***Pervasiveness of Communication Disorders and Fatigue in Stroke
Patients: A Systematic Scoping Review***

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Short Title: Communication Disorders in Post-Stroke Fatigue Research

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Abstract

Background— After a stroke, it is highly likely that an individual will experience substantial fatigue that can significantly affect recovery and function; stroke survivors also have more than a 50% chance of having at least one communication disorder. Current reviews of post-stroke fatigue have not provided evidence focused on communication disorders or the potential influence they may have on post-stroke fatigue and related recovery.

Objectives—The aim of this review was to determine how communication disorders are represented in post-stroke fatigue research and to catalogue methods used to identify communication disorders and measure fatigue.

Methods— A systematic, scoping review was conducted to identify studies measuring post-stroke fatigue. To identify these studies, a comprehensive literature search was conducted using relevant databases and grey literature sources, followed by several stages of review that adhered to PRISMA guidelines. We evaluated these studies using pre-established eligibility criteria and extracted data regarding the inclusion/exclusion of persons with communication disorders and the assessment methods used.

Results—The scoping review analysis was conducted on 161 studies. Of these, 41 (26%) excluded *all* communication disorders, 71 (44%) excluded *severe* communication disorders, and 49 (30%) *included* participants with communication disorders. Of the 120 studies that did not explicitly exclude all communication disorders, only 34 were confirmed to report data from at least one person with a communication disorder. Further, only 5 studies reported data that could be used to determine a relationship between these comorbidities.

Conclusions—Persons with communication disorders are underrepresented in post-stroke fatigue research and very few studies have examined the relationship between post-stroke fatigue and communication disorders, limiting conclusions that can be drawn. This is problematic because medical professionals relying on this evidence to guide clinical practice are likely to be treating individuals with co-occurring fatigue and communication disorders and the current research does not provide enough information about the potential impact of fatigue on communication disorders or vice versa. To bridge this gap, we suggest methods of assessment that could provide ways to more accurately 1) reflect the real patient population in post-stroke fatigue studies, and 2) measure and document fatigue in post-stroke communication disorder studies.

Keywords: fatigue, sleepiness, stroke, communication disorders, scoping review

1. Introduction

Recent systematic reviews have found there is a relatively high prevalence and significance of fatigue in the post-stroke population (Choi-Kwon & Kim, 2011; Cumming, Packer, Kramer, & English, 2016). The prevalence of post-stroke fatigue ranges from 23-85% with 40% reporting fatigue as one of the worst consequences of stroke (Choi-Kwon & Kim, 2011; Cumming et al., 2016; Staub & Bogousslavsky, 2001). Excessive daytime sleepiness has also been reported to significantly affect the stroke population (Davies, Rodgers, Walshaw, James, & Gibson, 2003; Sterr, Herron, Dijk, & Ellis, 2008). Sleepiness and fatigue represent two distinct concepts, yet these two terms are often used interchangeably in the medical literature (Shen, Barbera, & Shapiro, 2006). Given their common use and the frequent confusion surrounding these terms, it is often difficult to determine which specific phenomenon a research study aims to measure. In order to be as comprehensive as possible in our scoping review, we decided to include both types of measures and considered the terms interchangeable for this purpose. We will not make a further distinction between the terms 'sleepiness' and 'fatigue' and will use the term 'fatigue' to refer to these related concepts throughout the remainder of the manuscript.

A variety of factors have been found to affect fatigue, including stroke characteristics, co-morbidities, pre-stroke fatigue, and other personal factors (e.g., age, sex, level of support) (Lerdal et al., 2009). We have proposed a revised version of the Lerdal et al. model that considers the role of speech and language disorders (available on the Open Science Framework repository at <https://osf.io/48vj5/>). Most systematic reviews have focused on chronic neurological fatigue, the prevalence of and factors associated with post-stroke fatigue, or nursing interventions for fatigue (Chaudhuri & Behan, 2004; Choi-Kwon & Kim, 2011; Choi-Kwon, Mitchell, & Kim, 2015; Ponchel, Bombois, Bordet, & Hénon, 2015). One factor that systematic reviews suggest contributes to post-stroke fatigue is communication disorders. However, these reviews either do not cite direct evidence to support specific claims or cite sources that do not distinguish between communication disorders and cognitive impairment (Radman et al., 2012). Reviews that do include specific evidence cite the same two studies: one reporting a significant relationship between fatigue and presence of dysarthria, a motor speech disorder (Choi-Kwon, Han, Kwon, & Kim, 2005), and the other reporting the results of a large survey study that identified fatigue and speech impairment solely through patient self-report (Glader, Stegmayr, & Asplund, 2002). An additional issue arising from these studies is the inconsistent and interchangeable use of the terms referring to communication disorders (e.g., speech disorder, speech impairment, aphasia).

The term 'communication disorder' encompasses a broad range of speech and language disorders, including aphasia and motor speech disorders. Aphasia is a language disorder that has been estimated to occur in approximately 30% of those who have experienced an ischemic stroke (Engelter et al., 2006; Flowers, Silver, Fang, Rochon, & Martino, 2013). Persons with aphasia (PWA) can have difficulty understanding and producing both spoken and written language and variations in aphasia type and severity results in individual patterns of language deficit. Apraxia of speech and dysarthria are motor speech disorders (MSD) that are estimated to occur in approximately 11% and 42% of first-time stroke survivors, respectively (Flowers et al., 2013; Lawrence, Booth, Mercer, & Crawford, 2013). Persons with MSDs experience difficulty with speech production, but do not have impaired comprehension. To further complicate the issue, it is estimated that aphasia and dysarthria co-occur in approximately 15% of first-time stroke survivors, and those with apraxia of speech have a 50% chance of also having dysarthria and an even higher chance of having co-occurring aphasia (Flowers et al., 2013). Given these estimates, persons who have experienced a stroke have more than a 50% chance of having at least one communication impairment (Flowers et al., 2013). Thus, for this scoping review, we will refer to persons with communication disorders (PWCD) to mean an individual with aphasia and/or a motor speech disorder.

Many of the measures used to diagnose post-stroke fatigue are highly dependent on language comprehension and production and are administered as questionnaires (e.g., Fatigue Severity Scale; Epworth Sleepiness Scale) (Shen et al., 2006). These measures present a significant challenge to diagnosing post-stroke fatigue in PWCD because they rely on intact language comprehension. Some reviews have noted that communication disorders like aphasia and MSDs often disqualify individuals from participating in studies that use common fatigue measures (Choi-Kwon & Kim, 2011; Cumming et al., 2016). Furthermore, challenges of evaluating PWCD also contributes to our poor understanding of the relationship between communication disorders and post-stroke fatigue (Ponchel et al., 2015). Although this observation has been occasionally noted in post-stroke fatigue studies, thus far, there have been no systematic investigations of the actual representation of PWCD in this body of literature.

The incidence and prevalence of fatigue in the post-stroke population is relatively high and statistically, many of these individuals are likely to also have communication disorders. If PWCD are frequently excluded from post-stroke fatigue studies, it is possible that underrepresentation of communication disorders in this research could result in an underestimation of the prevalence of post-stroke fatigue and in misleading conclusions about the factors that may contribute to fatigue (Choi-Kwon & Kim, 2011; Cumming et al., 2016). Without a systematic investigation of this claim, one cannot accurately conclude that persons with communication disorders are underrepresented in this

research. Furthermore, it also remains unknown if traditional language-based fatigue measures can be used with individuals who have communication disorders.

For post-stroke fatigue studies that have considered whether or not to include PWCD, a cursory look at the literature suggests that methods of identifying communication disorders are quite variable and descriptions of these methods also vary greatly in the level of detail provided. In order to fully understand the role of fatigue and communication disorders in stroke patients, it is essential to first understand how communication disorders have typically been identified in this type of research so that recommendations can be offered as to which methods are most appropriate.

Others have suggested that few studies have addressed the relationship between language ability and fatigue (Ponchel et al., 2015) and it remains unclear if findings across these studies support the claim that having a communication disorder increases the chances or severity of fatigue. Given the currently available literature reviews focusing on post-stroke fatigue, this question is still difficult to answer because it is unclear how many of the studies contained in these reviews actually included persons with communication disorders.

The purpose of this study was to 1) determine the extent to which existing literature on fatigue in stroke patients includes PWCD, and 2) to catalogue the methods used in these studies to identify communication disorders (i.e., aphasia and MSD). We hypothesized that relatively few post-stroke fatigue studies would address communication disorders and that a wide variety of methods would be used to identify them.

2. Methods

To address study aims, a systematic scoping review was conducted. The review protocol is registered in Prospero, the International prospective registry of systematic reviews, Registration Number: CRD42018088053, URL: https://www.crd.york.ac.uk/prospero/display_record.php?RecordID=88053, and adheres to PRISMA guidelines.

2.1 Search protocol and study identification

A comprehensive search of the literature was conducted to identify studies measuring patient fatigue, either quantitatively or qualitatively, in any phase of stroke recovery. The databases searched included: PubMed, MEDLINE (Web of Science), The Cochrane Library, Scopus, Web of Science, PsycINFO, CINAHL, Google Scholar, Linguistics and Language Behavior Abstracts, Communication Source, Speech Pathology Database for Best Interventions and Treatment Efficacy (speechBITE), Communication Science and Disorders Information Service (ComDisDome), BioMed Central, Embase, and ClinicalTrials.gov. A search for pre-prints and grey literature was also performed

to look for clinical trials with published results and conference proceedings. Reference lists and cited references from sentinel articles were reviewed to locate additional studies, and we used the related citations function in PubMed. There were no publication date filters applied to the search, and results contained articles up through April of 2020. Keywords used in the search, and the search strategy for PubMed, are included in Appendix A. The Yale MeSH Analyzer (Cushing/Whitney Medical Library, 2015) was used to help identify relevant MeSH terms (Grossetta Nardini & Wang, 2018).

2.2 Study selection criteria

To guide our study selection and eligibility criteria, we used the SPIDER framework (Sample, Phenomenon of Interest, Design, Evaluation, Research type). PICO is the most popular framework for systematically reviewing interventions and is most appropriate for evaluating questions of effectiveness; however, alternative frameworks (e.g., SPIDER), are more commonly used in reviews where mixed methods or qualitative studies are included (Littlewood & Kloukos, 2019). Given that our systematic scoping review would include qualitative, quantitative, and mixed methods studies, we selected the SPIDER framework (Cooke, Smith, & Booth, 2012; Littlewood & Kloukos, 2019). Table 1 shows our application of the SPIDER tool to frame our primary research question: *How frequently do patient groups in post-stroke fatigue studies include patients with communication disorders?* Table 2 lists our eligibility criteria as they relate to the individual components of our research question. Studies were excluded if they did not meet one of the listed criteria, were not in English, or did not report original data (e.g. reviews, comments, letters).

2.3 Study selection and critical appraisal

We used the CADIMA Evidence Synthesis Tool (<https://www.cadima.info/index.php/area/evidenceSynthesisDatabase>) to manage the following processes during the scoping review: combining search results, the deduplication of studies in combination with the citation management program Zotero, the title/abstract and full text reviews, data extraction, and critical appraisal. Reviewers A and B each assessed half of the 2,333 results identified in the literature search for their relevance (focus on fatigue) and inclusion of the population of interest (stroke participants). If title/abstract content was not comprehensive enough to clearly exclude the article at this stage, it proceeded to full-text review. Any questions about title/abstract eligibility were resolved by Reviewer A. The full text of 1,125 studies were then assessed for eligibility using criteria in Table 2. Reviewers A, C, D, and E each reviewed 25% of these studies and reliability was completed on 30% of the studies for each reviewer (e.g., Reviewer A completed independent reliability scoring for 30% of the studies reviewed by Reviewer C). See Figure 1, PRISMA Flow Diagram for the study selection process and details regarding the 723 articles

excluded during the full-text review stage. A total of 402 articles reached the critical appraisal stage. Each article was assessed by Reviewer A for methodological quality using the inclusion/exclusion criteria outlined in Table 3. Reviewers C, D, and E each completed a reliability check on a third of the articles in the critical appraisal stage. Based on the critical appraisal criteria, 241 additional studies were excluded at this stage.

2.4 Data collection and analysis

Reviewers C, D, and E each completed data extraction for a third of the articles remaining after critical appraisal (see Appendix B for data extracted for each study; see Tables 4 and 5 for lists of tests). Reviewer A completed independent reliability on 10% of the articles for each reviewer to ensure accuracy and consistency. The following data were extracted from each eligible study to use for subsequent analysis: general study purpose (descriptive/observational, intervention); sample source (e.g., hospital, skilled nursing); method used to measure fatigue (e.g., self-report scale, structured interview); name of fatigue measure; purpose of fatigue measure (e.g., to qualify participants, study outcome); method used to identify communication disorder (e.g., specific test, previous diagnosis); name of communication disorder measure; inclusion/exclusion status of PWCD (e.g., exclude all communication disorders); verification status of inclusion of PWCD.

Primary data analysis and results synthesis were carried out on the remaining 161 studies by Reviewer A, using Excel software. Frequency data for were summarized to determine the percentage of post-stroke fatigue studies that 1) excluded *all* PWCD, 2) excluded only *severe* PWCD, and 3) *included* PWCD. The number of studies using each specific fatigue measure and each specific measure to identify communication disorders were also summarized with percentages. Detailed data are provided in Appendix B and in Tables 4 and 5.

As a secondary analysis, Reviewer A examined the 161 studies to determine how many of these reported data from at least one PWCD. To meet this criterion, a study needed to include at least one verified PWCD and have either reported raw data from the fatigue measure specifically for this population or have reported a direct comparison between PWCD and another group without communication disorders. Results of this categorization process for each article are included in the Appendix B.

2.5 Risk of bias

In an attempt to mitigate bias, 4 reviewers and 1 librarian participated in this systematic scoping review. Reviewers independently evaluated studies and performed reliability checks across all stages of selection and evaluation. Given that the aim of this study was to provide a broad, scoping

overview of the representation of communication disorders in the existing body of post-stroke fatigue literature, we focused on reporting population data related to our study questions and only assessed the methodological quality of the inclusion/exclusion criteria for those studies.

3. Results

A total of 2,333 records were identified through our literature searches (after duplicates were removed) and screened using their titles and abstracts. We assessed the full text of 1,125 articles and further excluded 723 articles, resulting in 402 articles included in the critical appraisal stage. From this process, another 241 articles were excluded, leaving 161 articles that were included in our final analysis (see Figure 1). Inter-rater reliability across reviewers was high, with an average of 95% overlap in the full-text review stage and 98% overlap in the critical appraisal stage.

Of the 161 studies included in our final review, 49 (30%) explicitly allowed communication disorders, 41 (26%) excluded all communication disorders, and 71 (44%) specifically excluded severe communication disorders (Figure 2a).

Of the 120 post-stroke fatigue studies that did not explicitly exclude all PWCD, a total of 34 (28%) were confirmed to measure fatigue in at least one participant with a communication disorder. If we consider the actual total number of post-stroke fatigue studies identified (prior to the critical appraisal stage which eliminated studies that did not thoroughly describe inclusionary/exclusionary criteria), only 8.5% of studies investigating post-stroke fatigue reported data from at least one participant with a communication disorder. Furthermore, only 5 of these studies included at least one participant with a communication disorder *and* directly addressed the relationship between communication disorders and fatigue.

Of the 161 studies included in our analysis, a total of 16 (10%) identified communication disorders by experimenter/clinician observation, 3 (2%) used patient self-report, 40 (25%) used a previous diagnosis, 10 (6%) administered a general stroke screening, 17 (10%) administered a specific aphasia and/or language test, and 75 (47%) did not provide enough information to determine how communication disorders were identified in their study sample (Figure 2b). Of the 10 studies that used a general stroke screening to identify persons with communication disorders, the NIH Stroke Scale was the most commonly used screening. Of the 17 studies that used specific aphasia and/or language tests to identify persons with communication disorders, the Token Test was most commonly used. Other screenings and language tests were rarely used (see Table 4).

Although some studies measured fatigue for multiple purposes, the most common purpose of fatigue measurement was to measure once as a study outcome (117, 71%) and several measured fatigue to

study change over time (42, 26%). Very few fatigue measures were used to qualify participants for a study (4, 2%), or were administered to determine termination time of an experiment (1, 1%) (Figure 2c). The most common method of measuring fatigue was by using a patient self-report scale (128, 80%). Fewer studies used structured interviews (17, 10%) observer-rated scales (4, 3%), or multiple fatigue/sleepiness measurement methods (12, 7%) (Figure 2d). Two specific assessments, the Fatigue Severity Scale (FSS) and the Epworth Sleepiness Scale (ESS), were the most commonly used methods of measuring fatigue. While other types of tests were used in these studies, they were rare (Table 5).

4. Discussion

This systematic, scoping review of 161 studies, shows that information about communication disorder status in post-stroke sleepiness and fatigue research is limited. The chance that a person who has experienced a stroke will also have a communication disorder is over 50%, yet our results showed that only 8.5% of *all* post-stroke fatigue studies (34 out of 402 selected before critical appraisal stage), were confirmed to have included at least one participant with a communication disorder (Flowers et al., 2013). Furthermore, even if communication disorders were reported within a study, the percentage of PWCD for most studies was still extremely low and not at all close to what we would expect to see in the real-world stroke population. These findings suggest that persons with communication disorders are severely underrepresented in post-stroke fatigue research, and confirms the informal observations others have reported regarding the frequent exclusion of this population (Choi-Kwon & Kim, 2011; Cumming et al., 2016).

Most (47%) of the 161 studies that claimed to include or exclude communication disorders did not provide information about how these disorders were identified. Of those that provided information, about 16% of the 161 studies administered a test or screening, while the majority of study authors relied primarily on participants' previous diagnoses.

The most common stroke screening used to identify communication disorders was the NIH Stroke Scale (NIHSS). This measure is designed to measure stroke severity and contains two subsections that are relevant to identifying communication disorders. The 'best language' subsection uses a 0-3 observer-rated scale to determine whether an individual has no aphasia (score = 0), mild-to-moderate aphasia (score = 1), severe aphasia (score = 2), or mute/global aphasia (score = 3). The 'dysarthria' subsection uses a 0-2 observer-rated scale to determine whether an individual has no dysarthria (score = 0), mild-to-moderate dysarthria (score = 1), or severe dysarthria (score = 2). The NIHSS has a relatively high intra- and inter-rater reliability across medical and non-medical staff and can be used to measure clinically-significant change (Kwah & Diong, 2014).

The most common specific language test used to identify communication disorders was the Token Test (De Renzi & Vignolo, 1962). The Token Test is designed to measure receptive language ability

(i.e., spoken language comprehension), but does not provide information about speech or language production. This test is not designed to determine disorder severity and therefore may not be the most useful test for identifying individuals with communication disorders. The Frenchay Aphasia Screening Test (FAST), however, was designed to be used by individuals who are not specially trained to identify communication disorders, can be administered quickly (< 10 minutes), and provides a cut-off score for presence/absence of aphasia (Enderby, Wood, Wade, & Hower, 1986). The FAST was also concluded to be the most comprehensively evaluated aphasia screening test available and is highly sensitive to identifying individuals with communication disorders (O'Neill, Cheadle, Wyatt, McGuffog, & Fullerton, 1990; Salter, Jutai, Foley, Hellings, & Teasell, 2006). These characteristics make the FAST an ideal tool for identifying communication disorders in the stroke population, therefore we suggest that future studies of post-stroke fatigue should consider using it. The FAST may be particularly useful when the researchers or clinicians have no background knowledge or training to specifically diagnose speech and language disorders.

For the studies that may have included individuals with communication disorders, the majority (130, 80%) used patient self-report scales of fatigue. The most commonly reported fatigue measure was the Fatigue Severity Scale (FSS), followed by the Epworth Sleepiness Scale (ESS), the Multidimensional Fatigue Inventory (MFI), and the Fatigue Assessment Scale (FAS) (Johns, 1991; Krupp, LaRocca, Muir-Nash, & Steinberg, 1989; Michielsen, De Vries, & Van Heck, 2003; Smets, Garssen, Bonke, & De Haes, 1995). All four of these measures require an individual to rate written statements about different aspects of fatigue using variations of Likert-type scales (e.g., strongly disagree to strongly agree (Likert, 1932)). Depending on the type and severity of an individual's communication disorder, completing self-report scales such as these may present significant challenges, particularly when additional supports or modifications are not provided to these individuals. For example, Riley, Owora, McCleary, and Anderson (2019) developed and implemented a modified version of the ESS and the Visual Analog Fatigue Scale (VAFS) to measure sleepiness and fatigue in persons with aphasia. These modifications included providing both verbal and written instructions, slowing speech rate, repeating instructions, and using a visually augmented response scale to ensure understanding of each rating. Modifications such as these are relatively simple to implement and can significantly improve patients' abilities to complete these common fatigue measures. For communication disorders researchers and speech-language clinicians who are unfamiliar with measuring fatigue, modified versions of the ESS and VAFS can be a great way to track and record self-reported fatigue in PWCD during research studies or clinical treatment (Riley et al., 2019).

We were also interested in how fatigue measures in these studies were being used to identify and quantify fatigue. In a previous survey study of speech-language pathologists (SLPs), findings indicated

that intensive rehabilitation could be contributing to fatigue in persons with aphasia, suggesting that it might be beneficial to look for evidence of within-session or task-based fatigue in the post-stroke research (Riley, 2017). In our review, we found that most studies measured presence or degree of fatigue as a primary study outcome or measured fatigue over the course of weeks or months to examine change over time. Very few studies attempted to measure fatigue within the same session or compare fatigue measures administered immediately before and after a task. Of the studies that did measure fatigue change within-session, none were related to speech therapy. Given that SLPs perceive increased fatigue in their patients related to speech and language therapy, additional studies are needed to more specifically measure the relationship between specific tasks and fatigue (Riley, 2017).

4.1 Study limitations

Although we attempted to be as comprehensive as possible in our initial searches and screenings of the literature, it is possible that a relevant study was overlooked. For example, in our critical appraisal stage, per our inclusion/exclusion criteria, we eliminated any studies that failed to provide enough detail about whether or not PWCD were included or excluded from the study. This step was intended to decrease reporting bias to ensure that we were not unfairly counting a study as excluding PWCD if participant status could not be determined from the description; however, it is possible that studies excluded in the critical appraisal stage actually *did* exclude or include PWCD, but did not report it.

4.2 Conclusions & clinical recommendations

The primary finding of this review is that communication disorders are underrepresented in post-stroke fatigue research. Most post-stroke fatigue studies did not provide enough information to determine how they identified communication disorders in potential participants, and the fatigue measures most frequently used were heavily dependent on language. Based on these findings, we recommend that future research investigating post-stroke fatigue should include participants with communication disorders, use comprehensive and validated measures to identify these individuals, and modify administration of subjective fatigue measures in order to make them more accessible to this population. Additionally, we recommend that future research investigating post-stroke communication disorders should include appropriately modified fatigue measures to report patients' perceived fatigue as it relates to treatment and recovery.

Although none of the studies included in this scoping review specifically investigated the impact of speech therapy on fatigue, given what has been reported by speech-language pathologists (Riley, 2017), there is probably good reason for clinicians to be aware of fatigue in patients with communication disorders. A related concept, vigilant attention, is associated with performance in

language therapy, with low levels of attention resulting in more errors in therapy (Riley et al., 2019). Rehabilitation therapy sessions (e.g., speech, physical, occupational) may contribute to fatigue and reduce vigilant attention in person with aphasia, therefore, we suggest that clinicians and researchers take pertinent steps to minimize fatigue in these sessions. For example, some persons with aphasia may benefit from frequent breaks during therapy sessions. Others may benefit from alternating therapy tasks throughout a session to prevent task-specific fatigue. Furthermore, clinicians and researchers should strive to find the time of the day where patients are least fatigued to schedule therapy sessions. Clinicians and researchers should also monitor how general fatigue (e.g., due to travelling) may impact a patient vs. fatigue from the therapy itself. Different types of fatigue may require different solutions. For example, if individuals with aphasia experience fatigue related to a particular task, that task might be scheduled separately or towards the end of a session whereas more general fatigue might be reduced by allowing a rest period before starting a therapy session. Structuring therapy in this way may reduce the impact of fatigue on performance during the therapy session and ultimately aid in improving response to treatment. Results of this scoping review have revealed that although there are hundreds of studies investigating post-stroke fatigue, there are not yet enough data available in the literature to evaluate the potential impact of fatigue on persons with communication disorders. Until this significant gap in knowledge is filled, SLP clinicians will not have the tools and guidance they need to maximally facilitate recovery in patients with post-stroke communication disorders and co-occurring fatigue.

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Table 1. Application of SPIDER framework for formulating research question.

SPIDER Category	General Definition	Applied to this Scoping Review
<u>S</u>ample	Who is the group being studied?	Post-stroke patients included in research studies measuring fatigue
<u>P</u>henomenon of Interest	What are the reasons for examining this sample?	Communication disorders and fatigue both highly prevalent in post-stroke patients
<u>D</u>esign	How have the data been collected?	Interviews, rating scales, observation
<u>E</u>valuation	What is the outcome being impacted?	<u>Primary:</u> Inclusion and exclusion of patients with communication disorders <u>Secondary:</u> Methods used to identify communication disorders and measure fatigue
<u>R</u>esearch type	What type of research is included?	Qualitative, quantitative, mixed methods.

Table 2. Selection and eligibility criteria for systematic scoping review

SPIDER Category	Related Eligibility Criteria	How Applied
<u>S</u>ample	Adults with stroke are included as a target population in the study.	If no, study was excluded.
<u>P</u>henomenon of Interest	Study includes at least one participant with type of stroke likely to be associated with communication disorders (e.g., left hemisphere MCA stroke).	If no, study was excluded.
	Study provides an operational definition of fatigue/sleepiness.	If no, study was excluded.
	Study defines fatigue/sleepiness in terms related <i>only</i> to physical activity.	If yes, study was excluded.
<u>D</u>esign	Study includes at least 1 quantitative or qualitative measure of fatigue/sleepiness.	If no, study was excluded.
	Study measured fatigue/sleepiness in participants post-stroke and at the time of study data collection (e.g., not retrospective data from chart review).	If no, study was excluded.
<u>R</u>esearch type	Study design is quantitative, qualitative, or mixed methods.	If no, study was excluded.

Table 3. Critical appraisal criteria

NOTE: Given the nature of a scoping review, the focus of critical appraisal was only to evaluate the methodological quality of the selected studies’ inclusion/exclusion criteria.

Criterion	Type of Bias	Scale	How Applied
Participant characteristics are adequately described to determine whether or not aphasia/speech/language/communication disorder was included or excluded from the study. <ul style="list-style-type: none">Defined as a discussion of inclusion/exclusion criteria with enough detail to include some mention of aphasia/speech/language/communication disorder.	Reporting bias	1 (yes) 2 (no)	If no, study was excluded.

Table 4. Frequency of tests used to identify communication disorders. Note: Studies that used multiple measures and are represented more than once on this table, whereas studies that used other methods (e.g., previous diagnosis) are not included here.

		# studies reporting
Specific Language and Aphasia Tests	Token Test (TT)	8
	Frenchay Aphasia Screening Test (FAST)	2
	Boston Naming Test (BNT)	1
	Brief Aphasia Checklist (BACL)	1
	The Aphasia Scale (AS)	1
	Boston Diagnostic Aphasia Exam (BDAE)	1
	Sheffield Screening Test for Acquired Language Disorders (SSTALD)	1
	Chapman Reading Task (CRT)	1
	Ullevål Aphasia Screening Test	1
	Western Aphasia Battery	1
General Stroke Screening Measures	NIH Stroke Scale (NIH)	8
	Scandinavian Stroke Scale (ScSS)	1
	Stroke Impact Scale (SIS)	1
	Stroke Impairment Assessment Set (SIAS)	1
	Stroke Levity Scale (SLS)	1

Table 5. Frequency of sleepiness/fatigue measures. Note: Studies that used multiple measures are represented more than once on this table, whereas other studies that did not use published measures are not included here.

		# studies reporting
Commonly used (10% or more)	Fatigue Severity Scale (FSS)	50
	Epworth Sleepiness Scale (ESS)	21
Rarely used (3-9%)	Multidimensional Fatigue Inventory (MFI)	15
	Fatigue Assessment Scale (FAS)	17
	Visual Analog Fatigue Scale (VAFS)	9
	Checklist of Individual Strength (CISSF)	6
	RAND 36-Item Health Survey Questionnaire (RAND)	5
Very rarely used (fewer than 3%)	Stanford Sleepiness Scale (SSS)	5
	Profile of Mood States (POMS)	4
	Stroke-Specific Quality of Life Scale (SS-QOL)	3
	Fatigue Impact Scale (FIS)	3
	Short Form Health Survey (SFHS)	2
	Utrecht Scale for Evaluation of Clinical Rehabilitation (USER)	2
	Berlin Questionnaire (BQ)	2
	Assessment Tool for Long-Term Consequences After Stroke (ACAS)	1
	Barthel Index (BI)	1
	Borg Scale (BS)	1
	Canadian Neurological Scale (CAN)	1
	Detection Fatigue List (DLF)	1
	Goteborg Quality of Life Instrument (GQLI)	1
	Greater Manchester Stroke Assessment Tool (GM-SAT)	1
	Newcastle Stroke-Specific Quality of Life Measure (NEWSQOL)	1
	Riks-Stroke Questionnaire (RSQ)	1
	Self-Assessment Questionnaire for Mental Fatigue (SQfMF)	1
	Sheffield Profile for Assessment and Referral to Care (SPARC)	1
	Stroke Survivor Needs Survey (SSNS)	1
	Karolinska Sleepiness Scale (KSS)	1
	Mental Fatigue Scale	1
	PROMIS Fatigue Scale	1

Figure 1. Flow diagram of study selection.

Figure 2. Percentage of studies that specifically included and excluded communication disorders (A), methods of identifying communication disorders (B), purposes of measuring fatigue (C), and methods of measuring fatigue (D).

Appendix A

PubMed search strategy

Number	Search terms
#1	Search fatigue[MH]
#2	Search ((sleepy[TIAB] OR sleepiness[TIAB] OR drows*[TIAB] OR drowsy[TIAB] OR drowsiness[TIAB] OR tired[TIAB] OR tiredness[TIAB] OR fatigue[TIAB] OR fatigued[TIAB] OR fatiguing[TIAB]))
#3	Search #1 OR #2
#4	Search ((intracranial hemorrhages[MH]) OR brain ischemia[MH]) OR stroke[MH]
#5	Search (((stroke[TIAB]) OR strokes[TIAB]) OR "post stroke"[TIAB]) OR "post-stroke"[TIAB]) OR poststroke[TIAB]
#6	Search (("post stroke fatigue"[TW]) OR "post-stroke fatigue"[TW]) OR "poststroke fatigue"[TW]
#7	Search #4 OR #5 OR #6
#8	Search #3 AND #7
#9	Search ("stroke rate"[TIAB] OR "stroke volume"[TIAB] OR swim[TIAB] OR swimming[TIAB] OR "muscle fatigue"[TIAB] OR "fatigue of materials"[TIAB] OR "heat stroke"[TIAB] OR heatstroke[TIAB] OR "sun stroke"[TIAB] OR "sunstroke"[TIAB])
#10	Search #8 NOT #9

Appendix B

Data extracted from studies that allowed persons with communication disorders (A); studies that excluded persons with communication disorders (B); and studies that excluded persons with severe communication disorders (C). Full references for these studies are included as Appendix C.

A

Authors	Publication Year	General Study Design	Sample Source	Method to Measure Fatigue	Purpose of Fatigue Measure	Method to Identify CD	Inclusion or Exclusion of PWCD	Verified Inclusion of PWCD
Alshaer, et al.	2018	I	RC	SRS	Cha	PD	ALLOW	NR
Andersen et al.	2012	D	H	SRS	Cha	PD	ALLOW	Y
Andrew, et al.	2014	D	C	SRS	Out	PSR	ALLOW	Y
Appelros	2006	D	M	SI	Out	GSS	ALLOW	Y
Bassetti, et al.	1999	D	H	SRS	Out	GSS	ALLOW	NR
Beaver, et al.	2016	I	H	SRS	Cha	PD	ALLOW	NR
Benbir, et al.	2012	I	H	SRS	Cha	GSS	ALLOW	Y
Bernhardt, et al.	2008	I	H	SRS	Out	EO	ALLOW	Y
Broussy, et al.	2019	D	H	SRS	Out	NR	ALLOW	Y
Bruhwyler, et al.	1997	I	H	ORS	Cha	EO	ALLOW	Y
Buck, et al.	2004	D	M	M	Out	GSS	ALLOW	Y
Burton, et al.	2010	D	H	SRS	Out	PSR	ALLOW	Y
Dawes, et al.	2006	D	RC	M	Out	SLAT	ALLOW	Y
Fens, et al.	2015	D	C	SI	Cha	PD	ALLOW	Y
Flinn, et al.	2010	D	C	SI	Out	PD	ALLOW	Y
Glader, et al.	2002	D	C	SRS	Out	PSR	ALLOW	Y
Groeneveld, et al.	2019	D	RC	SRS	Cha	SLAT	ALLOW	Y
Harris, et al.	2009	I	H	SRS	Out	PD	ALLOW	NR
Hoang, et al.	2012	D	RC	M	Out	EO	ALLOW	Y
Hofer, et al.	2014	I	C	SRS	Cha	SLAT	ALLOW	Y
Kristensen, et al.	2016	D	C	SRS	Out	PD	ALLOW	Y
Kruihof, et al.	2016	D	RC	M	Cha	PD	ALLOW	Y
Magee, et al.	2002	I	M	ORS	Cha	PD	ALLOW	NR

Mayo, et al.	2004	D	C	SRS	Out	NR	ALLOW	NR
Michael, et al.	2006	D	C	M	Out	GSS	ALLOW	NR
Michael, et al.	2007	D	C	SRS	Out	PD	ALLOW	NR
Morsund, et al.	2019	D	H	SRS	Out	SLAT	ALLOW	NR
Mutai, et al.	2017	D	H	SRS	Out	GSS	ALLOW	Y
Naess, et al.	2012	D	H	SRS	Out	PD	ALLOW	Y
Nguyen, et al.	2019	I	RC	SRS	Qual	NR	ALLOW	NR
Oliveira, et al.	2018	D	H	SRS	Out	NR	ALLOW	Y
Parra, et al.	2015	I	H	SRS	Out	PD	ALLOW	Y
Riley et al.	2019	D	C	SRS	Out	SLAT	ALLOW	Y
Ryan, et al.	2000	D	C	SRS	Term	PD	ALLOW	NR
Ryan, et al.	2011	I	RC	M	Cha	PD	ALLOW	NR
Sarfo, et al.	2018	I	H	SRS	Out	GSS	ALLOW	NR
Sico, et al.	2017	I	H	M	Out	PD	ALLOW	NR
Siengsukon, et al.	2009	I	M	SRS	Cha	PD	ALLOW	Y
Simpson, et al.	2018	D	RC	SRS	Out	PD	ALLOW	Y
Skånér, et al.	2007	D	C	SRS	Out	PD	ALLOW	NR
Ten Brink, et al.	2017	D	RC	SRS	Out	PD	ALLOW	NR
Tistad, et al.	2012	D	H	SI	Out	GSS	ALLOW	Y
van de Port, et al.	2006	D	RC	SRS	Out	SLAT	ALLOW	NR
Van Wijk, et al.	2006	D	RC	SRS	Out	SLAT	ALLOW	Y
Van Zandvoort, et al.	1998	D	H	SI	Out	SLAT	ALLOW	NR
Vock, et al.	2002	D	H	SRS	Qual; Cha	PD	ALLOW	Y
Walsh, et al.	2015	D	C	SRS	Out	PD	ALLOW	Y
Westergren	2008	D	H	SRS	Out	PD	ALLOW	Y
Yang, et al.	2013	D	RC	SRS	Cha	PD	ALLOW	Y

B

Authors	Publication Year	General Study Design	Sample Source	Method to Measure Fatigue	Purpose of Fatigue Measure	Method to Identify CD	Inclusion or Exclusion of PWCD	Verified Inclusion of PWCD
Badaru, et al.	2013	D	H	SRS	Out	PD	EXCL	NR
Chen, et al.	2018	D	H	SRS	Out	PD	EXCL	NR
Chestnut	2011	D	H	SRS	Out	NR	EXCL	NR
Dharmakulaseelan, et al.	2019	I	C	SRS	Out	NR	EXCL	NR
Drummond, et al.	2017	D	H	SRS	Cha	NR	EXCL	NR
Graber, et al.	2019	D	H	SRS	Out	NR	EXCL	NR
Herron, et al.	2018	I	C	SRS	Out	NR	EXCL	NR
Hubacher, et al.	2012	D	RC	SRS	Out	EO	EXCL	NR
Kellett, et al.	2014	D	RC	SRS	Out	PD	EXCL	NR
Kim, et al.	2017	D	H	SRS	Out	NR	EXCL	NR
Kozlowski, et al.	2015	D	C	ORS	Out	NR	EXCL	NR
Lamb, et al.	2013	D	H	SRS	Out	SLAT	EXCL	NR
Lau, et al.	2017	D	H	SRS	Cha	NR	EXCL	NR
Lynch, et al.	2007	D	RC	M	Out	NR	EXCL	NR
Maris, et al.	2018	I	RC	SRS	Cha	NR	EXCL	NR
Marsh, et al.	2018	D	H	SRS	Cha	NR	EXCL	NR
Nakase, et al.	2016	D	H	SRS	Cha	NR	EXCL	NR
Pajediene, et al.	2020	D	H	SRS	Out	NR	EXCL	NR
Park, et al.	2009	D	C	SRS	Out	NR	EXCL	NR
Parks, et al.	2012	D	H	SRS	Out	NR	EXCL	NR
Patel, et al.	2018	I	H	SRS	Cha	NR	EXCL	NR
Ramirez-Moreno, et al.	2019	D	H	SRS	Cha	PD	EXCL	NR
Redgrave, et al.	2018	I	C	SRS	Out	NR	EXCL	NR
Reeves, et al.	2014	D	H	M	Out	NR	EXCL	NR
Rothwell, et al.	2013	D	C	SI	Out	NR	EXCL	Y*
Saengsuwan, et al.	2014	D	H	SRS	Out	NR	EXCL	NR
Schepers, et al.	2006	D	RC	SRS	Out	NR	EXCL	NR
Schepers, et al.	2009	D	RC	SRS	Out	PD	EXCL	NR

Shiina et al.	2019	D	H	SRS	Out	EO	EXCL	NR
Suh, et al.	2014	D	H	SRS	Out	NR	EXCL	NR
Tang, Lu, Mok, et al.	2011	D	H	SRS	Out	NR	EXCL	NR
Tang, Lu, Liang, et al.	2011	D	H	SRS	Out	NR	EXCL	NR
Tang, et al.	2013	D	H	SRS	Out	SLAT	EXCL	NR
Tang, et al.	2015a	D	H	SRS	Out	NR	EXCL	NR
van de Port, Kwakkel, Bruin, et al.	2007	D	RC	SRS	Out	SLAT	EXCL	NR
van de Port, Kwakkel, Schepers, et al.	2007	D	RC	SRS	Out, Cha	NR	EXCL	NR
Van Vugt, et al.	2014	I	RC	SRS	Cha	NR	EXCL	NR
Van Vugt, et al.	2016	I	RC	SRS	Cha	PD	EXCL	NR
Vuletić, et al.	2011	D	H	SRS	Out	NR	EXCL	NR
Wendel, et al.	2008	D	C	SRS	Out	GSS	EXCL	NR
Zedlitz, et al.	2011	D	M	SRS	Out	SLAT	EXCL	NR

C

Authors	Publication Year	General Study Design	Sample Source	Method to Measure Fatigue	Purpose of Fatigue Measure	Method to Identify CD	Inclusion or Exclusion of PWCD	Verified Inclusion of PWCD
Aaronson, et al.	2015	D	RC	SRS	Out	PD	S-EXCL	NR
Aaronson, et al.	2016	I	RC	SRS	Cha	NR	S-EXCL	NR
Bakken, et al.	2012	D	H	SRS	Cha	PD	S-EXCL	NR
Barbour, et al.	2012	D	H	M	Out	NR	S-EXCL	NR
Başkurt, et al.	2017	D	H	SRS	Out	NR	S-EXCL	NR
Bezeij, et al.	2016	I	RC	SRS	Cha	NR	S-EXCL	NR
Byun, et al.	2020	D	C	SRS	Out	NR	S-EXCL	NR
Carlsson, et al.	2004	D	NR	SI	Out	EO	S-EXCL	NR
Carlsson, et al.	2009	D	H	SI	Out	NR	S-EXCL	NR
Chen, et al.	2015	D	H	SI	Out	NR	S-EXCL	NR
Choi-Kwon, et al.	2005	D	RC	SRS	Out	NR	S-EXCL	Y

Choi-Kwon, et al.	2007	I	RC	SRS	Out	NR	S-EXCL	NR
Choi-Kwon, Choi, et al.	2017	D	H	SRS	Out	NR	S-EXCL	NR
Choi-Kwon, Ko, et al.	2017	D	H	SRS	Out	NR	S-EXCL	NR
Christensen, et al.	2008	D	H	SRS	Out	NR	S-EXCL	NR
Dam, H.	2001	D	H	SRS	Out	PD	S-EXCL	NR
de Coster, et al.	2005	D	H	SRS	Out	SLAT	S-EXCL	NR
Delva, I	2018	D	NR	SRS	Cha	PD	S-EXCL	NR
Douven, et al.	2017	D	H	SRS	Cha	NR	S-EXCL	NR
Duncan, et al.	2014	D	M	SRS	Cha	NR	S-EXCL	NR
Elgh, et al.	2019	D	C	SRS	Out	NR	S-EXCL	NR
Emery	2015	I	C	SRS	Qual; Cha	PD	S-EXCL	NR
Hsieh, et al.	2011	I	H	SRS	Cha	NR	S-EXCL	NR
Huang, et al.	2016	I	H	SRS	Qual; Cha	NR	S-EXCL	NR
Hummel, et al.	2006	I	NR	SRS	Cha	PD	S-EXCL	NR
Ikuno, et al.	2012	I	RC	SRS	Out	NR	S-EXCL	NR
Ingles, et al.	1999	D	C	SRS	Out	NR	S-EXCL	NR
Khan, et al.	2017	D	RC	SRS	Out	NR	S-EXCL	NR
Kim, et al.	2015	D	H	SRS	Out	NR	S-EXCL	NR
Kutlubaev, et al.	2013	D	O	SRS	Out	NR	S-EXCL	NR
Lerdal, et al.	2011	D	H	SRS	Out	EO	S-EXCL	NR
Lerdal, et al.	2012	D	H	SRS	Out	PD	S-EXCL	NR
Liu	2016	D	H	SRS	Cha	SLAT	S-EXCL	NR
Loureiro, et al.	2017	I	C	SRS	Out	NR	S-EXCL	NR
Mazure, et al.	2014	D	O	SRS	Cha	NR	S-EXCL	NR
McKechnie, et al.	2010	D	H	SRS	Out	NR	S-EXCL	NR
Mead, et al.	2007	D	M	SI	Out	EO	S-EXCL	NR
Medeiros, de Bruin, Paiva, et al.	2011	D	H	SRS	Out	EO	S-EXCL	NR
Medeiros, de Bruin, de Castro-Silva, et al.	2011	D	H	SRS	Out	NR	S-EXCL	NR

Miller, et al.	2013	D	M	SRS	Out	PD	S-EXCL	NR
Palsdottir, et al.	2020	I	H	SRS	Out	NR	S-EXCL	NR
Pihlaja, et al.	2014	D	H	SRS	Cha	SLAT	S-EXCL	NR
Ponchel, et al.	2016	D	H	SRS	Cha	NR	S-EXCL	NR
Röding, et al.	2003	D	NR	SI	Out	NR	S-EXCL	NR
Rogeanu, et al.	2014	D	RC	M	Out	SLAT	S-EXCL	NR
Sarfo, et al.	2017	D	RC	SRS	Out	NR	S-EXCL	NR
Smith, et al.	2008	D	RC	SRS	Out	NR	S-EXCL	NR
Spalletta, et al.	2005	D	H	SRS	Out	EO	S-EXCL	NR
Sterr, et al.	2018	D	C	SRS	Out	NR	S-EXCL	NR
Stokes, et al.	2011	D	C	SRS	Out	EO	S-EXCL	NR
Tang, Chen, et al.	2014	D	H	SI	Cha	NR	S-EXCL	NR
Tang, Liu, et al.	2014	D	H	SI	Out	NR	S-EXCL	NR
Tang, et al.	2015b	D	H	SRS	Cha	NR	S-EXCL	NR
Terroni, et al.	2009	D	H	SRS	Out	NR	S-EXCL	NR
Thompson, et al.	2009	D	O	SI	Out	PD	S-EXCL	NR
Türkbey, et al.	2017	I	RC	SRS	Cha	NR	S-EXCL	NR
van de Port, van den Bos, et al.	2007	D	RC	SRS	Out	NR	S-EXCL	NR
van de Port, et al.	2008	D	C	SRS	Out	EO	S-EXCL	NR
van der Zee, et al.	2013	D	RC	ORS	Out	PD	S-EXCL	NR
Van Rijsbergen, et al.	2019	D	H	SRS	Out	NR	S-EXCL	NR
Van Rijsbergen, et al.	2020	D	H	SRS	Out	NR	S-EXCL	NR
Wang, et al.	2014	D	H	SRS	Out	PD	S-EXCL	NR
West, et al.	2019	I	H	SRS	Out	EO	S-EXCL	NR
White, et al.	2012	D	C	SI	Out	EO	S-EXCL	NR
Widar, et al.	2004	D	H	SI	Out	NR	S-EXCL	NR
Williams, et al.	1999	D	H	SI	Out	GSS	S-EXCL	Y
Winkens, Van Heugten, Wade, et al.	2009	I	M	SRS	Out	NR	S-EXCL	NR

Winkens, Van Heugten, Fasotti, et al.	2009	D	RC	SRS	Out	EO	S-EXCL	NR
Worthington, et al.	2017	D	H	M	Out	SLAT	S-EXCL	NR
Yayla, et al.	2016	D	O	SRS	Out	NR	S-EXCL	NR
Zhang, et al.	2019	D	H	SRS	Out	EO	S-EXCL	NR

CD = Communication disorder; PWCD = person with communication disorder;

D = Descriptive; I = Intervention;

RC = rehabilitation or outpatient clinic; H = hospital; C = community;

SRS = self-report scale; SI = structured interview; ORS = observer rated scale;

Out = study outcome; Cha = change over time; Qual = to qualify; Term = to terminate task;

PD = previous or physician's diagnosis; GSS = general stroke screening; EO = experimenter observation; SLAT = specific language/aphasia test; PSR = patient self-report;

ALLOW = speech-language disorder allowed; EXCL = all speech-language disorders excluded; S-EXCL = severe speech-language disorders excluded

Y = yes; N = no; NR = Not reported; M = multiple sources or methods

Appendix C.

References for articles listed in Appendix B

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