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Survey on neurological monitoring practices and clinician perspectives in acute stroke care

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ABSTRACT

Aims: To examine current practice and views regarding neurological assessment and monitoring across stroke services in the United Kingdom.
Methods: A cross-sectional survey of UK secondary care stroke services was conducted between December 2019 and September 2021.
Results: The response rate was 80 % ($n = 125/156$ services). Glasgow Coma Scale was the most frequently used routine neurological assessment (96 %). Variation in frequency, duration and response to monitoring was evident across all stroke types. Medical escalation was the most frequent response to neurological deterioration (99 %). Respondents acknowledged the importance of neurological monitoring, inadequacies of common tools, and supported further work to improve assessments and response protocols.
Conclusion: The extent of variation in clinical practice of neurological assessment and monitoring across the UK was unknown. Variation was found to be greater than anticipated. There is a need, and desire for, stroke type scenario-specific monitoring and standardised response guidance in acute stoke care. Introducing standardised care in this area would strengthen clinical protocols and could remove unwarranted variation in patient care ultimately improving outcomes.
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Introduction

Acute stroke services provide specialist multidisciplinary care for diagnosis, treatments, and prevention of complications[1]. Prevention and management of complications, through organised and standardised processes of care, is known to improve patient outcomes[2]. One key complication after stroke is early neurological deterioration (END), which is the worsening of symptoms in the initial hours or days irrespective of cause. Occurrence of END after stroke has been reported to be between 5 and 40 % in the first 24 h[3]. Early recognition of END along with quick and appropriate response may reduce mortality and improve outcomes in stroke unit setting[2,4]. However, reasons for END can sometimes be difficult to separate from other factors, notably the underlying pathophysiology of stroke.

Although not all causes of END are treatable or reversible recognition remains important as all stroke patients, not just those receiving thrombolysis or thrombectomy, are at risk from this common complication. Neurological assessment and monitoring is recognised as an important element of acute stroke care in National and International policy and guideline documents. The National Clinical Guideline for Stroke for the United Kingdom and Ireland advises that neurological assessment and management of neurological status are fundamental components of acute stroke care[1]. However, there are no specific guidelines on the format, content, and frequency of neurological assessment and monitoring that should be achieved, except for those patients who receive thrombolysis and/or thrombectomy[1,5].

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Numerous tools have been specifically created for the assessment and monitoring of neurological status within acute stroke, which vary in content, length, and complexity, affecting their utility for frequent monitoring of all patients for early signs of END. The authors were aware of non-stroke specific scales such as The National Early Warning Score (NEWS) 2[6] and the Glasgow Coma Scale (GCS)[7] being used for routine monitoring in stroke units. Although NEWS 2 improves detection and response to clinical deterioration in adults it does not assess or provide feedback on functional neurology. The GCS was developed and validated to measure conscious levels in traumatic brain injury and is insensitive to the detection of focal neurological deficit. Therefore, both tools would be insufficient to detect END in an acute stroke population.

The current lack of guidance for best practice to routinely detect END means different services could have widely varying practices across units and patient groups. Such inconsistency could cause variation in patient care and outcomes[8] and have implications for clinical practice resources like staffing. Variation in monitoring could result in END not being recognised or being identified late, and where possible treated, resulting in secondary brain injury that could have been prevented. Greater standardisation could not only lead to better recognition of END but wider policy and clinical practice improvements. Currently, the level and type of variation in neurological assessment and monitoring practice is unknown. This survey aimed to examine practice, explore clinicians' experiences and views of neurological assessment and monitoring, and response to END across UK services.

Methods

A cross-sectional survey of UK stroke services. No existing validated questionnaires were available for this study, so a new one was designed informed by the literature and the authors' knowledge of practice.

The questionnaire (Supplemental material 1) aimed to:

1. Ascertain the tools used for neurological assessment and monitoring
2. Outline practice in frequency of monitoring across a range of stroke patients and time periods
3. Explore how change in neurological status is identified and managed
4. Check clinicians' understanding of the importance of neurological assessment and monitoring and whether they feel change is warranted in this area.

Development was iterative with multiple drafts developed and reviewed by the authors. Most questions had a closed response format to ensure consistency in responses and allow easier comparison[9], although some free-text options were available. Likert- type scales were employed to measure respondent attitudes and agreement/disagreement with statements. Initial piloting applied a cognitive interviewing style during completion find experienced nurse with both clinical and research experience. This involved the nurse completing the questionnaire in the presence of the author, discussing the interpretation of the questions, questionnaire design, and other factors that could impact completion. After changes, the questionnaire was further piloted with experienced stroke nurses, who provided verbal and written feedback on the design and potential interpretation of the questions. No formal assessment of validity or reliability were completed. Completion took approximately 30 mins.

All UK services, identified through the Sentinel Stroke National Audit Programme (SSNAP)[10] and Scottish Stroke Care audit[11] data as admitting acute stroke patients, were eligible to complete a single questionnaire (paper based or electronic completion). Clinicians, who self-identified as having a working knowledge of neurological assessment and monitoring practices were initially invited to participate by e-mail alerts through UK-based professional networks. Where participants were not identified either local research departments suggested potential contacts, or the stroke services were directly contacted by phone to identify a participant. There was a risk of responder bias but it was deemed to be minimal as it was felt that although practice within a specific unit can vary between individuals generally there is a consensus on monitoring practice. Non-response bias and generalisability were considered, and the aim was to achieve a minimum response rate of 60 % to represent the range of UK units admitting acute stroke.

A Participant Information Sheet (PIS) was emailed to those who expressed interest in taking part. Participation was voluntary, and informed consent was implied on return of a completed questionnaire. Questionnaires were anonymised with only a key number to identify the hospital location. Information on contacts was kept separately, password protected on secure servers. Non-responders were followed up every 2 to 3 weeks for a maximum of five times, (three times by e-mail and twice by telephone) to optimise response rates. Optional entry to a prize draw was offered to incentivise completion.

Data from the surveys were entered into a Microsoft Excel (Version 2108, Microsoft Corporation, Redmond, WA, USA), checked against the questionnaires to remove inputting errors and missing data. Data were then uploaded to Statistical Package for the Social Sciences (SPSS, Version 28, IBM Corporation, Armonk, NY, USA) for analysis. Analysis involved descriptive statistics reported as counts and percentages. Qualitative data from open-ended questions were collated and underwent content analysis. The primary author undertook the analysis and immersed themselves in the data to allow insights to emerge based on participants' responses. Credibility was maintained through prolonged data engagement, discussion of findings and process of analysis with other authors, and triangulation with other data where possible and appropriate.

Ethical approval was obtained from the Science, Technology, Engineering, Medicine, and Health (STEMH) committee at the University of Central Lancashire (reference STEMH 1018) and the Health Research Authority (project ID 261850, REC reference 19/HRA/4113). Local approval was obtained from each Trust's research department before questionnaires were sent to participants.

Results

Data were collected between December 2019 and September 2021. From 156 eligible services, 138 issued local approval and received questionnaires. From these 125 (80 %) returned the questionnaire. The percentage return rate by region is available (supplemental material 2).

Most respondents held a clinical role (94 %). Nurses were the largest group ($n = 102$, 82 %), followed by doctors ($n = 14$, 11 %) and therapists ($n = 2$, <2 %). Seventy-two percent of services ($n = 90$) were designated as providing care only to stroke patients.

All services reported using more than one tool for completion of neurological assessment and monitoring (supplemental material 3). The tools used most often were the Glasgow Coma Scale (GCS)[7], AVPU (Alert, Voice, Pain, Unresponsive)[12], and NIHSS (National Institutes for Health Stroke Scale)[13]. The GCS and AVPU were used for regular and ongoing monitoring. The NIHSS was mainly used on admission and at key time points, including at 2 and 24 h post thrombolysis and/or thrombectomy. Thirty (24 %) responses described ad hoc NIHSS use for assessment if a patient's neurological status changed. Only thirteen responses (10 %) outlined regular use of the NIHSS for monitoring patients' neurological status. Four reported daily use, and the rest reported frequencies varying from hourly to weekly.

The questionnaire asked for the most common frequency of assessment and monitoring, for different patient groups, across different time periods in the first 72 h. Tables 1 & 2 show the most commonly reported frequency, and range of frequencies reported. The questionnaire allowed participants to state if a particular patient group was not seen in their service at all or at particular time periods (e.g., service who does not deal with thrombectomy patients or patients may receive thrombolysis in higher acuity areas).

The greatest variation of frequency across all time periods was in the ischaemic stroke patients (not receiving thrombolysis or thrombectomy)

Table 1
Frequency of observations for thrombolysis and thrombectomy patient groups

Time Period (hrs)	Thrombolysis				Thrombectomy			
	Most Common Frequency	No.in Time Period	No. (%) MCF	Range	Most Common Frequency	No.in Time Period	No. (%) MCF	Range
0-8	15 mins	116	96 (83 %)	15mins to hrly	15 mins	25	11 (44 %)	15 mins to 2 hrly
8-16	hrly	116	72 (62 %)	30 mins to 4 hrly	Hourly	28	19 (68 %)	30 mins to 4 hrly
16-24	hrly	115	58 (50 %)	30 mins to 6 hrly	Hourly	29	13 (45 %)	30 mins to 4 hrly
24-48	4 hrly	114	84 (73 %)	hrly to 12 hrly	4 hrly	43	27 (63 %)	hrly to 6 hrly
48-72	4 hrly	109	77 (71 %)	Hourly to 12 hrly	4 hrly	43	27 (63 %)	2 hrly to 8 hrly
>72	4 hrly	107	39 (36 %)	2 hrly to 12 hrly	4 hrly	45	19 (42 %)	4 hrly to 12 hrly

Key for Table 2.
hrs = hours.
MCF = Most Common Frequency.
mins = minutes.
hrly = hourly.

group. Initially both the Intracerebral Haemorrhage (ICH) groups appeared similar, with hourly being the most common frequency in the 0-24 h period, and four hourly beyond that. However, patients requiring blood pressure alteration have greater frequency of neurological assessment and monitoring frequency and this was sustained over time. The thrombolysis and thrombectomy group showed the greatest variability in the 0-8 h period than across any other group or time period. The most common reported frequency for the thrombolysis and thrombectomy group was 15 min (22 %, $n = 28$). However, 68 free-text responses were reported, representing 22 different frequency schedules with 66 of them starting at 15-minute intervals.

Variation was visible in both the level of agreement on the most common frequency and the range of frequencies. E.g., in the thrombolysis group more services agreed on the common frequency after thrombolysis for 24 to 48 h (74 %) than in the beyond 72 h period (36 %). The thrombectomy patients had less responses as 60 % ($n = 75$) of services did not manage this group. More services reported on monitoring at later time points when patients were repatriated from specialist thrombectomy centres. Overall, the data indicated that there was extensive variation across all patient groups and time periods. Agreement across services is between 35 % and 83 % at any specific time point, when exploring the most common frequency. The range of frequencies highlights the lack of consistency in terms of neurological monitoring being completed across the UK. Data on discontinuation of neurological assessment and monitoring is available in Supplemental Material 4.

Lack of stroke specific evidence-based protocols in neurological assessment and monitoring could account for variation in current practice. Competing priorities with limited staffing could also impact on completion of this element of care even when protocols are agreed. Three questionnaires mentioned using audits and senior staff overview to try and increase adherence to protocols and ensure completion, but this again requires a formal agreement on procedure and frequency of monitoring.

Respondents were asked what they would observe in a patient that would make them aware they had deteriorated. Respondents provided multiple answers (410 responses from 121 questionnaires). Table 3 presents an overview of the number of responses, and the most common responses within each of the five coded themes.

Table 4

Respondents were given options of the actions that would be taken if deterioration was noted. Escalation for medical review was the most frequent action reported if change was identified (99 %, 124). Others included additional scan (95 %, 119), additional observations (90 %, 113), inform senior nurse (89 %, 111), treatment to alter blood pressure (83 %, 104), glycaemic control (74 %, 92), neuro-surgical review (69 %, 86), and other (13 %, 16).

Most respondents, 95 % ($n = 119$), felt that neurological assessment and monitoring is important for all stroke patients. This was supported by large numbers disagreeing that it should only be for patients considered for or who received treatments (90 %, $n = 112$), or in ICH (98 %, $n = 121$). Tailoring to individual patients was generally supported with 66 % ($n = 82$) agreeing and a further 13 % ($n = 16$) unsure.

Most respondents, 71 % ($n = 89$), thought that changes were needed in neurological assessment and monitoring. In terms of what they would change, 152 free-text comments (86 questionnaires) were categorised into five themes: Assessments, Guidelines, Training, Documentation, and Staffing.

Potential barriers and facilitators to neurological assessment and monitoring were explored within the questionnaire and those data are available in Supplemental Material 5.

Discussion

This is the first UK-wide survey that has explored neurological assessment and monitoring after stroke. The survey was indicative of acute stroke services as sites were selected through national audit data and there was a high response rate (80 %). The high level of engagement signifies this is an important topic area for clinicians.

Within each stroke service a range of tools are used, some stroke specific and some generic. The choice of tool used is dependent upon the time of and purpose of the assessment. The NIHSS is advocated for routine monitoring in international guidelines[14, 15]. However, the survey showed it is not used for monitoring in the UK. Instead, it is used mainly on admission and at 2 and 24 h post thrombolysis and/or thrombectomy, which is in keeping with the requirements for national audit reporting through SSNAP[10]. The lack of routine use could be because the NIHSS is seen as too complicated and time consuming for repeated use on all patients [16, 17]. The GCS and AVPU were used most often for regular monitoring across the UK despite the GCS showing poor sensitivity to detect change after acute stroke [18, 19]. A stroke-specific assessment for routine monitoring, such as the SNOBS, are only used in a very small number of sites.

The survey reported extensive variation in monitoring frequencies across all groups, and time periods. This variation indicates that patients are receiving different monitoring regimens which may be having implications for identification and timely management of END, which could affect patient outcomes. The range of most commonly reported frequencies widens across all patient groups as the time period from stroke increases. This further suggests uncertainty across the UK about

Table 2
Frequency of observations for different patient groups

Time period (hrs)	Ischaemic Stroke (without Thrombolysis or Thrombectomy)				Intracerebral Haemorrhage (ICH) (with blood pressure alteration)				ICH (without blood pressure alteration)				Potential hemicraniectomy ^			
	Most Common Frequency	No.in Time Period	No. (%) MCF	Range	Most Common Frequency	No.in Time Period	No. (%) MCF	Range	Most Common Frequency	No.in Time Period	No. (%) MCF	Range	Most Common Frequency	No.in Time Period	No. (%) MCF	Range
0-24	4 hrly	116	61 (53 %)	15 mins to 6 hrly	hrly	108	47 (44 %)	15 mins to 4 hrly	hrly	117	57 (49 %)	15 mins to 6 hrly	hrly	51	31 (61 %)	15 mins to 6 hrly
24-48	4 hrly	114	77 (68 %)	hrly to 12 hrly	hrly	108	42 (39 %)	15 mins to 6 hrly	4 hrly	116	65 (56 %)	30 mins to 12 hrly	hrly	45	32 (71 %)	15 mins to 6 hrly
48-72	4 hrly	113	66 (58 %)	hrly to 12 hrly	4 hrly	106	58 (55 %)	30 mins to 12 hrly	4 hrly	111	68 (61 %)	hrly to 12 hrly	hrly	48	17 (35 %)	15 Mins to 6 hrly
Beyond 72	4 hrly	110	39 (35 %)	hrly to 12 hrly	4 hrly	104	47 (45 %)	30 mins to 12 hrly	4 hrly	110	51 (46 %)	hrly to 12 hrly	4 hrly	48	18 (38 %)	hrly to 12 hrly

Key for Table 3.
hrs= hours.
^= Patient who has been identified as large middle cerebral artery (MCA) stroke who may be at risk of a malignant MCA.
MCF= Most Common Frequency.
mins= minutes.
hrly = hourly.

Table 3
What clinicians observe in a patient to know that deterioration has occurred

Theme	Responses (n)	Most common response
Changes in relation to assessments or tools	160	Change or reduction, in the GCS ($n = 71$) Changes in neurological assessments generally ($n = 30$) and specific tools: NIHSS ($n = 31$) SNOBS ($n = 2$) FAST ($n = 2$) and CNS ($n = 1$).
Changes noted in patient condition (without mention of assessment/tool)	106	Change linked to level of consciousness (LOC): altered or reduced LOC, increased drowsiness, and loss of alertness or responsiveness ($n = 41$).
Alterations in physiological observations	90	Change in the National Early Warning Score (NEWS) or physiological readings generally ($n = 84$) which included: change in blood pressure, pulse or heart rate, altered breathing or respiration rate, and oxygen saturation.
Specific symptoms	36	The three most common specific symptoms reported as indicating deterioration were confusion ($n = 11$), headache ($n = 10$), and vomiting or nausea ($n = 10$).
Miscellaneous	18	Having a gut feeling, or intuition, or knowing from experience that something is wrong with the patient ($n = 11$).

what frequency should be used and when assessment and monitoring should be discontinued. This variation has implications in terms of ability to identify END but also in resources, especially staff workload, across units.

The potential hemicraniectomy group's data showed the most consistency in the range of reported frequencies. In this group the most common frequency remained more consistent and at greater frequency than for any other group, potentially because this group may deteriorate over a longer period. Patients potentially eligible for hemicraniectomy are not managed within all stroke services and may be sent to specialised or higher acuity areas within the same or different hospital. However, with the challenge of increasing access to thrombectomy, earlier repatriation is likely to increase and stroke services will need to monitor increasing numbers of patients[20] which will have implications for service delivery.

Variation persisted even within established guidelines, particularly during the first 24 h post-thrombolysis.[21]. However, some of the variation reported after acute treatments may have been exaggerated in the first 24 h due to the change in intervals as the risk of complications is felt to reduce. This high-intensity schedule of physiological and neurological monitoring after thrombolysis has implications for staffing levels and patient disturbance. Researchers from Genentech, John Hopkins University, and The George Institute for Global Health in Australia are collaborating on OPTIMISTmain (Optimal Post tPA-IV Monitoring in Ischemic Stroke). This international trial is exploring whether simple monitoring is equivalent to complex schedules in stable thrombolysed patients [22]. Although this should provide some answers about neurological monitoring schedules for this group of patients, better evidence and guidance is needed across the whole stroke population.

Reporting on the overall range of frequencies added greater depth to the most common frequency data. In the ischaemic stroke group (without thrombolysis or thrombectomy), although the most commonly reported frequency was four-hourly, this group also had the broadest range of monitoring frequencies indicating a high level of uncertainty about what frequency to follow. As this group represents the largest proportion of the overall population such variation has implications for care provision and staffing, as well as potentially impacting END

Table 4
Themes, sub-themes, justification of, and specific suggestions of changes from respondents that felt change was warranted in neurological assessment and monitoring.

Theme (n, %)	Sub- Theme (n, %)	Justification/ explanations (n)	Specific suggestions for change (n)
Assessments (66, 74 %)	GCS not appropriate or NIHSS more suitable (23, 26 %)	Aphasia is lost in the assessment (4)	Adaptation of the GCS for aphasic and dysarthric patients (4)
		GCS was designed for traumatic brain injury (2)	Adaptation of the FAST tool using elements of the NIHSS to detect changes quicker (1)
		Communication difficulties (1) and confusion (1) can cause incorrect assessment	Using something like the localised Stroke Thrombolysis Observation Complication (STOC) chart (1)
	Stroke specific assessment (not GCS or AVPU) that is up to date and validated in stroke (21, 24 %)	Important to have a neurological baseline (1)	Monitoring needs to be considered in terms of - what do the team need to know and how this will change treatment (1)
	Tool Use (14, 16 %)	NIHSS too difficult (2)	Individualised (8) Easier to use (2) Increased frequency post thrombolysis is warranted (1) Less reliance on scoring and more on clinical judgement in conjunction with assessment (1)
	Specific Patient Groups (3, 3 %)	NIHSS not suitable for posterior circulation (1)	TIA patients should receive neurological monitoring (1)
Guidelines (45, 51 %)	Clearer guidelines and standards (27, 30 %)	Ensure standard practice and equity of care (17)	What we should be doing for which patients including detail on frequency and duration (15)
		Historical practices (1)	Across local, regional, and national arenas (7)
Training (29, 32 %)	Need to have clear and standardised training (18, 20 %)	Not data reported	Improved training in specific scales: NIHSS (6) GCS (3) Training in language and cognition as they are hard to assess (2) All staff (2) Competency assessments (1) Multi-disciplinary team approach with shared learning (1) Addressing confidence and skills (1) Delivered regularly (1)

(*continued on next page*)

Table 4 (*continued*)

Theme (n, %)	Sub- Theme (n, %)	Justification/ explanations (n)	Specific suggestions for change (n)
Documentation (8, 9 %)	Improvements in electronic observation and record keeping systems (5, 4 %)	Not data reported	Improvements in electronic patient observation systems to provide a more in-depth neurological assessment (4) Clear documentation of neurological care plans by doctors (3) System that would immediately let clinicians know when there was a change (1)
Staffing (4, 4 %)	Need for additional staff and resources 3 (3 %)	Not data reported	Allowing continuity of care so subtle changes can be identified (1)

identification.

Evidence supports specialised in-patient stroke care and optimal management through multidisciplinary led interventions[23, 24]. Prompt identification and treatment of subtle signs of neurological change could be crucial to prevent further injury and improve outcomes for some patients. Although respondents reported multiple ways that neurological change after stroke was recognised the data indicated a reliance on total score reduction, particularly in the GCS. Alteration in level of consciousness is a late sign of deterioration so the GCS, a crude indicator of gross change, may not be suitable to identify more subtle neurological change in this population. There was an awareness that some tools might not be appropriate for purpose, and some reported a lack of confidence in their use. Specifically, a quarter of those who felt change was needed, suggested that the GCS was not appropriate in a stroke population.

In terms of response to neurological change it was not possible to know from the data the sequence of actions, and whether some actions are completed before the medical review or whether the review instigates other actions.

There was strong agreement in the responses that neurological assessment and monitoring is important for all stroke patients to detect neurological change, specifically deterioration. Although there was an indication that certain groups, such as those receiving treatments, may require more frequent monitoring the justification was not explored.

A key finding was that clinicians want change to improve assessment and monitoring. Currently, there is a reliance on non-stroke-specific tools (GCS and NEWS) for monitoring and there is also a lack of evidence and guidance to support what needs to be done, when, and for which patients[1]. The results of this survey call for change in this important element of care. The need for improved guidance has global significance beyond the UK as the both the numbers of strokes and their impact differ between countries, geographical regions and ethnic groups[27]. Also, organisation of care differs globally with some countries using different acuity levels for certain patient groups that could be altered if there greater understanding of how best to identify END in a timely manner[28].

Respondents highlighted a need for the development of protocols and guidelines that include tools for routine monitoring that are specific to stroke, achievable in busy clinical environments, and result in appropriate action if deterioration is noted. Evidence-based clinical guidelines effectively implemented have the potential to reduce unwarranted variation and improve healthcare quality and safety[25, 26]. Clinicians indicated they want this element of practice underpinning by appropriate training, documentation, and staffing.

It was intended the survey would provide a 'snapshot' of practice in relation to neurological assessment and monitoring. However, study delays due to the Covid-19 pandemic, meant it took one year and nine months to complete. No major changes to care provision or factors have been identified that may have influenced results, so it is likely that the data remained indicative of practice.

The questionnaires were mainly returned by senior clinicians which could have caused bias in the responses received. These respondents may have a better understanding of practice and therefore the responses may be more reflective of practice, or they might not know the realities more junior staff face. The authors believe that in terms of the aims of the study to be able to ascertain current practice across the UK these respondents will not have been hugely impactful. However, they are aware that were opinions was sought bias could have been introduced and that single responses may not highlight additional variation that could exist within units that could be heightened due to lack of protocols or training. It was not ascertained whether the questionnaires represented single opinions or whether other team members were involved in completion. This may have impacted in that team completion may have been more robust however, it could have led to what was reported being controlled by agreement rather than reality.

Conclusion

This survey explored variation and clinicians' experiences of neurological assessment and monitoring. Despite respondents acknowledging the importance of identifying stroke-related deterioration, there is dissatisfaction with some commonly used assessment tools and uncertainty about the optimum frequency of monitoring according to reported frequencies by patient groups. This uncertainty and variation across the UK could potentially cause differences in outcomes for some stroke patients. There is an expressed need for stroke-specific neurological assessment and monitoring practices. Guidelines and protocols are needed that are specific to stroke, achievable in busy clinical environments, and result in appropriate action if deterioration is noted. Further research is needed to identify the optimal neurological assessment and monitoring practices for all stroke patients to develop stroke specific evidenced based protocols.

CRediT authorship contribution statement

Alison McLoughlin: Writing – review & editing, Writing – original draft, Visualization, Validation, Project administration, Methodology, Investigation, Funding acquisition. **Caroline Watkins:** Writing – review & editing, Supervision, Resources, Conceptualization. **Philippa Olive:** Writing – review & editing, Supervision, Conceptualization. **Christopher Price:** Writing – review & editing, Supervision. **Catherine Elizabeth Lightbody:** Writing – review & editing, Supervision, Methodology, Conceptualization.

Declaration of competing interest

We declare no competing interests

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.jstrokecerebrovasdis.2025.108247.

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