50,55] compared IRR. The remaining relevant studies include one study [54] comparing cross-tool agreement between both tools in a general ICU cohort; one study [52] evaluating the predictive validity, convergent validity and reliability of the FOUR score in patients with aneurysmal subarachnoid haemorrhage (SAH); and one [46] assessing the IRR of the GCS in patients with altered consciousness.

Regarding predictive validity, three studies [43,51,57] compared the accuracy of nurse-assessed GCS and FOUR score in predicting mortality in patients with traumatic brain injury (TBI). Two prospective studies from Iran [43,57] assessed hospital mortality in cohorts with mixed consciousness distributions, while a retrospective study from Taiwan [51] examined ICU mortality predictions in a predominantly alert cohort. These studies found both tools had adequate-to-outstanding predictive accuracy, though the FOUR score demonstrated higher overall accuracy and specificity. Another study [53] found low FOUR scores, but not lowest GCS (GCS 3), consistently predicted poor functional outcome at 6 months for patients with acute brain injury. This study also found patients with GCS 3 achieved FOUR scores of 4 to 5 due to preserved cranial nerve functions. Overall, the FOUR score demonstrated superior predictive performance and responsiveness in cohorts with moderate-to-severe impairments, while advantages over the GCS were less apparent in more alert cohorts.

The IRR of the GCS and FOUR score were assessed for a pair of nurse-assessors in two studies [50,55], both reporting high IRR, with slightly higher estimates for the FOUR score. Each included intubated but non-sedated patients and used pseudoscoring for the GCS verbal component. In contrast, another study [46] reported estimates indicative of inadequate IRR for the GCS when assessing a general ICU cohort with impaired consciousness. A separate study [52] of patients with aneurysmal SAH reported outstanding-to-perfect IRR for the FOUR score between two nurse-assessors alongside excellent internal consistency, and high correlations between FOUR scores and SAH severity scales. Finally, one study [54] of nurses' perceptions of the GCS and FOUR score's utility in a general ICU cohort found nurses preferred the FOUR score (48%) over the GCS (41%), despite low familiarity.

Subtheme 2: Nurses' Knowledge of the Glasgow Coma Scale in ICU Settings

Four studies explored ICU nurses' knowledge of the GCS [31,32,38,41], including two cross-sectional studies [32,41] and two pre-post studies [31,38]. Surveys were used in the pre-post studies to evaluate the efficacy of an educational intervention in improving nurses' knowledge of GCS assessment. The observational studies and a pre-post study from neighbouring LMICs found nurses' GCS knowledge was inadequate, with mean or pre-test scores consistently below 55% [31,32,41]. Both pre-post studies [31,38] found didactic and case-based education significantly improved GCS knowledge; one study [31] assessed knowledge retention at 2 months, with gains remaining significant from pre-test scores.

Research Theme 2: Nurses' Assessment of Pupils in ICU Settings

Research within this theme investigated the accuracy of nurses' assessments of pupils in ICU settings, predominantly in comparison to pupillometer measurements, and nurses' perceptions of pupillometry. Six studies [34,36,40,47,53,58] investigated nurses' assessment of pupils, with five [34,36,40,53,58] investigating pupillometer use in neuroscience ICUs. Three studies [36,53,58] compared nurses' visual inspections of pupils with pupillometer measurements, finding nurses' assessments slightly underestimated pupil size. Two such studies reported negative mean bias from Bland-Altman analyses (–0.2 mm [58] to –0.4 mm [36]), although limits of agreement were wide. A third study [53] reported a median absolute difference of 0.4 mm, with plots

Table 3
Summary of Findings.

Research Theme 1: Nurses' Assessment of Level of Consciousness in ICU Settings *(n = 13)*

Subtheme 1: Psychometric Performance of Consciousness Assessment Tools (n = 9)

Study ID *Country & Setting*	**Design** *Analytic Focus (if applicable)*	**Aims**	**Sample Characteristics**	**Measures & Procedures**	**Key Results/Findings**
Jalali, 2014 *Iran* Single-site: Gen/Mix ICU	Prospective Cohort: Psychometric *- Predictive Validity*	To determine the predictive accuracy of nurse-assessed GCS & FOUR score in patients with TBI.	*Nurses:* n = 3 *Patients:* n = 104 with TBI. Excluded if "heavily" sedated - 35% were "alert" - 36.5% died	Nurses were reinstructed in use of GCS & FOUR prior to study period. *Index measure/s:* Day 0 GCS & FOUR *Outcome measure/s:* Hospital mortality	GCS (cut off 5): Se 68.4%, Sp 63.60%, Acc. 64.5%, Younden's J 32% FOUR Score (cut off 6): Se 68.4%, Sp 77.30%, Acc. 74%, Younden's J 46%
Sepahvand, 2016 *Iran* Single-site: Gen/Mix ICU	Prospective Cohort: Psychometric *- Predictive Validity*	To determine the predictive accuracy of nurse-assessed GCS & FOUR score in patients with TBI.	*Nurses:* n = 3 *Patients:* n = 198 with TBI. Excluded if sedated -Mean GCS 8.6 - Mean FOUR 9.4; mode 16 - 34.9% died	Nurses were provided with instructional handout regarding GCS & FOUR assessment prior to study period. *Index measure/s:* Day 1 GCS & FOUR *Outcome measure/s:* Hospital mortality	GCS (cut off 5): AUROC 0.928 Se 85%, Sp 83% FOUR Score (cut off 6): AUROC 0.961 Se 76%, Sp 90%
Nyam, 2017 *Taiwan* Single-site: NScICU	Retrospective Cohort: Psychometric *- Predictive Validity*	To determine the predictive accuracy of nurse-assessed GCS & FOUR score in patients with TBI.	*Nurses:* n = 3 *Patients:* n = 55 with TBI. Excluded if SAS $\leq$2. - Median GCS 10 - 35% FOUR = 16; 56% FOUR $\geq$13 - 14.6% died	Assesor preparation n.r. *Index measure/s:* Day 0 GCS & FOUR *Outcome measure/s:* ICU mortality	GCS: AUROC 0.747 Se/Sp n.r. FOUR Score (cut off 5): AUROC 0.745 Se 62.5%, Sp 89.4%
Olsen, 2020 *Denmark* Single-site: NScICU	Prospective Cohort: Psychometric *- Predictive Validity* *- Responsiveness*	To determine if the FOUR score could provide more clincially meaningful assessments for patients with lower GCS.	*Nurses*: n = 5 *Patients:* n = 56 with acute brain injury* - Median GCS 6; Median FOUR 7 - 66.1% unfavourable outcome	Nurses received instruction on use of FOUR score prior to study period. GCS training not reported. *Index measure/s:* Day 0 GCS & FOUR *Outcome measure/s:* 6m GOSE (GOSE >4 = favourable outcome)	GCS: n = 13 (36%) patients with GCS 3 had favourable outcome. FOUR: No patients with FOUR score $\leq$3 had favourable outcome. Patients with GCS 3 had FOUR scores between 0-6, with most achieving FOUR scores between 4–5 due to preserved brainstem function.
Oh, 2019 *Korea* Single-site: Gen/Mix ICU	Prospective Cohort: Psychometric - Predictive Validity - Convergent Validity - Interrater Reliability - Internal Consistency	To evaluate the construct validity and reliability of the FOUR score in patients with spontaneous aSAH.	Nurses*:* n = 2 *Patients:* n = 72 with aSAH. - 27.8% with midline shift	*Index measure/s:* Day 0 four *Convergent comparators:* Day 0 Hunt-Hess & Fisher CT scores *Outcome measure/s:* 1m post aSAH event GOS (GOS $\leq$3 unfavourable) Patients were assessed by 1 nurse for all outomes except IRR, for which 2 nurses assessed a subgroup of 10 patients. Specific assessment procedures n.r.	Predictive Validity: Odds of favourable outcome for every 1-point increase in FOUR score: OR 1.64 95% CI 1.07–2.51 Convergent Validity: FOUR had strong, significant correlations for both CT severity scores: Hunt-Hess r −0.71 (p <0.001) Fisher CT r −0.64 (p <0.001) IR Reliability (ICC values): FOUR sum 0.99; E 0.94; M 1.00; B 1.00; R 1.00 Internal Consistency Cronbach α 0.93
Peng, 2015 *China* Single-site: NScICU	Prospective Cohort: Psychometric *- Interrater Reliability*	To evaluate the psychometric performnce of the Mandarin translation of the FOUR score compared to the GCS in neurosurgical ICU patients.	*Nurses:* n = 2 *Patients:* n = 120 with acute brain injury Excluded if sedated - 50.8% alert or drowsy	Assessors watched a video regarding FOUR score assessment, received a handout covering assessment of both FOUR score & GCS, then given the opportunity to practice assessment of both tools.	ICC values: GCS sum 0.949 E 0.933; M 0.894; V 0.893 FOUR sum 0.973 E 0.928; M 0.968; B 0.919; R 0.955

(*continued on next page*)

Table 3 (*continued*)

			- 49.2% stuporous or comatose - 48% intubated	Both tools assessed within one hour; unclear if randomised order. Assessors were blinded to the others findings. *Pseudoscoring of GCS-V?* Yes – GCS-V = 1 for intubated patients	
Momenyan, 2017 *Iran* Single-site: Gen/Mix ICU	Prospective Cohort: Psychometric *- Interrater Reliability*	To evaluate the psychometric performnce of the Persian translation of the FOUR score compared to the GCS in ICU patients with TBI.	*Nurses:* n = 2 *Patients:* n = 87 'unconscious' with TBI. Excluded if sedated - 73% intubated	Instruction given to all assessors regarding both GCS & FOUR score,with an opportunity to practice. Both tools assessed within one hour in randomised order. *Pseudoscoring of GCS-V?* Yes – GCS-V = 1 for intubated patients	Kw values: GCS sum 0.832 E 0.955; M 0.931; V 1.00 FOUR sum 0.866 E 1.00; M 0.932; B 0.894; R 0.952
Kebapci, 2020 *Turkey* Single-site: Gen/Mix ICU	Prospective Cohort: Psychometric *- Interrater Reliability*	To evaluate the IRR of the GCS when assessed by nurse–nurse-researcher pairs.	*Nurses:* n = 21 + 2 nurse-researchers *Patients:* n = 202 with neurological illness. Excluded if RASS ≤-4 - 68% intubated	Nurses had no prior instruction but had access to scoring cards. Each patients primary nurse assessed each patient using GCS followed by each of the 2 researchers, all were blinded to the others' findings. Pseudoscoring of GCS-V? No – GCS-V = T for intubated patients	Kripp.α values (RN-Researcher 1/RN-Researcher 2): GCS Sum 0.419/0.490 E 0.641/0.629 M 0.649/0.666 V 0.552/0.569
Özçelik, 2021 *Turkey* Single-site: Gen/Mix ICU	Prospective Cohort: Psychometric *- Convergent Validity* *- Face Validity*	This study reported aims to assess IRR for nurse-assessed GCS and FOUR scores, however, only cross-tool agreement estimates were reported. Nurses percptions of both tools' utility were also assessed.	*Nurses:* n = 27 *Patients:* n = 92 with any diagnosis Excluded if sedated - 44.6% intubated	Nurses received instruction on GCS & FOUR assessment prior th the study period. Nurses then assessed GCS & FOUR in blinded pairs, although agreement between-raters (i.e.IRR) is not reported. Instead, two separate contingency tables presenting cross-tool agreement between dichotomised GCS & FOUR are provided, one for nurses performing the first assessment and one for those performing the second. Nurses completed a survey to ascertain their perceptions of the utility of both tools.	K values taken from contingency tables presenting tool-tool agreement (not rater-rater agreement/IRR): Nurses performing 1st assessment: 0.935 Nurses performing 2nd assessment: 0.927 n = 25 nurses (93%) had no prior knowledge of the FOUR score 74% stated FOUR was easy to use. 48% preferred the FOUR score 41% preferred the GCS
Subtheme 2: Knowledge of the Glasgow Coma Scale (n = 4)					
Study ID *Country & Setting*	**Design** *Analytic Focus (if applicable)*	**Aims**	**Sample Characteristics**	**Measures & Procedures**	**Key Results/Findings**
Ahamed, 2017 *Egypt* Single-site: NScICU	Quasiexperimental	To investigate efficacy of an educational program on nurses' knowledge of GCS assessment.	*Nurses:* n = 37	Nurses completed GCS knowledge questionnaire & independent practical assessments pre/post 60-min didactic educational session; reassessed immediately & at 2 months to evaluate knowledge retention.	Improvement in GCS knowledge & practical competency across all domains post-education (p < 0.001). This was sustained at 2-month follow-up (p < 0.05). Decline in knowledge regarding indications & importance of GCS assessment between post-test and follow-up (p = 0.04).
Enriquez, 2019 *USA* Single-site: NScICU	Quasiexperimental	To investigate efficacy of an educational program on nurses' knowledge of GCS assessment.	*Nurses:* n = 20	Nurses completed baseline GCS knowledge/application survey using clinical scenarios; attended 90-min didactic + case-based education session; 16 nurses completed identical post-survey within 5 months.	Overall knowledge did not improve (p = 0.19). General GCS knowledge improved (p = 0.016). No improvement in knowledge of specific GCS components or sum scores.

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Table 3 (*continued*)

Al-Quraan, 2016 Jordan Multi-site: 4 Gen/Mix ICU; NScICU	Prospective: Cross-sectional	To assess nurses' knowledge of the GCS & associations between knowledge & nurse or hospital characteristics.	Nurses: n = 85	Nurses from ICU, NScICU, and high acuity wards completed questionnaire assessing theoretical & practical (scenario-based) knowledge of GCS assessment.	Mean test scores (max score 15) Overall: 7.38 ± 1.96 ICU nurses achieved higher scores than ED nurses ((7.56 ± 1.99 vs 6.67 ± 2.17, $p < 0.05$) No associations with experience, education, or prior training were found.
Andualem, 2022 *Ethiopia* Multi-site: 4 Gen/Mix ICU	Prospective: Cross-sectional	To assess nurses' knowledge of the GCS & associations between knowledge & nurse or hospital characteristics.	Nurses: n = 121	Nurses from four ICUs completed questionnaire assessed theoretical and practical (scenario-based) knowledge of GCS assessment.	% accurate answers: GCS assessment knowledge: 51.2% GCS assessmnet practice: 62% Male sex and master's-level education were associated with higher knowledge (AOR = 4.13; 95% CI: 1.87–9.10; AOR = 7.40; 95% CI: 1.40–38.0, respectively).
Research Theme 2: Nurses' Assessment of Pupils in ICU Settings (*n = 6*)					
Study ID *Country & Setting*	**Design** *Analytic Focus (if applicable)*	**Aims**	**Sample Characteristics**	**Measures & Procedures**	**Key Results/Findings**
Couret, 2016 *France (Mainland & Réunion)* Multi-site: 2 NScICU	Prospective Cohort: Diagnostic Accuracy	To evaluate the accuracy of nurses' visual inspections of pupil size, reactivity & symmetry compared to pupillometer measurements.	*Nurses:* n = 10 *Patients:* n = 59 with acute brain injury (406 individual pupil assessments) - 42% ICH/SAH & 22% TBI - 76.3% intubated - 54.2% receiving opioid infusion	The patients' primary nurse visually inspected pupils. After 5 min intermission, a blinded physician assessed pupils with a pupillometer. Anisocoria defined as ≥1mm difference. PLR defined as ≥15%.	Pupil Size: Mean bias (LoA) –0.36mm (–2.11 to 1.39mm) AUROC 0.75 (0.70–0.79) r = 0.75 (0.71–0.79; p = 0.001) Reactivity: 82% agreement n = 41 (18.4%) false negatives (nurses missed absent PLR) Symmetry/Anisocoria: 50% agreement (15/30 missed)
Smith, 2020 *Australia* Single-site: NScICU	Prospective Cohort: Diagnostic Accuracy	To evaluate the accuracy of nurses' visual inspections of pupil size & reactivity compared to pupillometer measurements.	*Nurses:* not reported *Patients:* n = 22 with neurological illness (935 individual pupil assessments) - 81.8% with SAH, SDH or ICH - 81.8% sedated (propofol: 81.8%; opioids: 77.2%; thiopentone: 9.1%)	Bedside nurses recorded visual inspection of pupils. Senior nurses not directly involved with patient assessed pupils with pupillometer. Reactivity measured as per NPi proprietary algorithm.	Pupil Size: Mean bias (LoA) –0.15mm (–1.60 to 1.29mm) Reactivity: 97.7% agreement K = 0.84 (0.79–0.90) n = 11 (1.1%) false negative (nurses missed areactivity)
Olsen, 2020 *Denmark* Single-site: NScICU	Prospective Cohort: Diagnostic Accuracy	To evaluate the accuracy of nurses' visual inspections of pupil size & reactivity compared to pupillometer measurements.	*Nurses:* n = 5 *Patients:* n = 56 with acute brain injury (468 individual pupil assessments) - 32% aSAH - 27% ICH - 25% TBI	Nurses received instruction regarding both inspection of pupils manually & use of pupillometer, then practiced both techniques under supervision prior to study period. Pupils were first assessed manually by a nurse, the same nurse then performed an assessment with a pupillometer. Patients were assessed a median of 5 times.	Pupil Size: Median absolute difference = 0.4mm (IQR 0.2–0.7; range 0–3.4; p = 0.006) Reactivity: 92.3% agreement n = 7 (1.5%) false negative (nurses missed areactivity)
Anderson, 2018 *USA* Single-site: NScICU	Prospective: Longitudinal	To evaluate whether automated pupillometry could be effectively integrated into the existing nursing workflow and assess nurses' knowledge, knowledge retention and satisfaction regarding pupillometer use.	*Nurses:* n = 22	Surveys evaluating nurses' knowledge of pupillometer use, interpretation of findings and nurses' satisfaction were administered 4 times at 3-month intervals following implementation of pupillometers. Satisfaction was rated on a 10-point scale.	Knowledge regarding pupilometer use and interpretation/reporting of findings remained high over the study period. Nurses' preference for the pupilometer increased over the study period (mean rating 4.6 increased to 5.8 on 10-point scale; p = 0.02).

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Giarmino, 2022 *USA* Single-site: NScICU	Qualitative: Focus Groups	To explore nurses' experiences with pupillometers and their perspectives on the clinical utility of these devices for neurological assessments.	*Nurses:* n = 9	3 focus groups were conducted with open-ended questions. Discussions were transcribed, data analysis methods n.r. Online survey used to collect self-reported comfort levels regarding use of pupillometer (5-point Likert scale).	Mean comfort rating of 3.78 out of 5. 44% felt extremely comfortable with using pupillometer; 22% felt extremely uncomfortable. Five key themes emerged from the discussions: clinical assessment, provider notification, interventions, benefits, and frustrations.
Kebapaci & Topcu, 2020 *Turkey* Single-site: Gen/Mix ICU	Prospective Cohort: Psychometric *- Interrater Reliability*	To evaluate the IRR of visual inspections of pupil size, reactivity and anisocoria when assessed in nurse–nurse-researcher pairs.	*Nurses:* n = 20 + 2 nurse-researchers *Patients:* n = 200 with neurological illness Excluded if RASS ≤-4 - 62% intubated	Assessments of pupil size, symmetry and reactivity were performed independently and in a blinded fashion first by an ICU nurse, then immediately by the two nurse-researchers.	IRR amongst all 3 observers (1 nurse & 2 nurse-researchers): Pupil size (ICC values): Right 0.70; 0.75 Pupils ≥4mm Right 0.52; Left 0.65 Symmetry: K = 0.58 Reactivity: K = 0.89
Research Theme 3: Nurse-led Monitoring of Electroencephalography in ICU Settings (*n = 6*)					
Study ID *Country & Setting*	**Design** *Analytic Focus (if applicable)*	**Aims**	**Sample Characteristics**	**Measures & Procedures**	**Key Results/Findings**
Dericoglu, 2014 *Turkey* Single-site: NScICU	Prospective: Diagnostic Accuracy *- NCS detection with qEEG*	To evaluate non-expert clinicians' ability to detect NCS on qEEG.	*Nurses:* n = 2 (+ 2 non-expert physicians) *Patients:* n = 20 10 with NCS + 10 without NCS 615 h of qEEG data incl. 289 h from NCS group containing 700 seizures	Post hoc transformation of purposively sampled cEEG data from medical records into qEEG displays (aEEG, DSA) All assessors received 5-6h of didactic & individual training. qEEG displays were then provided to assessors in a randomised order. Assessors marked the timepoints where NCS events were observed. Sweep controlled by assessor. *Reference measure:* NPhys-assessed cEEG.	Overall AUROC for seizure detection: Nurses: 0.949 Physicians: 0.926 Nurse 1: Se 92%, Sp 89%, AUROC 0.91 Nurse 2: Se 99%, Sp 90%, AUROC 0.95 Physician 1: Se 88%, Sp 91%, AUROC 0.90 Physician 2: Se 92%, Sp 95%, AUROC 0.94
Swisher, 2015 *USA* Single-site: NScICU; CVICU; Gen/Mix ICU	Prospective: Diagnostic Accuracy *- NCS detection with qEEG*	To evaluate ICU nurses ability to detect NCS on qEEG compared to EEG techs and Nphys	Nurses: n = 5 (+ 7 EEG techs & 5 NPhys) *Patients:* n = 45 30 with NCS + 15 without NCS 4 qEEG displays per patient = 180 panels 105 panels (58.3%) contained ≥1 NCS.	Post hoc transformation of of purposively sampled cEEG data from medical records into qEEG displays of 1h epochs (aEEG, CDSA, asymm.I, rhythm.spect.) All assessors received 15 mins of didactic education. qEEG panels were reviewed by assessors (blinded to cEEG and clinical data), who counted the number of seizures present in each panel & reported which qEEG display type was most useful *Reference measure:* NPhys-assessed cEEG.	IRR (seizure detection): Nurses: K 0.33 EEG tech: K 0.46 NPhys: K 0.48 Nurses: Se 87.1%, Sp 61.6% EEG techs: Se 79.7%, Sp 79.8% NPhys: Se 87.4%, Sp 61.1% No significant differences in Se/Sp between these groups. Nurses and NPhys both found the rhythm.spect. most useful for NCS detection.
Amorim, 2017 *USA* Multisite: 2 NScICU	Prospective: Diagnostic Accuracy *- NCS detection with qEEG*	To evaluate nurses' ability to detect NCS on qEEG compared to expert Nphys	*Nurses:* n = 33 (+ 4 Nphys) *Patients:* n = 30 40 qEEG complex panels chosen NCS present in 50% of qEEG panels	Post hoc transformation of of purposively sampled high-complexity cEEG data into qEEG displays of 2h epochs (CDSA & asymm.I.) Nurses received 40 mins of didactic education then reviewed the 40 qEEG images and indicated the presence & frequency of NCS through a web-based questionnaire.	IRR (seizure detection): Nurses: AC1 0.43 NPhys: AC1 0.46 Nurses: Se 73.8%, Sp 37.6%, Acc. 55.7% False alarm rate 1 per 3.2 hours. NPhys: Se 66.3%, Sp 68.8%, Acc. 67.5% False alarm rate 1 per 6.4 hours.

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				Reference measure: NPhys-assessed cEEG.	
Kang, 2019 *USA* Single-site: NScICU	Prospective: Diagnostic Accuracy *- NCS detection with qEEG*	To evaluate nurses' ability to detect NCS in real-time with bedside qEEG.	*Nurses:* not reported *Patients:* n = 20 with prior NCS on cEEG. 70% had ≥1 NCS NCS present in 27% of the 174 hourly blocks	Nurses received 15 min of didactic education. Bedside qEEG (aEEG, rhythm. spect.) was then reviewed hourly by primary nurse throughout their shift. Nurses recorded NCS frequency every hour. *Reference measure:* NPhys-assessed cEEG.	Se 85.1%, Sp 89.8% False alarm rate 0.1/hour Error rate of 11.5% (20 hourly blocks with error), including 13 false positives and 7 false negatives.
Kaleem, 2021 *USA* Single-site: NScICU	Prospective: Diagnostic Accuracy *- NCS detection with qEEG*	To evaluate nurses ability to detect NCS in real-time with bedside qEEG & determine nurses' time to seizure detection.	*Nurses:* n = 65 *Patients:* n = 109 undergoing cEEG Excluded if indicated for HIE 723 qEEG panels total n = 8 patients (7%) had NCS	Nurses received 10 min of didactic education. Bedside qEEG (aEEG, rhythm. spect.) was then reviewed hourly by primary nurse throughout their shift. Nurses recorded NCS frequency every hour. *Reference measure:* NPhys-assessed cEEG ("standard of care" for comparisons of Tt NCS detection).	Se 74%, Sp 92% False alarm rate 0.08/hour Mean time to seizure detection: Nurses: 53 mins Standard care (NPhys review): 185 mins Seizure detection by nurses vs standard care HR = 6.96 (95%CI 1.31–36.9, p = 0.023).
Picinich, 2015 *USA* Single-site: NScICU	Quasiexperimental *– cEEG monitoring*	To explore the feasibility of nurse-led cEEG monitoring by evaluating the efficiacy of an educational intervention designed to train nurses to monitor cEEG, identify burst supression, its duration, and titrate sedation accordingly.	*Nurses:* n = 9	A survey was developed to test nurses' knowledge of cEEG monitoring, common patterns including artifact and burst supression, and asked nurses' level of comfort in monitoring cEEG (10-point Likert scale). 25 nurses participated in the pre-test (PT0) of which 9 underwent a training program (involving 4 h of didactic & practical education) & answered all post-tests; one immediately after the training program (PT1), one 3m post (PT3) & one 6m post (PT6).	MD in test scores (PT-1 − PT-0): +21% (95% CI 12.4–29.7; p < 0.001). Confidence levels increased from 5.7 (PT0) to 8.0 (PT1). MD of +2.3 points (95% CI 1.13 to 3.51; p = 0.001). No difference between post test scores (PT1, PT3, &PT-6 all 88.6%; p = 1.00).
Research Theme 4: Clinical Utility of Nurse-Performed "Neurochecks" in ICU Settings (*n* = *5*)					
Study ID *Country & Setting*	**Design** *Analytic Focus (if applicable)*	**Aims**	**Sample Chareacterisitics**	**Measures & Procedures**	**Key Results/Findings**
Stone, 2014 *USA* Single-site: Gen/Mix ICU	Retrospective Cohort	To determine the duration of hourly neurochecks in ICU patients with TBI and evaluate associations between prolonged hourly monitoring (> 4 days) and clinical outcomes.	*Patients:* n = 124 with TBI: - 50% Mild TBI - 14.4% Mod TBI - 35.5% Severe TBI Mean (range): LOS 10.8d (0–109d) GCS 10.8 (median 12)	Medical records of patients with TBI over a 6-month period were reviewed. Patient characteristics, injury severity scores, and outcome data were collected. Duration of hourly neurochecks were determined for each patient from nursing documentation of GCS. *Definition of "neurocheck":* Not reported – "Sedation pause & focused neurological exam"	n = 89 (72%) received Q1 neurochecks from admission for a mean duration of 67.7h (2.8 days). n = 18 (20.2%) patients underwent Q1 neurochecks for >4 days. These patients had significantly longer hospital LOS (23 vs 9d, p = 0.001). For severe TBI cases, prolonged monitoring (>4 days) associated with longer LOS (26d vs 7d; P = 0.001), even when accounting for surgical intervention (29d vs 7d; p = 0.002); injury & midline shift severity comparable between groups.
Maas, 2015 *USA* Single-site: NScICU	Prospective Cohort	To evaluate whether GCS-based neurochecks detect early neurological change after ICH & examine associations with functional outcomes.	*Patients:* n = 132 with ICH Median (IQR): ICH score 1 (0–3) Initial GCS 14 (9–15) Δ GCS initial 12h 0 (-1– 1)	Baseline GCS assessed by neurologist/neurosurgeon on ICU admission; nurses performed hourly GCS-based neurochecks for up to 5 days post-ICH event. *Definition of "neurocheck":* Not reported – "GCS-based"	Rate of Δ GCS diminished significantly every 3 hours in the first 12 hours (all p <0.05). No significant differences in rate of Δ GCS after 12 hours. Of the 92 (70%) patients who had admission GCS available:

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					n = 25 (27%) GCS worsened n = 43 (47%) had no GCS change n = 24 (26%) GCS improved Δ GCS in the first 12 hours was associated with 3m mRS: OR 0.81 (0.66–0.99)
LaBuzetta, 2022 *USA* Single-service: (n not reported) NScICU; CVICU; Gen/Mix ICU	Retrospective Cohort	To evaluate practices and patterns of hourly neurochecks along with associated clinical outcomes.	9,513 Q1 neurocheck orders across 8,936 hospitalisations Admission diagnosis: - 64% neuro illness - 36% non-neuro illness - 24% unlisted diagnosis	Records of ICU admissions requiring Q1 neurochecks over 75-month period were reviewed to evaluate ordering practices & patterns including order duration, ordering service, and discontinuation practices. *Definition of "neurocheck":* GCS, attention, language, pupils, cough, facial symmetry, pronator drift.	Median (IQR) neurocheck durations: Overall: 1.13d (0.71–2.46d), max 81d 74% orders lasted <3d, 19% lasted ≥3d, & 7% lasted ≥7d Longest duration for patients with SAH (4.68d, max 55d) & ICH (1.81d, max 22d); Lowest for patients with 'other' neuro illness (0.80d, max 38d). Duration longest for orders by non-neuroICU (7%; 1.60d, max 81d) and shortest for NSx (22%, 0.87d, max 65d) Q1h neurocheck discontinuation practices: Transition to Q2-3h: 45%; all neurochecks ceased: 23% Median hospital LOS 4.3d (2.3–9.6d). Each additional day of Q1h neurochecks increased LOS by 1.21d (p <0.001).
Fonseca, 2024 *USA* Single-site: Gen/Mix ICU	Retrospective Cohort	To evaluate the association between Q1h neurocheck duration & delirium development in older adults with mild-mod TBI.	*Patients:* n = 522 >55y with mild–mod TBI - 95% mild TBI - No difference in TBI severity between neurocheck duration groups - 8% intubated	Records of eligible patients were reviewed. Patients were grouped depending on duration of Q1h neurochecks: - Prolonged ≥24 h - Non-prolonged <24 h Delirium diagnosis was determined from positive CAM-ICU. Frequency of neurodeterioration also recorded. *Definition of "neurocheck":* Not reported *Definition of "neurodeterioration":* New focal deficit, pupil abnormality or ≥2 point GCS drop	n = 386 (73.9%) non-prolonged neurochecks (<24 h) n = 136 (26.1%) prolonged neurochecks (≥24 h) n = 78 (14.9%) experienced neurodeterioration (80.8% GCS drop; 19.2% focal deficit; no between-group differences) n = 8 (1.5%) received surgical intervention due to neurodeterioration (no between-group differences) Mean Tt intervention post-deterioration: 70.1 h No emergent interventions post-deterioration (shortest Tt intervention: 11.1 h) n = 48 (9.2%) had evidence of radiological deterioration on subsequent scans; higher incidence in ≥24h group (p <0.003) who underwent more scans (p <0.001) Hospital & ICU LOS longer with prolonged checks (p ≤0.001, p = 0.002, respectively). No between-group differences in ventilator-free days (p = 0.526) Adjusted odds of delirium with ≥24h neurochecks: OR 2.5, 95% CI 1.5–4.3, p <0.001 NNH for delirium with ≥24h neurochecks: 4.2
Brazel, 2024 USA Single-site:	Prospective Cross-sectional	To determine frequency of neurodeterioration across various diagnoses & whether that decline was identified by a scheduled neurocheck, & if it	212 nursing shifts observed *Patients:* most frequent indications: - 22% Elective	Nurses completed a survey at the end of each shift to report if neurodeterioration was detected on their shift, if it was detected during a scheduled hourly check, & if it prompted any change in	Neurodeterioration was detected on 30 (14%) of shifts. 20 (67%) events were detected from scheduled checks, and 10 (33%) from ad hoc assessments

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NScICU		prompted alterations in management.	craniotomy - 22% SAH - 14% Ischaemic stroke - 11% ICH	management. *Definition of "neurocheck":* Level of consciousness, language & speech, cranial nerves, movement & sensation *Definition of "neurodeterioration":* "any worsening"	Of the 20 events detected from scheduled checks, 11 events (55%) did not prompt changes in management. Neurodeterioration significantly more frequent for SAH (residual 3.10) and significantly less frequent for post-elective craniotomy (residual –2.21) Diagnosis not associated with higher frequency of interventions (p = 0.38).
Uncategorised Studies (*n = 2)*					
Study ID *Country & Setting*	**Design** *Analytic Focus (if applicable)*	**Aims**	**Sample Cheracterisitics**	**Measures & Procedures**	**Key Results/Findings**
Hutri, 2022 *Finland* Multi-site: 5 Gen/Mix ICU	Prospective Cross-sectional	To described nurses' self-reported competence in caring for patients with SAH, including assessment & monitoring skills.	*Nurses:* n = 127 nurses	The researchers developed a questionnaire consisting of five background questions & 61 competency statements rated on a 5-point Likert scale, 10 of which pertained to patient monitoring & 5 to assessment of consciousness.	19.6% response rate across 5 sites. Nurses' self-assessed competence (mean ± SD): Assessment of consciousness 4.56 ± 0.52 Monitoring 4.42 ± 0.52 Nurses' perceptions of their competence in assessment of assessment of consciousness & monitoring for patients with SAH were associated with length of experience (p <0.001). No difference in nurses' self-perceptions of competence between hospitals (p >0.05).
Banzon, 2023 *USA* Single-site: CVICU; MICU; SICU	Prospective Cross-sectional	To examine neurological assessment documentation practices in non-neurosciences ICUs.	*Nurses:* not reported *Patients:* n = 120 patients. - 53.3% sedated - 47.5% intubated	Medical records were prospectively examined with frequency of documentation of each of the 7 neurological assessment domains evaluated, namely: - Consciousness, - 'Injury severity' (GCS or NIHSS) - Speech - Cranial nerves (pupils, eye movement, corneal & cough) - Pain - Motor function - Sensory function. Frequency of documentation for each component were compared across the three non-NScICUs.	1,482 assessments were documented over the 7-day study period. Nurses documented considerably more assessments than providers overall and for each domain (p <0.001). Day shift nurses' documentation frequency: All 7 domains n = 168 (43.8%) vs 2 (0.5%) of providers Consciousness n = 377 (98.2%) GCS n = 356 (92.7%) Cranial nerves n = 347 (90.4%) Speech n = 15 (3.9%) Pain n = 255 (66.4%) Motor function n = 328 (85.4%) Sensory function n = 283 (73.7%) Differences in documentation practices for speech, cranial nerve function & pain were found between each sub-speciality ICU (p <0.05), but not for consciousness, 'injury severity', motor function & sensory function.

Table notes: Table 3. Summary of Findings.
Aims/Characteristics: *cEEG* – Continuous Electroencephalography; *qEEG* – Quantitative Electroencephalography; *FOUR* – Full Outline of UnResponsiveness (E – Eye; M – Motor; B – Brainstem; R – Respiratory); *GCS* – Glasgow Coma Scale (E – Eye; M – Motor; V – Verbal); *GOS(E)* – Glasgow Outcome Scale (± Extended); *HIE* – Hypoxic-Ischaemic Encephalopathy; *ICH* – Intracerebral (intraparenchymal) Haemorrhage; *IRR* – Interrater Reliability; *NCS* – Non-Convulsive Seizures; *NPhys* – Neurophysiologist; *PLR* – Pupillary Light Reflex; *RASS* – Richmond Agitation Sedation Scale; *SAS* – Ramsay Sedation Agitation Scale; *TBI* – Traumatic Brain Injury; *SAH* – Subarachnoid Haemorrhage; SDH – Subdural Haemorrhage.
Setting: *CVICU* – Cardiovascular ICU; *ED* – Emergency Department; *Gen/Mix ICU* – General ICU or unclear; *MICU* – Medical ICU; *NScICU* – Neurosciences ICU; *SICU* – Surgical ICU.
Findings: *Acc.* – Accuracy; *AUROC* – Area Under the Receiver Operating Characteristic Curve; *ICC* – Intraclass Correlation Coefficient; *K(w)* – Cohen's Kappa (± weighted); *Kf* – Fleiss' Kappa; *LoA* – Limits of Agreement; *LOS* – Length of Stay; *Kripp. a* – Krippendorff's alpha; *NIHSS* – National Institutes of Health Stroke Scale; *Non-neuroICU* – Non-neurosciences ICU; *NNH* – Number Needed to Harm; *NSx* – Neurosurgery; *Se* – Sensitivity; *Sp* – Specificity.
Methods: *IIC* – Interictal Continuum; NPhys – Neurophysiologist; *PLR* – Pupillary Light Reflex.
qEEG types: *aEEG* – Amplitude integrated EEG; *Asymm.I* – Asymmetry Index; *(C)DSA* – (± Colour) Density Spectral Array; *Rhythm.spect.* – Rhythmicity Spectrogram.
Timepoints: min (minute/s), h (hour/s), d (day/s), m (month/s), y (year/s), Q1h – Hourly.

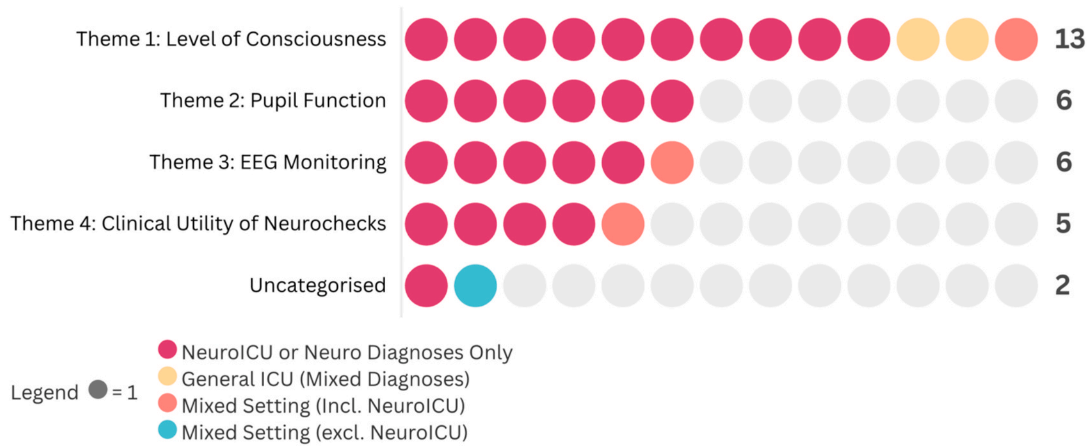

Fig. 2. Distribution of Studies Across Research Themes and Clinical Contexts.

showing similar patterns of slight underestimation. Agreement was high for pupillary light reflex (PLR) assessment, with percent agreement ranging from 82% [36] to 97.7% [58]. False negative rates (i.e., absent PLR not detected by nurses) were low (≤1.5%) in two studies [53,58], but substantially higher in another (18.4% [36]). One study [36] measured agreement between nurses' and pupilometer measurements in detecting anisocoria, with nurses missing 15 of 30 anisocoria cases.

The feasibility of nurse-performed pupillometry was explored in two studies: one longitudinal study [34] used surveys to evaluate nurses' knowledge and satisfaction with pupillometers, while one qualitative study [40] explored nurses' experiences in using the device. Both studies found nurses considered pupillometry a useful adjunct, valued for its objectivity, convenience, and support in decision-making. The longitudinal study [34] found nurses' knowledge and satisfaction with pupillometers remained high (mean satisfaction scores ≥ 8 out of 10). Preference for assessment using the pupillometer increased ($p = 0.02$), but was not overwhelmingly preferred. The qualitative study [40] reported nurses were generally comfortable using pupillometers (mean comfort rating 3.78 out of 5), with focus group discussions finding nurses perceived pupillometry as useful in confirming concerning findings, often prompting manual reassessment in dimmer lighting or sedation titration. Concerns centred around potential overshadowing of clinical judgement, variability in readings, and inconsistent engagement from medical staff.

The final relevant study investigated the IRR of pupil size, symmetry, and reactivity between nurse–nurse-researcher pairs [47]. The IRR was adequate for pupil size and PLR, but poor for symmetry (Fleiss' $K = 0.58$), though this estimate may be artificially low due to kappa paradox [61].

Research Theme 3: Nurse-Led Monitoring of Electroencephalography in ICU settings

Research within this theme examined the feasibility of nurse-led EEG monitoring in ICU settings, including nurses' ability to detect non-convulsive seizures using quantitative EEG (qEEG) displays and the role of training in supporting nurses to assess and manage burst suppression. Quantitative EEG involves computational processing of continuous EEG (cEEG) data into time-compressed displays suitable for monitoring by non-neurophysiologists [62]. Six studies explored the feasibility of nurse-led EEG monitoring in ICU settings [33,37,44,45,56,60]. All such studies were conducted in neuroscience ICUs in the USA, except for one study from Turkey [37]. Five studies [33,37,44,45,60] investigated ICU nurses' accuracy in detecting non-convulsive seizures (NCS) from qEEG displays. In these studies, the number of nurse assessors ranged from two to 65 nurses. In three studies [33,37,60], nurses reviewed qEEG panels from post-hoc transformations of archived cEEG data. Two studies [44,45] investigated real-time NCS detection by nurses with bedside qEEG; one study included any patient undergoing cEEG, the other included only those with prior NCS. The qEEG display type varied, though neurophysiologists' review of cEEG served as the reference standard in all studies.

Four studies reported moderate-to-excellent accuracy for nurses' detection of NCS, with sensitivity and specificity estimates exceeding 0.70 [37,44,45,60], while one study [33] reported markedly lower specificity (0.38), consistent with the researchers' deliberate selection of high-complexity qEEG panels. One study [44] evaluating real-time nurse-led qEEG monitoring found nurses detected NCSs 132 min earlier, on average, compared to standard neurophysiologist review ($HR = 6.96$, 95%CI 1.31–36.9, $p = 0.023$).

The final relevant study examined the efficacy of an educational programme in preparing neuroscience ICU nurses to perform cEEG monitoring [56], including monitoring and management of burst suppression (an EEG pattern characterised by alternating high-amplitude activity and periods of isoelectric silence [63]). Therapeutic burst suppression, achieved with deep sedation, is used for neuroprotective effects in acute brain injury [64]. Amongst the nine participating nurses, mean test scores and confidence levels increased after training ($p < 0.001$) and were retained at 6 months.

Research Theme 4: The Clinical Utility of Hourly Neurological Assessments

Research within this theme examined the clinical utility of hourly neurological assessments (neurochecks) in ICU settings, including associations between surveillance duration and patient outcomes, and the diagnostic yield in detecting neurological deterioration. Of the five observational cohort studies [35,39,48,49,59] investigating various dimensions of the clinical utility of hourly neurological assessment in ICUs, all studies were conducted in the USA and predominantly included patients with neurocritical conditions. Only two studies [35,48] detailed what domains were assessed; common elements included assessment of consciousness, language, cranial nerves and motor functions. Only one study [59] described pausing sedation before neurochecks.

Three retrospective cohort studies [39,48,59] examined associations between the duration of hourly neurochecks and patient outcomes, with longer durations consistently associated with unfavourable outcomes after adjustment for injury severity. The largest study [48] with data from 8,936 hospitalisations across multiple ICUs at a single-centre, reported a median hourly neurocheck duration of 1.13 days; 19% of orders exceeded 3 days, and 7% lasted 7 days or longer. Each additional day of hourly neurochecks was associated with a 1.21-day increase in hospital length of stay (LOS; $p < 0.001$). Considerable variability in de-escalation practices was described; most patients (45%) transitioned to 2–3 hourly checks while 23% had surveillance ceased entirely. A second study [59] involving 124 patients with mixed TBI severities reported a mean neurocheck duration of 2.8 days. Hourly monitoring exceeding 4 days was associated with longer hospital LOS when accounting for injury severity. The third study [39], involving 522 older adults with mild-to-moderate TBI, compared patients receiving prolonged ($\geq$24 h) versus non-prolonged (<24 h) neurochecks. Neurodeterioration occurred in 14.9% of patients but rarely prompted neurosurgical intervention (1.5%), with no between-group differences. Radiological deterioration was more frequent in the prolonged-neurocheck group, who underwent more scans despite few differences in injury characteristics. The incidence of delirium was higher in the prolonged-monitoring group, who also had longer hospital and ICU LOS (all $p < 0.05$). Prolonged neurocheck duration, and not injury severity, was independently associated with development of delirium in adjusted models.

Two prospective studies focused on the diagnostic yield of neurochecks. The first study [49] evaluated "GCS-based" neurochecks in the acute phase of intracerebral haemorrhage. The frequency of neurological changes declined significantly across each successive 3-hour interval following admission ($p < 0.05$), with no significant differences observed beyond 12 hours. During this hyperacute period, 27% of patients' GCS decreased and 47% had no change. The second study [35] observed 212 nursing shifts, finding neurodeterioration in 20 shifts (14%), most often during scheduled hourly checks (9.4%), rather than ad hoc assessments (4.7%; $p < 0.01$). Interventions were prompted by neurodeterioration detected from scheduled checks in nine shifts (4.3%). Neurodeterioration occurred more often for patients with SAH and less often for patients post elective craniotomy although diagnosis was not associated with differences in the frequency of interventions.

Uncategorised Studies

Two studies' foci did not align with the identified research themes: a survey of nurses self-perceived competence in caring for patients with SAH [42], and a study examining neurological assessment documentation practices in non-neuroscience ICUs [9]. The survey study found nurses rated their competence in assessing consciousness as 'very good' [42]. Greater nursing experience was associated with higher perceived competence, with no differences observed between the five sites. The final study prospectively reviewed documentation of neurological assessment across non-neuroscience ICUs in a single centre [9], finding nurses documented more assessments than medical staff ($p < 0.001$). Documentation of consciousness and cranial nerve functions were frequent (>80% of assessments), whereas motor and sensation were documented less often (<60%). Significant variation was observed between ICU sub-specialties in documentation of speech, cranial nerve functions, and pain.

Discussion

We sought to describe the scope and nature of evidence relevant to nurse-performed neurological assessment in adult ICU settings. This review found the evidence base is low in volume and concentrated within four dominant research themes: nurses' assessment of consciousness level, assessment of pupils, monitoring of EEG, and the clinical utility of hourly neurochecks. Across studies, there was significant variation in the specific aims, populations, methods and outcome measures, which precluded meaningful comparisons of findings within research themes.

The reviewed evidence base was geographically and clinically concentrated, limiting insight into neurological assessment practices across broader ICU populations. Almost half of included studies were conducted in the USA, with only sporadic representation from other high-income countries. A third of studies were from LMICs in West Asia and North Africa, where clinical resources and educational opportunities may differ. Additionally, a large majority of studies were conducted either in neuroscience ICUs or exclusively in patients with acute brain injury. Very few studies involved patients with non-neurological conditions, and only one focused on patients with non-neurological conditions exclusively. Consequently, this evidence base offers a limited understanding of assessment practices in general or mixed cohorts. Moreover, very few studies compared findings across ICU sub-specialties, limiting insight into the comparability of practices between neuroscience ICUs and general/other ICUs. Accordingly, findings should be interpreted as context-specific rather than generalisable across ICU settings.

Assessment of consciousness was the most frequently studied theme, although studies were clinically and methodologically heterogeneous. Most studies were conducted in LMICs and compared the psychometric performance of nurse-assessed GCS and FOUR scores in neuroscience ICU settings or in patients with neurocritical conditions exclusively. However, the psychometric domains examined and specific populations varied. Findings generally favoured the FOUR score, as consistent with recent systematic reviews of ICU studies amongst mixed assessor groups [65,66]. Estimates of IRR were high for the FOUR score but less consistent for the GCS. Higher GCS estimates were reported where nurses received instruction immediately prior to assessment, echoing patterns observed across broader literature evaluating reliability amongst various ICU clinician-assessors, with acceptable IRR estimates limited to studies assessing the FOUR score concurrently following instruction [67,68]. Notably, under contemporary psychometric validation criteria [30], no study has reported adequate GCS reliability in ICU settings when assessed in isolation and without assessor preparation [65,67,69]. Threshold-dependent estimates of predictive accuracy favoured the FOUR score, also aligning with broader ICU literature [65,66,68]. However, included studies involved large proportions of alert and/or unsedated patients, introducing ceiling effects that may favour the GCS whilst obscuring the strengths of the FOUR score typically revealed in cohorts with moderate-to-severe impairments. Given these limitations, the psychometric performance and clinical utility of nurse-assessed GCS and FOUR score in ICU settings remains unclear. Further investigation under naturalistic conditions is needed, especially amongst general/other ICU cohorts.

Few studies investigated the accuracy and reliability of nurses' assessments of pupil function. All studies investigating nurses' use of pupilometers, or accuracy of visual inspections compared to pupillometers, were conducted in neuroscience ICUs. These studies found nurses consistently underestimated pupil size by 0.2–0.4 mm compared to pupillometer readings [36,53,58], although the clinical significance of this discrepancy remains unclear. Both IRR amongst nurse-assessors and agreement with pupillometer readings was high for pupil reactivity but potentially inadequate in detecting anisocoria. Acceptability of pupillometry amongst neuroscience ICU nurses was nuanced [34,40], with perceived benefits of objective confirmation for concerning findings tempered by low medical engagement and uncertain clinical significance. The precision and accuracy of nurses' pupil assessments in broader ICU settings remains uncertain.

Findings were more consistent amongst studies examining nurses' detection of non-convulsive seizures using qEEG, with all reporting at least adequate diagnostic accuracy. Reviewed evidence suggests nurse-led EEG monitoring may expedite NCS detection [33,37,44,45,60] and support management of burst suppression [56]. Closer monitoring of EEG could be especially beneficial in this setting, as prolonged or unintentional suppression from excessive sedation may adversely affect cerebral autoregulation, risking secondary injury and poor neurological outcomes [63,70]. Like the other themes described in this review, this evidence was limited mostly to studies conducted in neuroscience ICU settings. Nevertheless, reviewed findings align with systematic reviews and *meta*-analyses also supporting the technical feasibility of nurse-performed EEG monitoring in ICUs [71,72], although clinical efficacy and acceptability amongst ICU clinicians have not yet been established.

In contrast, findings from observational studies do not support sustained hourly neurochecks beyond the hyperacute phase of neurological injury, given potentially low diagnostic yield and associated risks [35,39,48,49,59]. Neurodeterioration requiring intervention is uncommon, and prolonged intensive monitoring may not yield clinically meaningful diagnostic returns [35,39,49]. Radiological deterioration was not associated with clinical neurodeterioration or surgical interventions, likely reflecting expected radiographic evolution and surveillance bias rather than clinically significant worsening [35,39]. Prolonged hourly neurochecks are independently associated with increased ICU and hospital LOS and higher delirium risk, without improving neurological outcomes [39,48,49,59]. Complementary evidence has described physiological mechanisms that may explain these associations: neurochecks may elicit an immediate physiological stress response, elevating cortisol and catecholamines [73], while sleep disruption impairs sleep-dependent glymphatic clearance of neurotoxic metabolites [74], as implicated in delirium and neurodegenerative conditions [75]. Collectively, these findings suggest the duration and intensity of neurochecks warrant careful consideration, as prolonged intensive surveillance may confer iatrogenic harms without clear diagnostic or therapeutic benefit. Further research evaluating the risks and benefits of intensive neurochecks is needed to inform the development of risk-stratified monitoring protocols.

Strengths and Limitations

This scoping review has several distinguishing strengths: it was designed and conducted in accordance with established methodological guidance [16–20], and integrated design elements to enhance rigour. Nevertheless, this review is not without limitations. The conceptual breadth of this topic necessitated detailed, specific search strategies, and some relevant studies may have been missed. As the review aimed to map current evidence, searches were limited to reports published from 2014; therefore, review findings are not exhaustive, and relevance extends only to contemporary practice. Additionally, including only English-language studies may have introduced a language bias.

Notably, the purpose of scoping reviews is to characterise the evidentiary landscape surrounding a broader topic [76]. Their value lies in revealing evidence gaps that direct high-quality research, rather than synthesising effect sizes and appraising quality [18–20,76]. Accordingly, this review describes only the overall direction of relevant findings and does not constitute a definitive critical synthesis intended to guide practice [18].

The most notable limitation of reviewed evidence is the lack of studies conducted in non-neuroscience ICUs and/or involving patients with non-neurological primary diagnoses. Therefore, most findings are specific to neurocritical care cohorts and may not be generalisable to broader ICU populations. Additionally, although formal quality appraisal was not undertaken, the included studies collectively reflect a fragmented evidence base characterised by methodological and operational heterogeneity, potential case-mix artefact, and weak ecological validity, given the predominance of controlled conditions over naturalistic settings. Furthermore, limited attention to statistical power and potential confounders constrain interpretation of findings and highlight the need for more rigorous and conceptually coherent research in this area. Overall, relevant evidence remains incohesive, context-bound, and likely of very low certainty. Therefore, the current evidence base does not yet provide a sufficient foundation for more focused evidence syntheses capable of informing meaningful recommendations for practice or robust evidence-based clinical guidelines.

Implications for Future Research

This review identified several areas for prioritisation in future research:

- The psychometric performance of nurse-assessed GCS and FOUR scores in ICU settings, including non-neurocritical and mixed cohorts, and sedated patients.
- The accuracy of nurses' assessment of pupils and cranial nerves.
- Nurse-led EEG monitoring and management of non-convulsive seizures and burst suppression.
- The clinical utility of hourly neurochecks, including evaluation of associated risks adjusted for illness severity.

Uncertainty regarding the reliability and validity of core nursing neurological assessment practices remains the central issue identified in this review. Such uncertainty may constrain meaningful exploration of clinical decision support systems and artificial intelligence-assisted approaches in future research, as these technologies depend on stable and clearly defined underlying constructs. In the interim, nursing education has an important role in supporting ICU nurses to strengthen theoretical knowledge and technical assessment skills to support more consistent understanding and application of neurological assessment when caring for critically ill adults.

Conclusions

This scoping review of research on nursing neurological assessment in adult ICU settings revealed an evidence base of limited empirical maturity. Current evidence is constrained within narrow empirical foci characterised by substantial heterogeneity in aims, methods, and clinical context. Consequently, this evidence base lacks the volume, coherence, and convergence required for higher-order syntheses from which practice-oriented conclusions may be drawn. Further rigorous inquiry is urgently needed to verify the reliability, validity, and clinical utility of existing practices and guide refinements that balance necessary vigilance with meaningful clinical outcomes. Such refinements must be responsive to the complex needs of the critically ill adult and grounded in the expertise of the specialist intensive care nurse.

Registration

The protocol for this review was registered prospectively on Open Science Registries: https://doi.org/10.17605/OSF.IO/JFCNG.

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Ethics Statement

This manuscript adheres to the Committee on Publication Ethics ethical guidelines. As this paper reports the findings of a scoping review, institutional and/or national human research ethics board approval was not required.

CRediT authorship contribution statement

Jaime E. Schey: Writing – original draft, Visualization, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Debra Kerr:** Writing – review & editing, Visualization, Validation, Supervision, Methodology, Investigation, Conceptualization. **Claire Crossfield:** Writing – review & editing, Validation, Investigation. **Glenna Mae Guiriba:** Writing – review & editing, Validation, Investigation. **Tracey**

Bucknall: Writing – review & editing, Visualization, Validation, Supervision, Methodology, Investigation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.iccn.2026.104398.

References

[1] Rubinos C, Ruland S. Neurologic Complications in the Intensive Care Unit. Curr Neurol Neurosci Rep 2016;16(6):57. https://doi.org/10.1007/s11910-016-0651-8.
[2] Sharshar T, Citerio G, Andrews PJD, Chieregato A, Latronico N, Menon DK, et al. Neurological examination of critically ill patients: a pragmatic approach. Report of an ESICM expert panel. Intensive Care Med 2014;40(4):484–95. https://doi.org/10.1007/s00134-014-3214-y.
[3] Billington ME, Seethala RR, Hou PC, Takhar SS, Askari R, Aisiku IP. Differences in prevalence of ICU protocols between neurologic and non-neurologic patient populations. J Crit Care 2019;52:63–7. https://doi.org/10.1016/j.jcrc.2019.03.002.
[4] Réa-Neto Á, Bernardelli RS, de Oliveira MC, David-João PG, Kozesinski-Nakatani AC, Falcão ALE, et al. Epidemiology and disease burden of patients requiring neurocritical care: a Brazilian multicentre cohort study. Sci Rep 2023;13(1):18595. https://doi.org/10.1038/s41598-023-44261-w.
[5] Tan SC, Evans T, Durie ML, Secombe PJ, Pilcher D. Mortality among people admitted to Australian intensive care units for reasons other than COVID-19 during the COVID-19 pandemic: a retrospective cohort study. Med J Aust 2023;218(10):467–73. https://doi.org/10.5694/mja2.51933.
[6] Frontera JA. Metabolic encephalopathies in the critical care unit. Continuum 2012;18(3):611–39. https://doi.org/10.1212/01.CON.0000415431.07019.c2.
[7] Noda K, Koga M, Toyoda K. Recognition of strokes in the ICU: a Narrative Review. Journal of Cardiovascular Development and Disease 2023;10(4). https://doi.org/10.3390/jcdd10040182.
[8] Wijdicks EFM. The Comatose Patient. Second edition. ed: Oxford University Press; 2014.
[9] Banzon PC, Vashisht A, Euckert M, Nairon E, Aiyagari V, Stutzman SE, et al. Practice Variations in Documenting Neurologic Examinations in Non-Neuroscience ICUs. Am J Nurs 2023;123(1):24–30. https://doi.org/10.1097/01.NAJ.0000905564.83124.2d.
[10] Livesay SL. The Bedside Nurse: the Foundation of Multimodal Neuromonitoring. Crit Care Nurs Clin North Am 2016;28(1):1–8. https://doi.org/10.1016/j.cnc.2015.10.002.
[11] Musick S, Alberico A. Neurologic Assessment of the Neurocritical Care Patient. Front Neurol 2021;Volume:12–2021. https://doi.org/10.3389/fneur.2021.588989.
[12] Devlin JW, Skrobik Y, Gélinas C, Needham DM, Slooter AJC, Pandharipande PP, et al. Clinical Practice guidelines for the Prevention and Management of Pain, Agitation/Sedation, Delirium, Immobility, and sleep Disruption in Adult patients in the ICU. Crit Care Med 2018;46(9):e825. https://doi.org/10.1097/ccm.0000000000003299.
[13] Halverson CC, Scott TD. Nursing surveillance: a concept analysis. Nurs Forum 2022;57(3):454–60. https://doi.org/10.1111/nuf.12702.
[14] Kim Y, Kim Y, Kim J, Choi M. Nursing surveillance for clinical deterioration among intensive care unit patients: a scoping review. Intensive and Critical Care Nursing 2026;92:104218. https://doi.org/10.1016/j.iccn.2025.104218.
[15] Campbell WWJ, Barohn RJ. DeJong's the neurologic examination. Eighth edition. ed: Lippincott Williams & Wilkins; 2020.
[16] Arksey H, O'Malley L. Scoping studies: towards a methodological framework. Int J Soc Res Methodol 2005;8(1):19–32. https://doi.org/10.1080/1364557032000119616.
[17] Khalil H, Peters M, Godfrey CM, McInerney P, Soares CB, Parker D. An Evidence-based Approach to Scoping Reviews. Worldviews Evid Based Nurs 2016;13(2):118–23. https://doi.org/10.1111/wvn.12144.
[18] Munn Z, Peters MDJ, Stern C, Tufanaru C, McArthur A, Aromataris E. Systematic review or scoping review? Guidance for authors when choosing between a systematic or scoping review approach. BMC Med Res Method 2018;18(1):143. https://doi.org/10.1186/s12874-018-0611-x.
[19] Peters MDJ, Godfrey CM, Khalil H, McInerney P, Parker D, Soares CB. Guidance for conducting systematic scoping reviews. JBI Evidence Implementation 2015;13(3). https://journals.lww.com/ijebh/fulltext/2015/09000/guidance_for_conducting_systematic_scoping_reviews.5.aspx.
[20] Peters MDJ, Marnie C, Tricco AC, Pollock D, Munn Z, Alexander L, et al. Updated methodological guidance for the conduct of scoping reviews. JBI Evidence Synth 2020;18(10):2119–26. https://doi.org/10.11124/jbies-20-00167.
[21] Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D, et al. PRISMA Extension for Scoping Reviews (PRISMA-ScR): Checklist and Explanation. Ann Intern Med 2018;169(7):467–73. https://doi.org/10.7326/m18-0850 %m 30178033.
[22] Adams AMN, Chamberlain D, Brun Thorup C, Maiden MJ, Waite C, Dafny HA, et al. Patient Agitation in the Intensive Care Unit: a Concept Analysis. J Adv Nurs 2025. https://doi.org/10.1111/jan.17000.
[23] Adams AMN, Chamberlain D, Grønkjær M, Brun Thorup C, Conroy T. Nonpharmacological interventions for agitation in the adult intensive care unit: a systematic review. Aust Crit Care 2023;36(3):385–400. https://doi.org/10.1016/j.aucc.2022.02.005.
[24] Lewis K, Balas MC, Stollings JL, McNett M, Girard TD, Chanques G, et al. A Focused Update to the Clinical Practice guidelines for the Prevention and Management of Pain, anxiety, Agitation/Sedation, Delirium, Immobility, and sleep Disruption in Adult patients in the ICU. Crit Care Med 2025;53(3):e711. https://doi.org/10.1097/ccm.0000000000006574.
[25] Pollock D, Evans C, Menghao Jia R, Alexander L, Pieper D, Brandão de Moraes É, et al. "How-to": scoping review? J Clin Epidemiol 2024;176:111572. https://doi.org/10.1016/j.jclinepi.2024.111572.
[26] Pollock D, Peters MDJ, Khalil H, McInerney P, Alexander L, Tricco AC, et al. Recommendations for the extraction, analysis, and presentation of results in scoping reviews. JBI Evidence Synth 2023;21(3):520–32. https://doi.org/10.11124/jbies-22-00123.
[27] Bland JM, Altman DG. Statistical methods for assessing agreement between two methods of clinical measurement. Lancet 1986;1(8476):307–10.
[28] Mandrekar JN. Receiver operating characteristic curve in diagnostic test assessment. J Thorac Oncol 2010;5(9):1315–6. https://doi.org/10.1097/JTO.0b013e3181ec173d.
[29] McHugh ML. Interrater reliability: the kappa statistic. Biochem Med (zagreb) 2012;22(3):276–82.
[30] Mokkink LB, Terwee CB, Patrick DL, Alonso J, Stratford PW, Knol DL, et al. The COSMIN checklist for assessing the methodological quality of studies on measurement properties of health status measurement instruments: an international Delphi study. Qual Life Res 2010;19(4):539–49. https://doi.org/10.1007/s11136-010-9606-8.
[31] Ahamed ST, Ebraheim MN. Glasgow Coma Scale technique: effect of theoretical and practical educational program on nurses' compliance. Journal of Nursing and Health Science 2017;6(3):21–8.
[32] Al-Quraan H, AbuRuz ME. Assessment of Jordanian Nurses' Knowledge to Perform Glasgow Coma Scale. European Scientific Journal, ESJ 2016;12(27). https://doi.org/10.19044/esj.2016.v12n27p208.
[33] Amorim E, Williamson CA, Moura LMVR, Shafi MM, Gaspard N, Rosenthal ES, et al. Performance of Spectrogram-based Seizure Identification of Adult EEGs by critical Care Nurses and Neurophysiologists. J Clin Neurophysiol 2017;34(4):359–64. https://doi.org/10.1097/WNP.0000000000000368.
[34] Anderson M, Elmer J, Shutter L, Puccio A, Alexander S. Integrating Quantitative Pupillometry into Regular Care in a Neurotrauma Intensive Care Unit. J Neurosci Nurs 2018;50(1):30–6. https://doi.org/10.1097/JNN.0000000000000333.
[35] Brazel M, Harris J, Carroll D, Davidson J, Levchak PJ, Malhotra A, et al. Reporting on Neurological Decline as Identified by Hourly Neuroassessments. J Neurosci Nurs 2024;56(4):118–22. https://doi.org/10.1097/JNN.0000000000000765.
[36] Couret D, Boumaza D, Grisotto C, Triglia T, Pellegrini L, Ocquidant P, et al. Reliability of standard pupillometry practice in neurocritical care: an observational, double-blinded study. Crit Care 2016;20:1–9. https://doi.org/10.1186/s13054-016-1239-z.
[37] Dericioglu N, Yetim E, Bas DF, Bilgen N, Caglar G, Arsava EM, et al. Non-expert use of quantitative EEG displays for seizure identification in the adult neuro-intensive care unit. Epilepsy Res 2015;109:48–56. https://doi.org/10.1016/j.eplepsyres.2014.10.013.
[38] Enriquez CM, Chisholm KH, Madden LK, Larsen AD, de Longpré T, Stannard D. Glasgow Coma Scale: Generating Clinical Standards. J Neurosci Nurs 2019;51(3):142–6. https://doi.org/10.1097/JNN.0000000000000448.
[39] Fonseca RA, Canas M, Diaz L, Aldana JA, Afzal H, De Filippis A, et al. Prolonged hourly neurological examinations are associated with increased delirium and no discernible benefit in mild/moderate geriatric traumatic brain injury. J Trauma Acute Care Surg 2024;97(1):105–11. https://doi.org/10.1097/ta.0000000000004296.
[40] Giamarino K, Reynolds SS. Pupillometry in neurocritical care. Nursing 2022;52(7):41–4. https://doi.org/10.1097/01.NURSE.0000832328.45947.ec.
[41] Andualem H, Beyene T, Tuli W. Knowledge and Practice about Glasgow Coma Scale Assessment among Nurses Working in Adult Intensive Care units of Federal Public Hospitals in Addis Ababa, Ethiopia: a Cross-Sectional Study. Ethiop J Health Sci 2022;32(5):895–904. https://doi.org/10.4314/ejhs.v32i5.4.
[42] Hutri I, Kotila J, Turunen H. Registered nurses' competence for subarachnoid haemorrhage patients in intensive care units. Br J Neurosci Nurs 2022;18:S12. https://doi.org/10.12968/bjnn.2022.18.Sup5.S12.
[43] Jalali R, Rezaei M. A comparison of the glasgow coma scale score with full outline of unresponsiveness scale to predict patients' traumatic brain injury outcomes in

intensive care units. Critical Care Research & Practice 2014:289803. https://doi.org/10.1155/2014/289803.
[44] Kaleem S, Kang JH, Sahgal A, Hernandez CE, Sinha SR, Swisher CB. Electrographic Seizure Detection by Neuroscience Intensive Care Unit Nurses via Bedside Real-Time Quantitative EEG. Neurology Clinical Practice 2021;11(5):420–8. https://doi.org/10.1212/CPJ.0000000000001107.
[45] Kang JH, Sherill GC, Sinha SR, Swisher CB. A Trial of Real-Time Electrographic Seizure Detection by Neuro-ICU Nurses using a Panel of Quantitative EEG Trends. Neurocrit Care 2019;31(2):312–20. https://doi.org/10.1007/s12028-019-00673-z.
[46] Kebapçı A, Dikeç G, Topçu S. Interobserver Reliability of Glasgow Coma Scale Scores for Intensive Care Unit patients. Crit Care Nurse 2020;40(4):e18–26. https://doi.org/10.4037/ccn2020200.
[47] A. Kebapcı S. Topçu Interrater reliability in pupillary assessment among intensive care nurses Intensive Crit Care Nurs 58 2020 N .PAG–N.PAG 10.1016/j.iccn.2020.102801.
[48] LaBuzetta JN, Hirshman BR, Malhotra A, Owens RL, Kamdar BB. Practices and patterns of Hourly Neurochecks: Analysis of 8,936 patients with Neurological Injury. J Intensive Care Med 2022;37(6):784–92. https://doi.org/10.1177/08850666211029220.
[49] Maas MB, Berman MD, Guth JC, Liotta EM, Prabhakaran S, Naidech AM. Neurochecks as a Biomarker of the Temporal Profile and Clinical Impact of Neurologic changes after Intracerebral Hemorrhage. J Stroke Cerebrovasc Dis 2015;24(9):2026–31. https://doi.org/10.1016/j.jstrokecerebrovasdis.2015.04.045.
[50] Momenyan S, Mousavi SM, Dadkhahtehrani T, Sarvi F, Heidarifar R, Kabiri F, et al. Predictive Validity and Inter-Rater Reliability of the Persian Version of Full Outline of Unresponsiveness among Unconscious patients with Traumatic Brain Injury in an Intensive Care Unit. Neurocrit Care 2017;27(2):229–36. https://doi.org/10.1007/s12028-016-0324-0.
[51] Nyam T-T, Ao K-H, Hung S-Y, Shen M-L, Yu T-C, Kuo J-R, et al. FOUR score Predicts Early Outcome in patients after Traumatic Brain Injury. Neurocrit Care 2017;26(2):225–31. https://doi.org/10.1007/s12028-016-0326-y.
[52] Oh H, Shin S, Kim S, Seo W. Construct validity and reliability of the Full Outline of UnResponsiveness (FOUR) score in spontaneous subarachnoid haemorrhage caused by aneurysm rupture. J Clin Nurs 2019;28(21–22):3776–85. https://doi.org/10.1111/jocn.14877.
[53] Olsen MH, Jensen HR, Ebdrup SR, Topp NH, Strange DG, Møller K, et al. Automated pupillometry and the FOUR score - what is the diagnostic benefit in neurointensive care? Acta Neurochir 2020;162(7):1639–45. https://doi.org/10.1007/s00701-020-04381-y.
[54] Özçelik EE, Celik S. Comparison of the Turkish versions of the Glasgow coma scale and four score used by intensive care nurses for neurological evaluation. Journal of Clinical Nursing (john Wiley & Sons, Inc) 2022;31(9/10):1397–406. https://doi.org/10.1111/jocn.16001.
[55] Peng J, Deng Y, Chen F, Zhang X, Wang X, Zhou Y, et al. Validation of the chinese version of the FOUR score in the assessment of neurosurgical patients with different level of consciousness. BMC Neurol 2015;15(1):254. https://doi.org/10.1186/s12883-015-0508-9.
[56] Picinich C, Kennedy J, Thind H, Foreman C, Martin RM, Zimmermann LL. Continuous Electroencephalographic Training for Neuroscience Intensive Care Unit Nurses: a Feasibility Study. J Neurosci Nurs 2020;52(5):245–50. https://doi.org/10.1097/JNN.0000000000000535.
[57] Sepahvand E, Jalali R, Mirzaei M, Ebrahimzadeh F, Ahmadi M, Amraii E. Glasgow Coma Scale Versus Full Outline of UnResponsiveness Scale for Prediction of Outcomes in patients with Traumatic Brain Injury in the Intensive Care Unit. Turk Neurosurg 2016;26(5):720–4. https://doi.org/10.5137/1019-5149.JTN.13536-14.0.
[58] Smith J, Flower O, Tracey A, Johnson P. A comparison of manual pupil examination versus an automated pupillometer in a specialised neurosciences intensive care unit. Aust Crit Care 2020;33(2):162–6. https://doi.org/10.1016/j.aucc.2019.04.005.
[59] Stone JJ, Childs S, Smith LE, Battin M, Papadakos PJ, Huang JH. Hourly neurologic assessments for traumatic brain injury in the ICU. Neurol Res 2014;36(2):164–9. https://doi.org/10.1179/1743132813Y.0000000285.
[60] Swisher CB, White CR, Mace BE, Dombrowski KE, Husain AM, Kolls BJ, et al. Diagnostic Accuracy of Electrographic Seizure Detection by Neurophysiologists and Non-Neurophysiologists in the Adult ICU using a Panel of Quantitative EEG Trends. Journal of Clinical Neurophysiology : Official Publication of the American Electroencephalographic Society 2015;32(4):324–30. https://doi.org/10.1097/WNP.0000000000000144.
[61] Derksen BM, Bruinsma W, Goslings JC, Schep NWL. The Kappa Paradox Explained. J Hand Surg Am 2024;49(5):482–5. https://doi.org/10.1016/j.jhsa.2024.01.006.
[62] Hwang J, Cho S-M, Ritzl EK. Recent applications of quantitative electroencephalography in adult intensive care units: a comprehensive review. J Neurol 2022;269(12):6290–309. https://doi.org/10.1007/s00415-022-11337-y.
[63] Hogan J, Sun H, Aboul Nour H, Jing J, Tabaeizadeh M, Shoukat M, et al. Burst suppression: Causes and Effects on Mortality in critical Illness. Neurocrit Care 2020;33(2):565–74. https://doi.org/10.1007/s12028-020-00932-4.
[64] Alkhachroum A, Appavu B, Egawa S, Foreman B, Gaspard N, Gilmore EJ, et al. Electroencephalogram in the intensive care unit: a focused look at acute brain injury. Intensive Care Med 2022;48(10):1443–62. https://doi.org/10.1007/s00134-022-06854-3.
[65] Brun FK, Fagertun VH, Larsen MH, Solberg MT. Comparison of Glasgow Coma Scale and Full Outline of UnResponsiveness score to assess the level of consciousness in patients admitted to intensive care units and emergency departments: a quantitative systematic review. Aust Crit Care 2025;38(1):101057. https://doi.org/10.1016/j.aucc.2024.03.012.
[66] Schey JE, Schoch M, Kerr D. The Predictive Validity of the Full Outline of UnResponsiveness score Compared to the Glasgow Coma Scale in the Intensive Care Unit: a Systematic Review. Neurocrit Care 2024. https://doi.org/10.1007/s12028-024-02150-8.
[67] Reith FC, Van den Brande R, Synnot A, Gruen R, Maas AI. The reliability of the Glasgow Coma Scale: a systematic review. Intensive Care Med 2016;42(1):3–15. https://doi.org/10.1007/s00134-015-4124-3.
[68] Schey JE. The predictive validity of the Glasgow Coma Scale and the Full Outline of UnResponsiveness Score in the intensive care unit: A systematic review [Master's Thesis]: Deakin University; 2023 https://dro.deakin.edu.au/articles/thesis/The_predictive_validity_of_the_Glasgow_Coma_Scale_and_the_full_outline_of_UnResponsiveness_Score_in_the_intensive_care_unit_A_systematic_review/30816953.
[69] Kornbluth J, Bhardwaj A. Evaluation of Coma: a critical Appraisal of Popular Scoring Systems. Neurocrit Care 2011;14(1):134–43. https://doi.org/10.1007/s12028-010-9409-3.
[70] Andresen JM, Girard TD, Pandharipande PP, Davidson MA, Ely EW, Watson PL. Burst suppression on Processed Electroencephalography as a Predictor of Postcoma Delirium in Mechanically Ventilated ICU patients. Crit Care Med 2014;42(10):2244–51. https://doi.org/10.1097/ccm.0000000000000522.
[71] Kromm J, Fiest KM, Alkhachroum A, Josephson C, Kramer A, Jette N. Structure and Outcomes of Educational Programs for Training Non-electroencephalographers in performing and Screening Adult EEG: a Systematic Review. Neurocrit Care 2021;35(3):894–912. https://doi.org/10.1007/s12028-020-01172-2.
[72] Taran S, Ahmed W, Pinto R, Bui E, Prisco L, Hahn CD, et al. Educational initiatives for electroencephalography in the critical care setting: a systematic review and meta-analysis. Canadian Journal of Anesthesia/journal Canadien D'anesthésie 2021;68(8):1214–30. https://doi.org/10.1007/s12630-021-01962-y.
[73] Skoglund K, Enblad P, Hillered L, Marklund N. The neurological wake-up test increases stress hormone levels in patients with severe traumatic brain injury. Crit Care Med 2012;40(1):216–22. https://doi.org/10.1097/CCM.0b013e31822d7dbd.
[74] Xie L, Kang H, Xu Q, Chen MJ, Liao Y, Thiyagarajan M, et al. Sleep drives metabolite clearance from the adult brain. Science 2013;342(6156):373–7. https://doi.org/10.1126/science.1241224.
[75] Bohr T, Hjorth PG, Holst SC, Hrabětová S, Kiviniemi V, Lilius T, et al. The glymphatic system: current understanding and modeling. iScience 2022;25(9):104987. https://doi.org/10.1016/j.isci.2022.104987.
[76] Colquhoun HL, Levac D, O'Brien KK, Straus S, Tricco AC, Perrier L, et al. Scoping reviews: time for clarity in definition, methods, and reporting. J Clin Epidemiol 2014;67(12):1291–4. https://doi.org/10.1016/j.jclinepi.2014.03.013.