Relationship Between Sleep and Depression in Individuals with Post-Stroke Aphasia

by

Kaitlin Zarbis

B.A., Speech and Hearing Science, The Ohio State University, 2021

Submitted to the Graduate Faculty of the

School of Health and Rehabilitation Sciences in partial fulfillment

of the requirements for the degree of

Master of Science in Speech-Language Pathology

University of Pittsburgh

2023

UNIVERSITY OF PITTSBURGH

SCHOOL OF HEALTH AND REHABILITATION SCIENCES

This thesis was presented

by

Kaitlin Zarbis

It was defended on

March 17, 2023

and approved by

Sarah E. Wallace, Ph.D., CCC-SLP, ASHA-Fellow, Professor and Director of Master's Degree Program in Speech-Language Pathology, Department of Communication Science and Disorders, University of Pittsburgh

William Hula, Ph.D., CCC-SLP, Adjunct Assistant Professor, Department of Communication Science and Disorders, University of Pittsburgh

Rebecca Hunting Pompon, Ph.D., Assistant Professor, Department of Communication Sciences and Disorders, University of Delaware

Thesis Advisor: Michael Walsh Dickey, Ph.D., Professor, Communication Sciences and Disorders, University of Pittsburgh

Relationship Between Sleep and Depression in Individuals with Post-Stroke Aphasia

Kaitlin Zarbis, M.S.

University of Pittsburgh, 2023

Background: Many stroke survivors experience issues with their sleep following their stroke, such as difficulty falling asleep and staying asleep, or decreased sleep quality. Difficulties with sleep can also be related to and cause mental health obstacles, such as depression; at the same time, poor mental health can exacerbate and cause difficulties with sleep. It is very likely that people with aphasia (PWA) experience sleep impairments or disorders, which can impact their course of recovery and their mental health; however, there is a dearth of research that explores the relationship between sleep and depression in individuals with post-stroke aphasia. This study seeks to consider the association between self-reported sleep disturbance and self-reported depression symptoms while accounting for demographic, stroke, and language variables. Furthermore, this study provides preliminary findings exploring the correlations between self-reported sleep disturbance, sleep related impairments, fatigue, and depression in individuals with chronic post-stroke aphasia, while also commenting on the potential feasibility of specific self-report sleep questionnaires within the post-stroke aphasia population.

Procedures: This study includes an analysis of 72 PWA who completed measures of aphasia severity, depression, and sleep. Furthermore, this study includes seven PWA who completed subtests of the Comprehensive Aphasia Test; the Patient Reported Outcomes Measurement Information System (PROMIS) – Sleep Disturbance (SD), – Sleep Related Impairment (SRI), and – Fatigue; and the Patient Health Questionnaire – 8 (PHQ-8).

Results: The only statistically significant and meaningful predictor of PHQ-8 responses in the multiple regression model was PROMIS-SD Short Form 8a responses. Furthermore, positive correlations were revealed between self-reported sleep disturbance and depression (though modest), self-reported sleep related impairment and depression, self-reported fatigue and sleep disturbance, self-reported fatigue and sleep related impairment, and self-reported sleep disturbance and sleep related impairment. There was a weak negative correlation found between self-reported fatigue and depression.

Conclusions: Given this preliminary data, it is important to consider sleep, fatigue, and depression as potential factors impacting rehabilitation and overall quality of life in the post-stroke aphasia population.

Table of Contents

List of Tables

List of Figures

Preface

Upon entering my first Language and Brain Lab (LABLab) meeting, I was elated to learn that I had walked into a room of people that were passionate about science and the advancement of research related to post-stroke aphasia. I would like to thank the leader of LABLab and my master's thesis advisor, Dr. Michael Walsh Dickey, who was the individual that initially inspired me to pursue a master's thesis regarding a topic that I am deeply interested in. With the added bonus of chocolate procured for each of our bi-weekly lab meetings, Dr. Dickey offered feedback, instruction, and mentorship that helped my project to succeed.

I would also like to acknowledge the members of my master's thesis committee who devoted their time and energy in order to support me and my master's thesis project. Dr. Sarah Wallace provided funding for this research study and also guidance related to specific aspects of my procedure. Dr. William Hula offered excellent feedback and ideas throughout the course of my research study. Dr. Rebecca Hunting Pompon permitted me to analyze data that she had previously collected, allowing me to obtain more robust results related to variables of interest to me. Thank you all for your support throughout this process.

The two final people that I must specifically highlight and acknowledge are my fellow *Team Sleep* members: Hannah Fleytekh and Emily Goldberg. Hannah—thank you for attending our weekly team meetings, offering your thoughts and opinions, and for taking moments out of your busy days to organize data for analysis. I appreciate all of your efforts and your excitement to learn. Emily—thank you for informally acting as my co-thesis advisor. I am so grateful for your endless support and mentorship, and our *Team Sleep* efforts have been the highlight of my graduate school experience. I could not have done this without your confidence in me and this project!

1.0 Introduction

Stroke is a leading cause of disability in the United States, resulting in motoric and cognitive impairments that often require rehabilitation. Anywhere from 20% to 50% of stroke survivors experience post-stroke sleep disturbance(s) (Katzan et al., 2020b; Khot & Morgenstern, 2019), including insomnia (inability to fall asleep) and excessive daytime sleepiness. High quality sleep is associated with optimized memory and learning function (Deak & Stickgold, 2010), both of which are fundamental in supporting physical, occupational, and speech-language rehabilitation following brain injury (Dignam et al., 2017; Galski et al., 1993; Skidmore et al., 2010). Furthermore, several human and animal studies have identified sleep as a factor predicting post-stroke rehabilitation outcomes; however, these investigations have predominantly focused on physical recovery or overall stroke severity rather than cognitive or language recovery (Duss et al., 2017; Joa et al., 2017; Kim et al., 2015; Siengsukon & Boyd, 2008; Wallace et al., 2012; Zunzunegui et al., 2011).

Another factor affecting post-stroke rehabilitation outcomes is depression. Approximately one-third of individuals post-stroke are affected by depression at some point following their stroke, with the highest frequency of depression occurring within the first year following stroke (Towfighi et al., 2017). The first year following stroke is known to be a critical period of time where patients can demonstrate robust improvements from rehabilitation, partially driven by neuroplasticity; depression and its negative psychological and biological impacts can create a more challenging rehabilitation course.

Aphasia is an acquired language disorder commonly caused by a left-hemisphere stroke. It affects approximately two million Americans, resulting in devastating and lasting impairments in one's ability to produce and understand language (Simmons-Mackie, 2018). Given the aforementioned prevalence of sleep disorders post-stroke, it is highly likely that people with aphasia (PWA) also experience sleep disturbance, negatively affecting the course of their recovery and their ability to respond to language treatment and rehabilitation. Furthermore, approximately 60% of individuals with aphasia also experience depression, creating an additional rehabilitative threat for this clinical population (Kauhanen et al., 2000; Laures-Gore et al., 2020).

Impaired sleep is both a risk factor and a symptom of depression. While sleep difficulties are often considered secondary to the onset of depression, sleep also strongly influences both the development and trajectory of depression (Franzen & Buysse, 2008). This highlights a clear bidirectional relationship between sleep and depression, where a lack of sleep or a reduction in sleep quality can result in greater depressive symptoms, or, where an increase in depressive symptoms can result in a lack of sleep or reduction of sleep quality. With sleep impairment and depression appearing heavily in the post-stroke population, it is important to acknowledge the effects that these factors can have on individuals with aphasia and, potentially, their response to speech-language rehabilitation.

Comparing measures of sleep and measures of depression is a vital first step in exploring the relationship between self-reported sleep function and self-reported depression symptoms as well as the impact that these issues can have on the outcomes of PWA. Self-report measures specifically provide a clinically viable option for measuring sleep in vulnerable populations such as PWA; speech-language pathologists, who are at the forefront of treatment of PWA, can briefly administer self-report measures within a clinical setting in order to make the necessary referrals

and support the overall well-being of PWA, in reference to the goals and holistic values of the Life Participation Approach to Aphasia (LPAA) (Chapey et al., 2000). The Patient Health Questionnaire – 8 (PHQ-8) is a valid measurement of depression that has been used frequently and successfully in PWA. The Patient Reported Outcomes Measurement Information System (PROMIS) Sleep Disturbance (SD), Sleep Related Impairment (SRI), and Fatigue subscales are self-reported measures that have been created to qualitatively measure sleep disturbance and its impact during waking hours. While minimal studies have used existing measures of sleep function (such as the PROMIS) in the post-stroke aphasia population, the PROMIS Sleep and Fatigue subscales appear to be practical options due to their validity and utility among a variety of other patient populations, including post-stroke without aphasia diagnosis.

The current study aims to examine the association between self-reported sleep disturbance and self-reported depression symptoms while accounting for demographic, stroke, and language variables. Furthermore, the current study presents preliminary findings considering the correlations between self-reported sleep disturbance, sleep related impairments, fatigue, and depression in individuals with chronic post-stroke aphasia, as well as anecdotal commentary related to the feasibility of the PROMIS sleep and fatigue subscales for PWA.

1.1 Sleep: A Brief Overview

Sleep is a function vital for sustaining life. The reason that sleep is so vital is widely studied but remains poorly understood, although some of sleep's critical roles have emerged from cellular and molecular investigations. For example, sleep appears to eliminate toxins that accumulate in

the brain in waking states that occur between periods of sleep (Inoué et al., 1995; Xie et al., 2013). Sleep is also implicated in thermoregulation (McGinty & Szymusiak, 1990), energy conservation (Berger & Phillips, 1995), and immune system function (Everson, 1997). Beyond restorative functions, sleep contributes to processes supporting brain plasticity, such as long-term potentiation and long-term depression, which positively impacts learning and memory (Krueger et al., 2016; Rasch & Born, 2013; Yang et al., 2014).

Throughout the night, individuals typically cycle through two stages of sleep that are responsible for diverse processes and result in different amounts of types of brain activity. The first stage is Non-Rapid Eye Movement (NREM) sleep, and the second stage is Rapid Eye Movement (REM) sleep. NREM predominates the first half of a night's sleep, while more time is spent in REM during the latter half of the night.

NREM itself is further sub-divided into three additional stages: N1 (stage 1 NREM), N2 (stage 2 NREM), and N3 (stage 3 NREM). N1 is considered to be an intermediate phase between wake state and sleep, where breathing and muscle tone do not differ dramatically from the awake state. During this stage, alpha waves that are present while humans transition from wake to sleep are replaced with low-amplitude mixed frequency brain activity (Léger et al., 2018; Patel et al., 2022). During N2, heart rate and body temperature drop, with sleep being considerably "deeper." Sleep spindles, or a pattern of brainwaves that appear during NREM sleep originating in the thalamus, assist with inhibiting external sensory stimuli to promote a continued sleep state; they also play a crucial role in supporting memory and learning by promoting synapse formation and strengthening (Deak & Stickgold, 2010; Schönauer, 2018; Wilson & McNaughton, 1994). Finally, N3 is often referred to as slow-wave sleep, named largely due to the high amplitude and slow frequency delta wave activity observed with EEG during this stage (Patel et al., 2022). Slow wave

sleep plays an important role in learning and memory; however, the mechanisms supporting this relationship remain under active investigation (Léger et al., 2018).

In the latter half of the night, REM sleep arises and appears to be crucial in supporting learning and memory, although this concept is not fully understood at this time. Some findings suggest that REM sleep is required for non-declarative memory success (Karni et al., 1994) as well as spatial and contextual memory consolidation (Boyce et al., 2017), and complex or even emotionally-charged declarative memories (Smith & Rose, 1996). Other findings suggest that REM sleep facilitates the processing of emotional information, exhibiting the importance of REM sleep especially as it relates to mental health. A lack of REM sleep can be harmful regarding the consolidation of more positive emotional content, leading to mental health disorders as a result due to higher retention of negative memories as compared to memories related to positive or neutral events (Walker & van der Helm, 2009). The body of literature characterizing the role of REM sleep with regards to a variety of processes is vast, with more to eventually be discovered.

It is important to acknowledge that the sleep cycle does not remain steady throughout the human lifespan, with aging adults often experiencing varying degrees of change in the macro-elements of their sleep (overall sleep duration and duration of time spent in each sleep stage) and in the micro-elements of their sleep (the quantity and quality of sleep) (Mander et al., 2017). Changes can include a more disorganized and unstable pattern of sleep rise times and bedtimes (Conte et al., 2014), a lower capacity for sleep and overall sleep duration (Klerman & Dijk, 2008), and less time spent in NREM and REM cycles of sleep (Landolt et al., 1996; Van Cauter et al., 2000). It is unclear if the propensity for older adults to get less sleep is due to a decrease in functional sleep need, or if older adults require higher amounts of sleep but are physically incapable of getting this sleep (Mander et al., 2017); however, reduced duration in each sleep stage

has implications for overall learning and memory consolidation, given the purported role of sleep stages for successful cognitive functioning. Age-related changes in sleep become important to consider in discussing changes in sleep within the post-stroke aphasia population, due to the fact that the post-stroke aphasia population tends to be comprised of older adults. Thus, as the discussion of sleep within the post-stroke aphasia population continues, considerations related to potential age-related changes in sleep function prior to stroke need to be regarded.

1.1.1 Definitions of Four Sleep Disorders

According to the Centers for Disease Control and Prevention (CDC, 2022), four of the most major sleep disorders are insomnia, excessive daytime sleepiness, restless legs syndrome, and sleep-disordered breathing (also known as sleep apnea). Insomnia can manifest as difficulties initiating sleep itself or difficulties maintaining sleep; often times, excessive daytime sleepiness may occur alongside insomnia, where an individual faces functional impairment due to extreme sleepiness that occurs throughout the course of the day. Excessive daytime sleepiness can also occur when an individual gets a perceived "enough" hours of sleep, but still faces sleepiness and often falls asleep throughout the day (Marquez-Romero et al., 2014). Restless legs syndrome causes aching and pains throughout the legs that can only be satisfied through movement, resulting in difficulty falling asleep. Finally, sleep apnea—diagnosed as either obstructive sleep apnea (disordered breathing during sleep because of an upper airway obstruction) or central sleep apnea (disordered breathing during sleep due to the brain not properly communicating with the muscles that control your breathing)—results in sleep that does not feel particularly refreshing or restorative; in other words, many individuals with sleep apnea face poor sleep quality. While all

of these sleep disorders (among others not mentioned in this paper) impact different facets of an individual's sleep, these disorders have the potential to disrupt an individual's typical sleep-wake cycle and thereby society's defined "circadian" cycle (i.e., the norm that an individual sleeps at night and is awake during the day). Furthermore, sleep disorders can reduce the time that an individual stays asleep or influence them to sleep too long and result in overall decreased sleep satisfaction.

1.1.2 Sleep Outcomes Post-Stroke

As previously mentioned, anywhere from 20% to 50% of stroke survivors experience post-stroke sleep disturbances (Katzan et al., 2020b; Khot & Morgenstern, 2019); however, there is a scarcity of research within the realm of sleep disorders in stroke patients. Stroke patients often spend less time asleep, have reduced sleep efficiency (or, the percentage of time spent asleep while the individual remains in bed), have reduced slow wave sleep, have increased wakefulness throughout a night's sleep, and have increased sleep latency (or, the amount of time that it takes a person to fall asleep); furthermore, when sleep-disordered breathing is present, REM sleep is also reduced in this patient population (Terzoudi et al., 2009). Certain sleep disorders are very prevalent among stroke survivors; over half of stroke survivors endorsing post-stroke sleep disturbance report insomnia and the estimated prevalence of obstructive sleep apnea after stroke is over 70%, leading to outcomes such as excessive daytime sleepiness (Khot & Morgenstern, 2019).

Issues with sleep can persist long after initial acute stroke recovery (Khot & Morgenstern, 2019); however, these sleep issues are at their worst and initially present themselves when stroke patients are in critical care and intensive care units, where patients of all diagnoses have been

found to be severely sleep deprived as a result of extremely fragmented and inconsistent sleep due to the ICU environment and general psychological stress related to the patient's environment and medical acuity (Krachman et al., 1995; Weinhouse & Schwab, 2006). There is a need for strategies to be developed in order to manage these symptoms, especially since the utilization of sedative medication after stroke does not necessarily result in sleep quality improvement in stroke patients, even resulting in a deterioration of sleep quality for some (Iddagoda et al., 2020). It can be posited that sleep disruptions and disordered sleep in the early stages of recovery following stroke have the potential to also obstruct the neurological healing processes necessary for recovery.

High quality sleep is associated with optimized cognitive performance for memory and learning abilities (Deak & Stickgold, 2010), which are fundamental in supporting physical, occupational, and speech and language treatment responses following stroke (Dignam et al., 2017; Galski et al., 1993; Skidmore et al., 2010; Vallila-Rohter & Kiran, 2013). Studies that have explored this possible relationship between sleep and rehabilitation outcomes have mainly focused on physical recovery or changes in general stroke severity (Duss et al., 2017; Joa et al., 2017; Kim et al., 2015; Siengsukon & Boyd, 2008; Wallace et al., 2012; Zunzunegui et al., 2011). Stroke patients with untreated sleep disorders generally have been found to lack the motivation, energy, and concentration necessary to participate in intensive rehabilitation therapy (Wallace et al., 2012), yet investigations examining the relationship between sleep and acquired cognitive communication disorders following stroke (such as aphasia) are minimal. As more research arises exhibiting the important role of treating sleep for purposes of secondary stroke prevention (Khot & Morgenstern, 2019) more investigations leveraging sleep as an intervenable mechanism to support stroke recovery are needed, especially as it relates to the speech and language outcomes of PWA.

One of the few studies investigating the relationship between sleep and post-stroke aphasia completed night-time sleep polysomnography (a sleep study utilized to diagnose sleep disorders through brain waves, blood oxygen level, eye and leg movements, and heart rate and breathing during sleep) with 18 PWA (Greenberg & Dewan, 1969). The study found that PWA who exhibited greater speech-language improvement spent significantly more time in REM sleep than non-improving individuals. As aforementioned, REM sleep is hypothesized to play a role in non-declarative and declarative memory success and consolidation, two processes that are important for the acquisition and maintenance of speech and language skills during rehabilitative treatment. Thus, this study's findings exhibit the potential importance of REM sleep in the presence of aphasia language treatment.

A second study by Sarasso et al. (2014) examined brain wave recordings in PWA using electroencephalography (EEG) immediately the night before and the night after language intervention. There were several major findings from this study including increased slow wave activity throughout the night after Intensive Mouth Imitation and Talking for Aphasia Therapeutic Effects (IMITATE) intervention (a computer-assisted aphasia intervention based on imitation of words, phrases, and sentences), and a positive correlation between increased slow wave activity intervention and increased scores on the Repetition Subtest of the Western Aphasia Battery (Sarasso et al., 2014). This study offers an abbreviated window into the neural changes that may occur while PWA engage in language therapy and establishes promising evidence associating brain activity during sleep with treatment gains. Although both the Greenberg and Dewan (1969) and the Sarasso et al. (2014) studies are useful in beginning to paint a picture of how sleep function may contribute to post-stroke aphasia recovery, a gap in knowledge exists surrounding the prevalence and characterization of sleep function in the post-stroke aphasia population.

1.2 Depression: A Brief Overview

Depression is a term that encompasses a variety of diagnoses that are inclusive of depressive symptomology but differentiated by duration, timing, and etiology; mood dysregulation disorder, major depressive disorder, and persistent depressive disorder are all examples of depressive disorder diagnoses that feature feelings of sadness, emptiness, and irritability, as well as functional changes due to these feelings (American Psychiatric Association [APA], 2022). Major depressive disorder is the focus of this study, as this diagnosis is representative of what is typically referred to as depression. According to the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition, Text Revision (DSM-5 TR), diagnostic criteria for major depressive disorder includes presence of five or more symptoms during the same two-week period, with at least one of these symptoms being depressed mood or loss of interest or pleasure (APA, 2022). Other symptoms listed in the DSM-5 TR include weight loss or weight gain, fatigue or loss of energy, insomnia or sleeping too much, restlessness and/or being so slow that it is observable by others, difficulty concentrating, feelings of worthlessness, and recurrent suicidal ideation; symptoms result in distress and impairments in occupational, social, and other areas of day-to-day function. It is important, when diagnosing major depressive disorder, to separate feelings of grief or general sadness from major depressive disorder, as an episode of major depressive symptoms are more persistent and not tied to any specific thoughts or events as compared to someone experiencing grief or someone perceiving sadness as a part of the typical human experience; as well as this, those experiencing grief tend to preserve their self-esteem, whereas those experiencing major depressive disorder tend to have lower self-esteem characterized by feelings of worthlessness (APA, 2022).

1.2.1 Post-Stroke Depression

Along with sleep, depression is considered to be one of the most important neuropsychiatric consequences of stroke, with approximately one-third of stroke survivors experiencing major depression with the potential to impact their recovery and even cognitive function (Alajbegovic et al., 2014; Hackett et al., 2005). Depression has the potential to develop in the acute period following a stroke, but heightened depressive symptoms that are lengthier in duration have the potential to develop in the months following stroke as well (Angelelli et al., 2004; Gaete & Bogousslavsky, 2008). Despite these statistics and the implicated consequences of depression on stroke recovery, approximately 80% of diagnoses of depression are missed by non-psychiatric physicians in individuals post-stroke (House et al., 1989). A factor contributing to missed diagnosis of post-stroke depression may be presence of aphasia (Gaete & Bogousslavsky, 2008).

Compared to the general stroke population, depressive symptoms have been found to occur at a higher rate in PWA, although depression has been minimally addressed in aphasia rehabilitation research (Pompon et al., 2022). It has been found that higher severity depression is correlated to lesion proximity to the left anterior frontal pole, which is important to consider for PWA, given that individuals with aphasia likely have left frontal lobe lesions or left temporal lobe lesions (Alajbegovic et al., 2014; Robinson et al., 1984). It is extremely oversimplified to say that aphasia itself causes depression, but because communication abilities are so intertwined with self-identity, it should be highlighted that aphasia can facilitate depression due to potential social isolation and lack of healthcare accessibility for PWA (Morrison, 2016). Presence of depression along with diagnosis of aphasia post-stroke adversely affects stroke and aphasia outcomes in a

number of ways: behaviorally, an individual with aphasia and depression may lack the motivation to attend rehabilitative treatment; medically, an individual with aphasia may have a difficult time attending psychotherapy due to overall language deficits (Laures-Gore et al., 2020). With aphasia being one of the most misunderstood and unrecognized disorders among healthcare professionals (including therapists, psychologists, and other healthcare professions centered around mental health), it is very easy for the treatment of depression in PWA to be impacted by this misunderstanding; specifically, many mental health professionals are not equipped to work with PWA with expressive and/or receptive language deficits due to limited training in this area (Strong & Randolph, 2021).

Despite the impact that depression clearly has on PWA, individuals with aphasia are often excluded from studies exploring post-stroke depression, most likely due to troubles completing the self-report questionnaires commonly used in post-stroke depression assessment procedures, a trend that is also prevalent in much of the post-stroke research related to sleep (van Dijk et al., 2016). It has been estimated that depression exists in up to 60% of adults with aphasia post-stroke, but this remains only a rough estimate due to the frequent exclusion of PWA from studies exploring post-stroke depression (Flowers et al., 2016; Kauhanen et al., 2000).

1.2.2 Sleep and Depression: A Bidirectional Relationship

Impaired sleep has been found to be both a risk factor and a symptom of depression (Steiger & Pawlowski, 2019). As many of 90% of people with depression will have sleep quality complaints; at the same time, two thirds of people undergoing a major depressive episode will have difficulties initiating sleep, maintaining sleep, or have early-morning awakenings (Franzen

& Buysse, 2008). In their study, Franzen & Buysse (2008) studied the bidirectional relationship between sleep and depression in healthy neurotypical adults. Although it is most commonly believed that sleep quality deficits occur secondarily to depression, they found that sleep quality strongly influenced both onset and trajectory of depression. Jaussent et al. (2011) helped to confirm these findings, exhibiting that sleep disturbances often precede depression and that those who present with sleep disturbance are more likely to have increased depression severity. In fact, it has been found that individuals with insomnia are twice as likely to develop depression as compared to individuals with no sleep difficulties; furthermore, individuals that exhibit insomnia that is comorbid with depression are more likely to remain depressed, even with depression treatment being administered (Anderson & Bradley, 2013). Overall, their findings combined suggest that interventions targeting sleep quality could be useful in treating symptoms of depression, as sleep is not just a comorbidity of depression—it is also a prodromal symptom whose treatment can predict the outcome and even occurrence of depression (Fang et al., 2019).

This bidirectional relationship between sleep and depression directly applies to the post-stroke aphasia population due to the approximated prevalence of both sleep disturbances and disorders and depression following stroke. It is important to explore depression and sleep dysfunction together for PWA, as depression and sleep dysfunction often support or exacerbate one another, leading to poorer outcomes for those who experience them together. Exposing the relationships that may exist between sleep and depression in PWA can elucidate the impact that these factors have on the population of individuals with post-stroke aphasia so that aphasia rehabilitation can be advanced to include depression and sleep as aspects needing to be managed to conduct successful speech and language treatment.

1.2.3 Post-Stroke Fatigue

Sleepiness and fatigue are terms that are interrelated and often utilized interchangeably. However, sleepiness and fatigue are two distinct phenomena: while sleepiness normally requires quality sleep for recovery, fatigue instead requires physical and/or psychological rest in order to recover. The concept of fatigue is directly related to the category of systemic conditions impacting the entirety of the body as a whole, which is a category that is inclusive of major depression (Neu et al., 2011). Fatigue can be a result of medical or psychiatric illnesses, but also related to lifestyle and situational factors, such as experiencing an increase of stress (Jason et al., 2010). Two types of fatigue can manifest: nonpathological fatigue, lasting fewer than three months with an identifiable cause; or pathological fatigue, with greater intensity, duration, and impact to quality of life. It is much more difficult to diagnosis fatigue versus a sleep disorder, resulting in overall less evidence to guide diagnostic practices; this is because while sleep dysfunction can be measured objectively with very specific diagnostic criteria, fatigue is a much more subjective phenomena with a looser overall definition (Jason et al., 2010).

Similar to depression and sleep dysfunction, post-stroke fatigue is a common and multi-factorial syndrome of stroke that has a paucity of research, characterized by a poorly understood pathophysiology and a capability to greatly reduce quality of life (Acciarresi et al., 2014). Notably PWA are underrepresented in the literature revolving around post-stroke fatigue, despite the fact that someone who has experienced a stroke will likely experience more day-to-day fatigue (Riley et al., 2021). Speech-language pathologists frequently observe signs of fatigue in their patients with aphasia during speech-language therapy, but it is unknown if fatigue has an impact on speech-language treatment and rehabilitation (Riley, 2017). With fatigue being one of the symptoms of

depression, the two issues are interconnected; Snaphaan et al. (2011) found that higher post-stroke depressive symptoms correlated to increased risk of post-stroke fatigue, suggesting that fatigue in the post-stroke population can be described as more of a mental fatigue, rather than a physical fatigue. Given the chronic nature of aphasia, the mental distress of not getting enough sleep, and the symptomology of depression, it is important to consider fatigue as a contributing factor while examining the relationship between sleep dysfunction and depression in individuals with post-stroke aphasia.

1.3 Self-Report Measures of Sleep and Depression

1.3.1 Patient Reported Outcome Measurement Information System (PROMIS)

Sleep quality can be defined as "how well one sleeps" (*What Is Sleep Quality?*, 2020) and is often gauged by subjectively asking an individual to reflect on how rested they feel or how deep they believe that they slept. Sleep function can also be quantified by measuring duration of sleep (Suni & Singh, 2021), the amount of time that lapses between going to bed and falling asleep (sleep latency), or the number of times awake per night. There are several methods that can be utilized to measure sleep function, some approaches gathering objective information while others focus on subjective reports. Objective methods for measuring sleep function include functional imaging, actigraphy, and electrophysiology.

The current "gold standard" of objectively measuring sleep function is electrophysiology, which includes polysomnography, also colloquially known as a sleep study (Buysse et al., 2010).

Polysomnography (PSG) requires simultaneous electroencephalography (EEG), electrooculography (EOG), and electromyography (EMG, with nodes particularly placed on the chin and floor of mouth muscles) during waking hours in order to establish a baseline and then over the course of a night's sleep. EEG, EOG, and EMG all contribute to the process of sleep staging, or labeling what stage of sleep an individual is in at a given time throughout the night. Clearly, PSG (while the gold standard) requires specific equipment, trained technicians, and facilities to be implemented properly; these factors serve as obstacles for application of PSG in clinical and research settings. Furthermore, it can be posited that the equipment utilized to measure sleep via PSG may cause general discomfort for patients undergoing the study, even though PSG attempts to replicate the individual's natural sleep environment.

Reliable and valid self-reported measures of sleep function are necessary because they offer the potential to measure sleep function, quality, and disturbances regardless of setting and resources. While it is hard to capture such a complex process as sleep in a questionnaire, validated and reliable sleep questionnaires are practical and viable substitutes for gold-standard objective sleep function measures across clinical and research contexts. Of interest to this study, the Patient Reported Outcomes Measurement Information System (PROMIS) banks offer multiple established sleep-related scales that have been used successfully with several clinical populations, including post-stroke patients (Buysse et al., 2010).

The PROMIS Sleep Disturbance (SD), Sleep-Related Impairments (SRI), and Fatigue were developed as part of a National Institute of Health consortium. The PROMIS-SD measures specific self-reported symptoms of disrupted sleep quality; for instance, the PROMIS-SD asks questions regarding the various ways in which sleep can be disturbed. The PROMIS-SRI captures the consequences of sleep disturbance by asking questions about difficulties experienced during wake

as a result of disrupted sleep; for instance, the PROMIS-SRI may ask test-takers to rate their difficulty focusing due to disturbed sleep. The PROMIS-Fatigue examines a separate but related scope of subjective feelings, from feelings of tiredness to debilitating and sustained exhaustion; it seeks to measure the impact that these subjective feelings have on an individual's physical, mental, and social well-being.

The PROMIS-SD and SRI were specifically constructed as computerized, adaptive, and self-report questionnaires that target key health-outcome domains affecting a multitude of patient populations. The PROMIS scoring falls on the T-scale (μ=50, σ=10) and is standardized to the general United States adult population (Katzan et al., 2020a), with a larger score signifying more difficulty with the symptoms of interest. Grounded in item response theory, these PROMIS sub-questionnaires are psychometrically sound and have been used with several patient cohorts, such as cancer survivors (Jensen et al., 2017), health adolescents (Hanish et al., 2017), older adults in independent and continuing care communities (Full et al., 2019), adults and children with atopic dermatitis (Fishbein et al., 2020; Lei et al., 2020), individuals with idiopathic Parkinson's Disease (Jones et al., 2021), and—most importantly to the current study—the post-stroke population (Katzan et al., 2020a). While the PROMIS-SD and PROMIS-SRI are self-report questionnaires, short forms exist in order to decrease the administration time, especially in clinical contexts. Yu et al. (2011) found that the full PROMIS-SD and PROMIS-SRI item banks offered the greatest test information. However, the corresponding short forms correlated significantly with the full item banks, displaying that the long and short forms both adequately measure sleep disturbance and sleep-related impairment domains and exhibit acceptable reliability and validity (Yu et al., 2011). This is important to note because one participant group in the current study was administered the

PROMIS-SD Short Form 8a, whereas the other participant group was administered the PROMIS-SD in full.

The PROMIS-Fatigue has also been utilized with diverse chronic conditions, such as chronic obstructive pulmonary disease, back pain, heart failure, major depressive disorder, rheumatoid arthritis, and cancer (Cella et al., 2016); as the participants in this study decreased in fatigue, their PROMIS scores decreased as such, reflecting the ability of the PROMIS-Fatigue to adapt based on fatigue levels of the participant. Most notably, the PROMIS-Fatigue has been utilized successfully alongside the PROMIS-SD in Katzan et al.'s (2020b) study in which factors associated with the presence of sleep disturbance were analyzed in a large cohort of participants following stroke; participants who scored worse on the PROMIS-SD scale also scored worse for related health domains, including higher scores on measures of depression and on the PROMIS-Fatigue scale.

By administering the PROMIS-SD, SRI, and Fatigue to a sample of PWA, it can be determined whether or not these self-reported measures of sleep can be feasibly implemented to measure a PWA's level of sleep dysfunction, day-to-day impairment due to sleep dysfunction, and fatigue. This is one of the first studies administering these self-report measures in full to the population of individuals with aphasia post-stroke, and the results will help to establish a building block in this understudied domain among aphasia research by providing preliminary data related to feasibility of these sleep questionnaires as well as anecdotal feedback provided by PWA themselves. Assessing the clinical utility of existing tools measuring sleep function among the post-stroke aphasia population can shed light on the factors that moderate aphasia and its rehabilitation.

1.3.2 Patient Health Questionnaire – 8 (PHQ-8)

The Patient Health Questionnaire – 8 (PHQ-8) is a self-report screening tool for mental health disorders that asks patients to rank eight different items in accordance to being "not at all" true, true "several days," true "more than half the days," or true "nearly every day." While the PHQ-8 has not specifically been validated on individuals with aphasia following a stroke, it is a valid and well-established screening tool that has been utilized successfully with this cohort in previous studies (Barrett et al., 2022; Pompon et al., 2022). To speak to its validity as a depression instrument, Kroenke et al. (2009) sought to assess the PHQ-8 ad its feasibility among a large population-based study, where 198,678 participants comprised of both healthy normals and those experiencing a variety of health conditions were administered the PHQ-8; this study highlighted and confirmed that the PHQ-8 is a valid measure of depression severity, which can be utilized clinically as a diagnostic tool (Kroenke et al., 2009).

Most established questionnaires that gather information about depression from PWA are completed by caregiver-proxy report (see the Stroke Aphasic Depression Questionnaire; see the Aphasia Depression Scale). Because the goals of this study are focused on independent self-report, these measures of depression will not be used.

By comparing responses on the PHQ-8 to responses on the PROMIS-SD, PROMIS-SRI, and PROMIS-Fatigue, preliminary correlational data can be highlighted that elucidates the bidirectional relationship between sleep and depression that is proposed by this study to exist in PWA.

1.4 Experimental Questions and Hypotheses

While the PROMIS Sleep Disturbance, Sleep Related Impairment, and Fatigue have been successfully administered to individuals' post-stroke in order to illuminate the high prevalence and impact of sleep dysfunction following stroke, these previous studies have omitted PWA due to language hinderances. Furthermore, due to the bidirectional relationship between sleep dysfunction and depression, it can be posited that PWA who self-report sleep disturbances, sleep-related impairments, and fatigue on the PROMIS Sleep and Fatigue questionnaires will likely self-report depressive symptoms when administered the PHQ-8, which is designed to measure clinically depressive symptoms. By comparing responses on the PHQ-8 to responses on the PROMIS, the theorized correlation between sleep and mental health in PWA can be highlighted, when other variables of interest are held constant. This has the potential to advance the field's knowledge about how PWA's self-perceptions, mental well-being, and current communicative function can affect their ability to respond to speech therapy interventions, so that healthcare professionals (such as speech-language pathologists) can consider more holistic approaches to intervention.

The research questions posed in the current study are listed below:

(1) (Aim 1): Building upon data presented in Hunting Pompon & Cohen (2018), what is the association between self-reported sleep disturbance and self-reported depression symptoms while accounting for demographic, stroke, and language variables?

(2) (Aim 2): What preliminary relationships emerge when examining self-reported sleep disturbance, sleep related impairment, fatigue, and depression in individuals with post-stroke aphasia?

It was hypothesized that PWA self-reporting worse sleep disturbance would also self-report worse depression symptoms, given the known bidirectional relationship that exists between sleep and depression. Furthermore, it was hypothesized that there will be a significant (r >0.50) positive correlation between depressive symptoms and fatigue, due to major depression being a major indicator of higher levels of fatigue. There will also be a significant (r >0.50) positive correlation between depression symptoms and sleep disturbance—again, due to the bidirectional sleep and depression relationship.

While not a specific aim of this study, preliminary evidence regarding the feasibility of the PROMIS Sleep Disturbance, Sleep Related Impairment, and Fatigue will be explored with anecdotal feedback collected via feasibility questionnaires and a summary of the average levels of support necessary across PROMIS Sleep and Fatigue questionnaires.

2.0 Methods

2.1 Participants

This study includes two separate participant groups contributing to different aims. The first participant group was utilized to measure Aim 1 and consisted of 72 PWA recruited from either the Veterans Administration Health Care System – Puget Sound or the Northwest Aphasia Registry and Repository; this data was collected by Dr. Rebecca Hunting Pompon from September 2016 through March 2017. The second participation group was utilized to measure Aim 2 and consisted of seven PWA recruited via advertisement flyers posted at and around the University of Pittsburgh and email communication. All study sessions for this second participation group occurred over Zoom within the Pittsburgh Translational Aphasia Research Initiative (PTARI) lab space at the University of Pittsburgh. The University of Pittsburgh IRB approved data collection for this study.

For Aim 2 and goals related to feasibility, specifically, an a priori power analysis was conducted using the "pwr" package in R studio (Acciarresi et al., 2014). Champely et al. (2020) for sample size estimation, based on data from Katzan et al. (2020a) (n = 2,190), which associated scores on the PROMIS-SD with various demographic and health variables in a post-stroke sample. With a significance criterion of α =0.05, r= 0.75, and power = 0.80, the minimum sample size needed with this effect size was n=11 for Pearson correlation. Thus, given the number of participants collected for Aim 2, data presented for this aim is only preliminary.

2.1.1 Study Inclusion Criteria

Aim 1 participants met the following criteria: absence of degenerative neurological disease, dementia, psychiatric disorders, substance abuse, diffuse brain injury or disease, pregnancy, or adrenocortical dysfunction. All participants included were at least one-year post-stroke and were clinically diagnosed with aphasia; PWA with apraxia of speech were also included in the study.

Aim 2 participants met the following criteria: at least 18 years of age or older, use of English as their primary language, access to reliable internet and a webcam if opting to participate in the study virtually, and no presence of any other neurological deficits other than stroke (such as degenerative neurological disease, dementia, diffuse brain injury, or brain disease). All included participants included a clinical diagnosis of post-stroke aphasia by a licensed speech-language pathologist.

2.2 Procedures

2.2.1 Aim 1 Preliminary Procedures

Following screening measures to ensure inclusion in the study as well as the consent process, the 72 participants for Study Aim 1 completed the comprehension subtests (spoken and written language) of the Comprehensive Aphasia Test (CAT) in order to establish a clear picture of each participant's strengths and weaknesses across language comprehension domains, as well as to measure aphasia severity.

2.2.2 Aim 2 Preliminary Procedures

The seven participants of Aim 2 participated in studies virtually utilizing Zoom. After the consenting process was complete, participants completed a demographic questionnaire in order to provide screening information related to their stroke, clinical aphasia diagnosis, medications, any mental health or sleep clinical diagnoses, and prior speech-language pathology treatment. The demographic questionnaire was completed through Zoom's screen-sharing feature; the investigator shared the questionnaire and highlighted each question as it was being answered. These demographic questions are listed in Table 1. Participants then completed the comprehension and naming subtests of the CAT, in order to estimate overall aphasia severity and calculate modality T-Scores. This was also completed via Zoom's screen-sharing feature, utilizing an adapted version of the CAT in order for virtual presentation. Only CAT comprehension and naming subtests were used (with measures of repetition and writing being excluded) in order to examine the language skills that were most applicable to answering self-report questionnaires (skills such as selecting a labeled answer choice, comprehension of each statement).

Table 1. Demographic Questionnaire Items.

#	Question
1	Age
2	Biological Sex
3	Primary Language
4	Race and ethnicity
5	Highest education level completed
6	Work status
7	Do you usually use glasses to read or see?
8	Do you usually use hearing aids to hear?
9	Approximate date of stroke

10	Are you right or left-handed?
11	Have you ever been diagnosed with a neurological deficit other than stroke?
12	Have you ever been diagnosed with aphasia by a licensed SLP?
13	Have you ever received speech-language pathology services/treatment?
14	Have you ever been clinically diagnosed with depression?
	If yes, please elaborate (date/diagnosis)
15	Have you ever been clinically diagnosed with a sleep disorder?
	If yes, please elaborate (date/diagnosis)
16	Please list all medications actively taking.

2.2.3 Aim 1 Sleep and Depression Tasks

The 72 participants of Aim 1 were administered a wider range of self-report measures, including those related to stress and resilience; however, of interest to the current study, these participants were also administered the PHQ-8 and the PROMIS-SD Short Form 8a in order to answer questions related to depression and sleep disturbance.

2.2.4 Aim 2 Sleep and Depression Tasks

The seven participants of Aim 2 were administered the full PROMIS-SD (27 questions), PROMIS-SRI (16 questions), and PROMIS-Fatigue (95 questions) self-report questionnaires, along with the PHQ-8 (8 questions). Completion of these questionnaires outside of preliminary measures took approximately 60 minutes for each participant, with the PROMIS-Fatigue requiring the most amount of time for administration due to its longer length. According to guidance by HealthMeasures (www.healthmeasures.net), a measurement resource developed by the National

Institute of Health (NIH) in order to curate and distribute quality of life measures such as the PROMIS, modifications that can be made to the PROMIS without disrupting established validity and reliability include underlining, italicizing, and bolding of words, as well presenting the self-report items in a grid-like format, such as via a PowerPoint presentation. Thus, questions and statements for each of the questionnaires were presented via PowerPoint, with key words and phrases underlined and bolded within each sentence. The investigator shared their screen via Zoom with the participant and asked for confirmation of being able to see the shared screen. Instructions for each questionnaire and all questions or statements were presented verbally by the investigator. As well as this, the investigator provided directions regarding the ranking scale, indicating which number on the scale corresponded to a severity selection (e.g., 1 = not at all to 5 = very much). Each test bank item was presented on its own PowerPoint Slide. This, along with the bolding and underlining of key phrases, was done in order to aid the language comprehension of each participant, due to potential difficulties given aphasia diagnosis. Questionnaires were presented in a randomized order per participant in order to combat order biases.

2.2.4.1 Feasibility Hierarchy and Questionnaire

On each of the above measures utilized to self-report sleep and depression, the Communicative Support Hierarchy and Independence Rating Scale created by Tucker, Edwards, Mathews, Baum, and Connor (2012) was utilized in order to establish a standardized method of providing support to each participant when answering self-report questionnaires. The hierarchy is composed of five steps and ensures that a consistent approach to the level of support, prompting, cueing, and repetition was utilized for each question in order to aid PWA in overall comprehension of each question, as necessary (Tucker et al., 2012). Each test bank item was verbally presented to

the participant; then, as necessary, the steps of the Communicative Support Hierarchy were utilized. For example, if an individual exhibited difficulty in comprehending the question, the investigator began by repeating the question-and-answer choices; if more support was then deemed necessary by the investigator, the question was simplified and restated, and so on based upon the level of support necessary. The final step of the hierarchy includes moving onto the next question, if an answer is unable to be reliably selected by the participant. The steps of providing support are listed below in Table 2.

The Independence Rating Scale is a seven point rating scale that allows the examiner to rate the level of support that each participant needed during administration of each assessment, indicating the average level of support needed per subtest (Tucker et al., 2012). This is a subjective rating based upon the average level of support necessary as evidenced by the Communicative Support Hierarchy. For example, if someone primarily benefitted from repetition of question and answer choices (step 1 of the hierarchy), then their independent level would be deemed to be a six out of seven. The Independence Rating Scale is listed below in Table 3.

Table 2. Communicative Support Hierarchy, based on Tucker et al. (2012).

Step #	Level of Support
1	Repeat the question and choices
2	Simplify and restate the question, reviewing the choice scale once again
3	Re-explain the entire choice scale (e.g., “If you choose ‘Quite a bit.’ This means that in the past seven days, you have had a difficult time falling asleep”). Then, repeat the re-stated question
4	Combine a yes-no question with the scale (e.g., “Do you feel lousy quite a bit of a time? Yes, or no?”).
5	Move onto the next question.

Table 3. Independence Rating Scale, based on Tucker et al. (2012).

#	Rating of Support Needed
1	Does not produce response with maximal support
2	Maximal support necessary in order to answer the question
3	Combined yes-no question with the scale necessary
4	Re-explanation of the entire choice scale necessary
5	Simplification and restatement of question necessary
6	Repetition of question and choices needed
7	Responds to the question with no need for additional support

Following the administration of each self-report questionnaire, participants were also asked feasibility related questions, where they provided open-ended feedback, rated their difficulty completing each subtest, rated the instructions of each subtest, and rated how well each subtest described their overall feelings. Each feasibility questionnaire was also shared via Zoom's screen-sharing function. The questions related on the Feasibility Questionnaire Forms are listed in Appendix A.

2.3 Analysis

To address Aim 1, a multiple linear regression model was utilized, predicting the dependent variable PHQ-8 score from several independent variables: age, education, months post-onset, CAT comprehension score, and the short (8a) form of the PROMIS-SD. By using a multiple linear regression model, the best fit line between multiple independent variables and a dependent variable was determined in order to find the optimal values of the intercept and coefficients to minimize error, or misrepresentations of the data that was be explored. The CAT comprehension score,

PROMIS-SD, and PHQ-8 scores for each participant were transformed into Z-scores so that these scores could be measured on the same scale.

To address Aim 2, a Pearson Correlation Matrix was created in order to measure linear relationships between two different variables. A Pearson Correlation ranges from -1 to 1 and serves as an indication of strength of a relationship between the variables being examined. A coefficient between 0 and 1 suggests a positive correlation, where one variable changes and the other variable changes in the same direction. A correlation of 0 suggests absolutely no relationship between the variables being examined; as well as this, positive correlation values that are closer to 0 are considerably less strong than those closer to 1. A correlation between -1 and 0 represents a negative correlation, where one variable changes and the other variable changes in the opposite direction. By using Pearson Correlations, associations between PROMIS sub-test scores and PHQ-8 scores will be explored.

3.0 Results

In the following sections, descriptive and statistical findings are presented for the purpose of describing the findings related to Aims 1 and 2. All analyses were executed using R statistical programming software (R Core Team, 2021).

3.1 Aim 1: Association Between Self-Reported Sleep Disturbance and Self-Reported Depression

Aim 1 focused on exploring the association between self-reported sleep disturbance and self-reported depression symptoms while accounting for demographic, stroke, and language variables of interest. This aim extends previous work of Hunting-Pompon, and analyses were therefore conducted using the pre-existing sample of (n = 72) individuals with post-stroke aphasia. The means, medians, standard deviations (SD), minimum, and maximum values of this sample's continuous variables (age in years, education in years, time post-onset (TPO) in months, CAT Comprehension Score, PROMIS-SD Form 8a Score, and PHQ-8 Score) are summarized in Table 4. Distributions of these variables are displayed in Figure 1. Additionally, categorial variables of interest (handedness, race, and sex) are visualized in Figure 2.

Table 4. Aim 1 Summary Statistics

	Mean	SD	Min	Max	Median
Age (years)	64.5	10.91	33	84	65
Education (years)	16.2	3.16	12	26	16
TPO (months)	81.1	54	12	228	66.5
CAT (Out of 128)	99.89	18.65	33	126	103
PROMIS-SD 8a (Out of 40)	16.92	6.83	8	37	16
PHQ-8 (Out of 24)	5.92	3.52	0	17	6

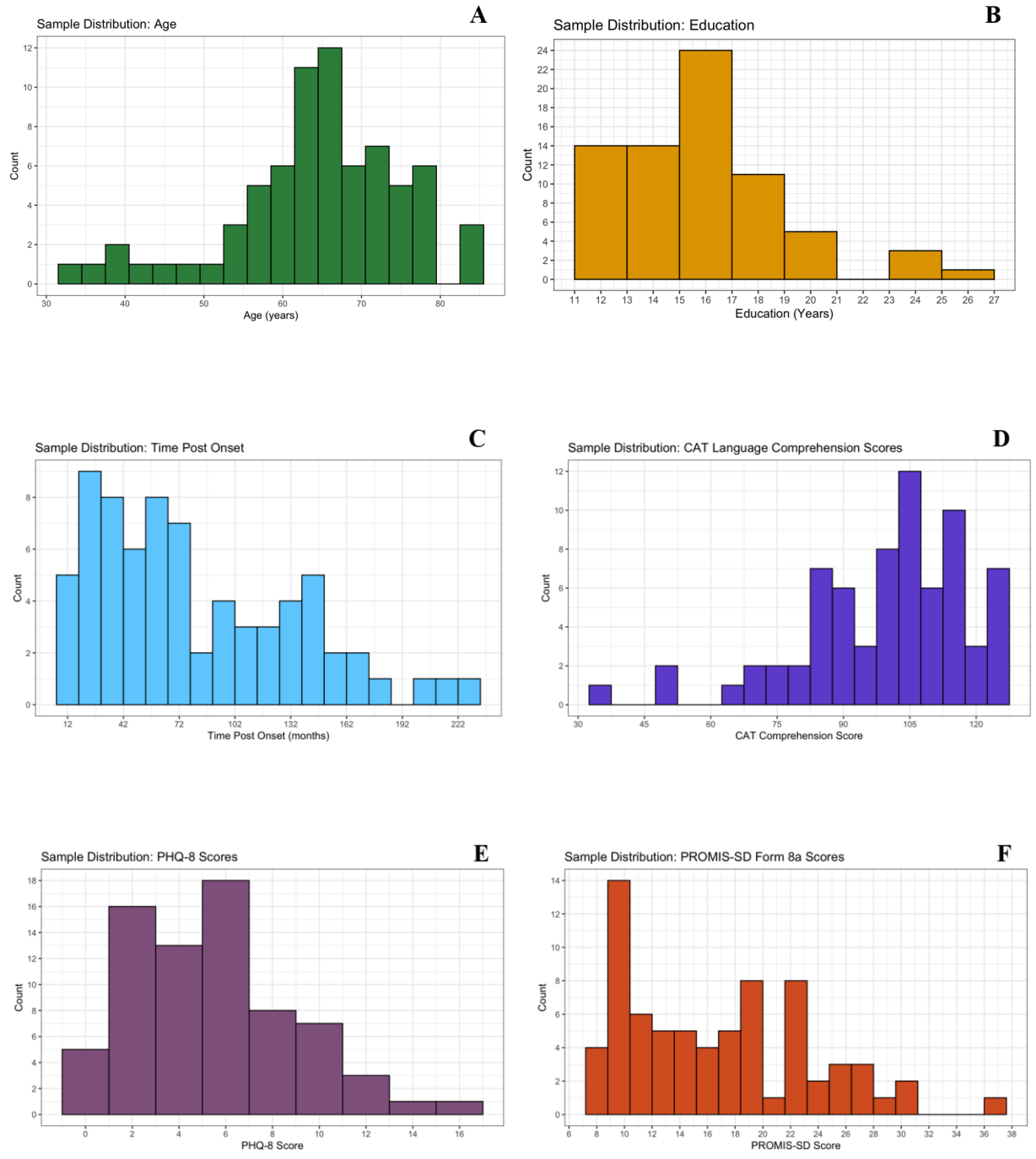

Figure 1. Aim 1 sample distributions across continuous variables of interest: (A) age (in years); (B) education (in years); (C) time post onset (in months); (D) CAT comprehension scores; (E) PHQ-8 scores; (F) PROMIS-SD scores.

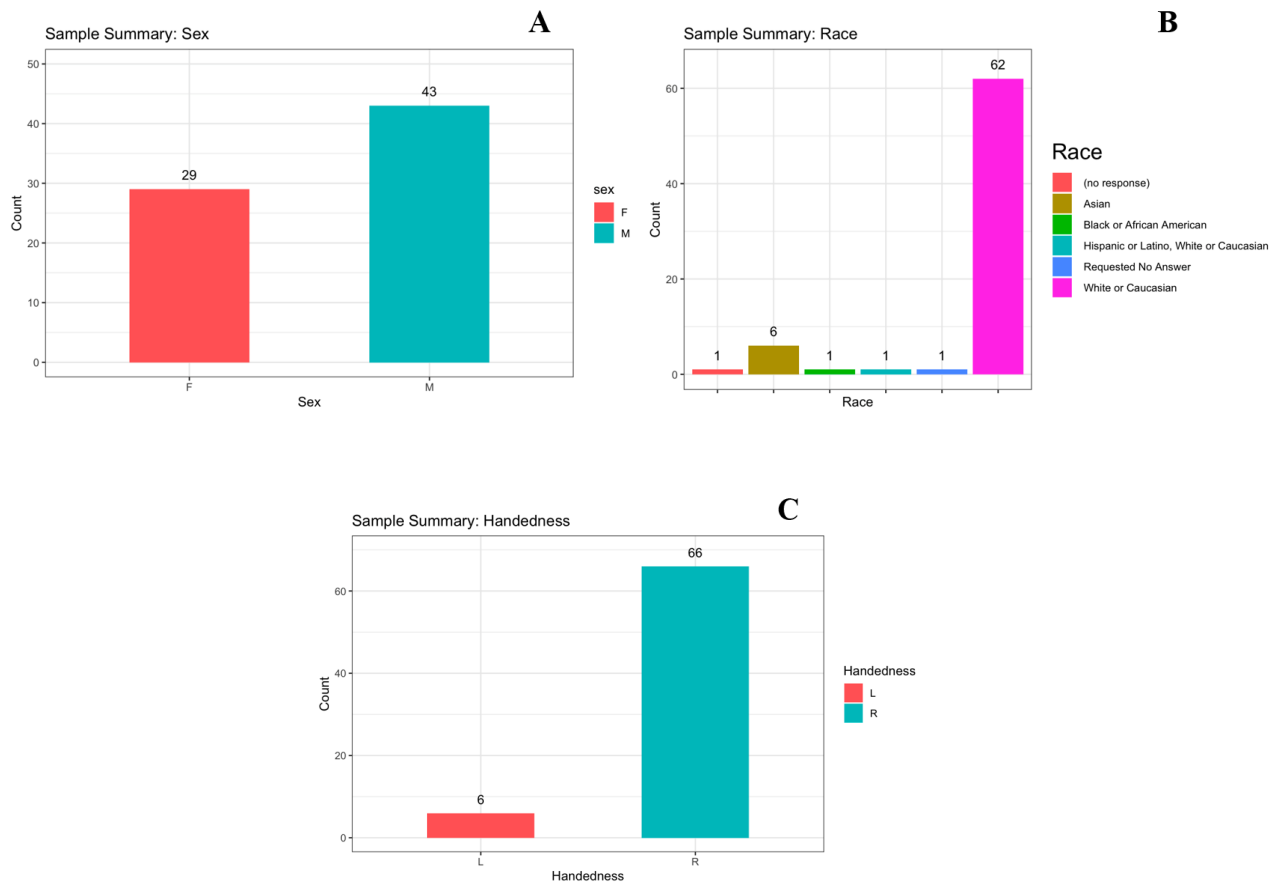

Figure 2. Aim 1 sample summary of categorial variables of interest: (A) sex; (B) race; and (C) handedness (post-stroke).

The multiple linear regression model predicting z-score transformed PHQ-8 values from age (years), education (years), months post-onset, z-scored CAT comprehension, and z-scored PROMIS-SD reached statistical significance [$R^2 = 0.265$, $F = 4.735$ (df: 5, 66), $p<0.001$). Table 5 displays model coefficients, standard error values, t-values, and p-values.

Table 5. Multiple linear regression model coefficients, standard error values, t-values, and p-values

	Estimate	Standard Error	t-value	p-value
Intercept	1.57	0.75	2.10	0.04
Age (Years)	-0.017	0.01	-1.63	0.11
Education (Years)	-0.013	0.036	-0.36	0.72
TPO (months)	-0.004	0.002	-1.71	0.09
Z-score CAT	-0.15	0.11	-1.37	0.17
Z-score PROMIS-SD	0.49	0.11	4.46	3.26e-05

Overall, the following variables included in this model did not reach statistical significance: age (years), education (years), time post-onset (months), and z-scored CAT comprehensions cores. Relationships between these insignificant predictors and the outcome variable, PHQ-8 score, are displayed in Figure 3. Notably, all non-significant predictors had weak negative relationships with the dependent variable (z-scored PHQ-8). Ultimately, the only significant predictor of depression symptoms in the model was z-scored PROMIS-SD values (see Figure 4). Specifically, a meaningful positive association between PROMIS-SD and PHQ-8 scores was discovered, such that participants with aphasia who self-reported worse sleep disturbance were more likely to also self-report worse depression symptoms.

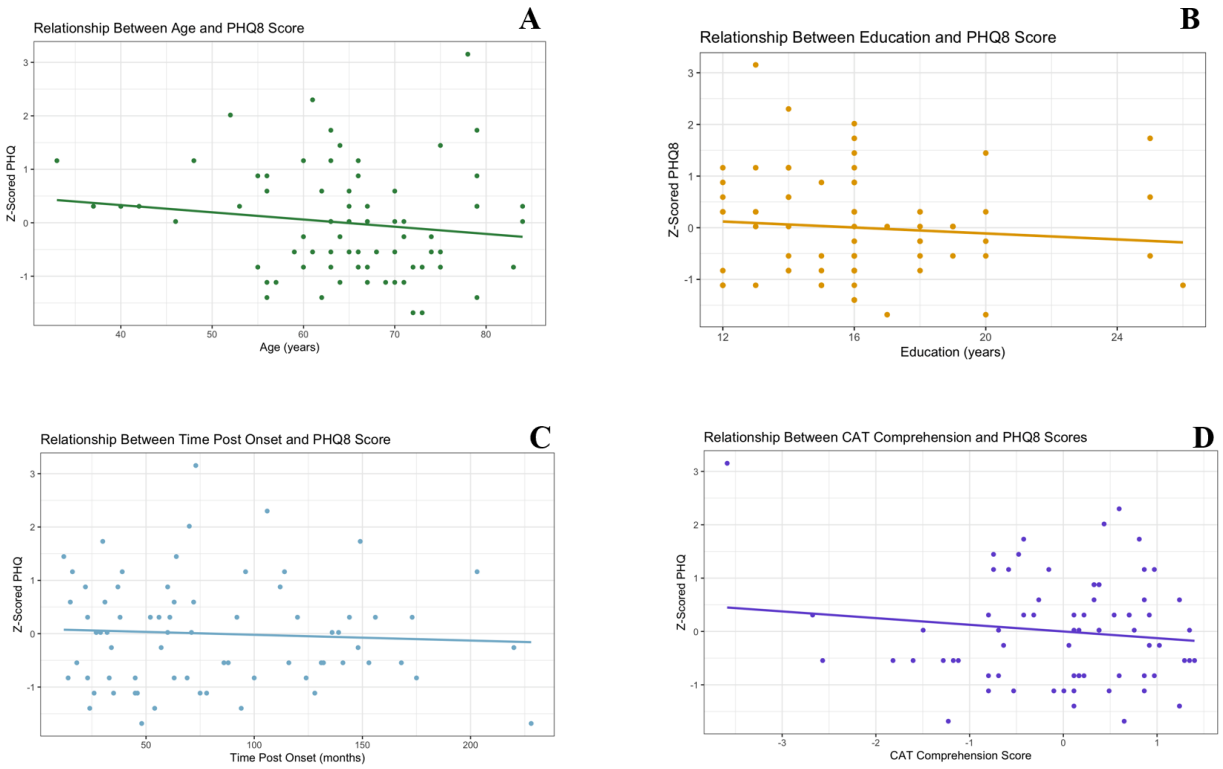

Figure 3. Relationships between non-significant predictors (A: age; B: education; C: TPO; D: CAT comprehension score) and the dependent variable (PHQ-8 scores).

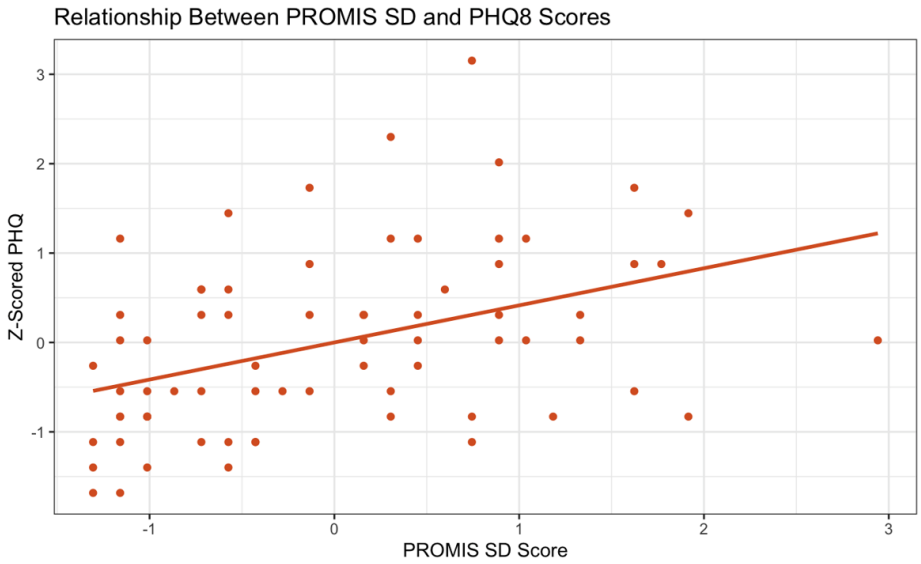

Figure 4. Relationship between the sole significant predictor (PROMIS-SD score) and the dependent variable (PHQ-8 score)

3.2 Aim 2: Correlations Between Self-Reported Sleep Disturbance, Sleep Related Impairments, Fatigue, and Depression

Aim 2 focused on examining relationships between self-reported sleep disturbance, sleep related impairments, fatigue, and depressive symptoms in a preliminary and exploratory fashion. This aim offers novel insights to the field of post-stroke aphasia using a recent sample (n = 7) of individuals with chronic post-stroke aphasia. Of note, data collection is ongoing, and the findings reported here are likely to change with the inclusion of more participants. The means, medians, standard deviations, minimum, and maximum values of this sample's continuous variables (age in years, education in years, time post-onset in months, CAT Comprehension and Naming Scores,

PROMIS-Fatigue score, PROMIS-SD score, PROMIS-SRI score, and PHQ-8 score) are summarized in Table 6. Additionally, given the small sample size, individual descriptive data for each of the seven participants are listed in Table 7. CAT Severity Score was yielded by averaging the t-scores of the CAT Spoken Language, Written Language, and Naming domains.

Table 6. Aim 2 Summary Statistics (*Note*: CAT scores reported across domains are t-scores. A score equal to 50 is the average t-score for the sample of PWA that this measure was normed on)

	Mean	SD	Min	Max	Median
Age (years)	54.7	10.42	41	67	56
Education (years)	16.6	1.51	14	18	16
TPO (months)	193.7	124.33	75.5	396.25	161.83
CAT- Spoken Language	49.29	6.42	41	55	54
CAT- Written Language	55.86	8.86	44	68	56
CAT- Naming	61	9	47	72	63
CAT- Severity	55.38	7.79	44	64.67	57.67
PROMIS-SD (Out of 135)	54.9	15.7	36	81	56
PROMIS-SRI (Out of 80)	28.9	8.73	18	41	30
PROMIS-Fatigue (Out of 475)	187	46.9	149	269	171
PHQ-8 (Out of 24)	10.3	4.92	3	19	11

Table 7. Individual Descriptive Data

#	Age (Years)	Diagnosis of Depression	Diagnosis of Sleep Disorder	Education (Years)	TPO (months)	Sex	Race	CAT Severity	PROMIS-SD (max = 135)	PROMIS-SRI (max = 80)	PROMIS-Fatigue (max = 475)	PHQ-8 (max = 24)
002	62	N	N	18	75.5	M	White	44	56	38	269	12
003	56	N	N	18	314.7	F	Native American	60	36	18	150	7
004	67	Y	N	18	75.8	F	White	64.7	68	20	171	11
005	46	N	N	16	108.2	F	Indian	57.7	44	30	149	19
006	46	N	N	16	161.8	F	Black	62.3	56	31	159	11
007	65	Y	N	14	395.3	M	White	51	81	41	236	9
008	41	Y	N	16	223.7	M	White	48	43	24	173	3

Multiple Pearson correlation coefficients were calculated to assess the linear relationships between variables of interest: (1) PROMIS-SD and PHQ-8 Z-scores, (2) PROMIS-SRI and PHQ-8 Z-scores, (3) PROMIS-Fatigue and PHQ-8 Z-scores, (4) PROMIS-Fatigue and PROMIS-SD Z-scores, (5) PROMIS-Fatigue and PROMIS-SRI Z-scores, and (6) PROMIS-SD and PROMIS-SRI Z-scores. Preliminary correlations between these variables can be viewed in Table 8. There was a weak correlation between PROMIS-SD and PHQ-8 (r = 0.07) and a weak negative correlation between PROMIS-Fatigue and PHQ-8 (r = 0.04). A modest positive correlation emerged between PROMIS-SRI and PHQ-8 (r = 0.30). There were strong (r > 0.50) positive correlations between PROMIS-Fatigue and PROMIS-SD (r = 0.55), PROMIS-Fatigue and PROMIS-SRI (r = 0.76), and PROMIS-SD and PROMIS-SRI (r = 0.57). Specifically, individuals with higher self-reported fatigue also reported higher sleep disturbance and sleep-related impairment. Additionally, individuals with higher self-reported sleep disturbance also indicated experiencing higher sleep-related impairments.

Table 8. Preliminary Correlations between the PROMIS-SD, PROMIS-SRI, PROMIS-Fatigue, and PHQ-8

	PROMIS-Fatigue	PROMIS-SD	PROMIS-SRI	PHQ-8
PROMIS-Fatigue	1.00	0.55	0.76	-0.04
PROMIS-SD	0.55	1.00	0.57	0.07
PROMIS-SRI	0.76	0.57	1.00	0.30
PHQ-8	-0.04	0.07	0.30	1.00

3.2.1 Feasibility

While not a specific aim of this study, preliminary information regarding feasibility of the PROMIS Sleep and Fatigue test banks can be explored through summarization of responses to the feasibility questionnaires as well as through examination of levels of support necessary via the Communicative Support Hierarchy. Of note, data collection is ongoing, and the findings reported here are likely to change with the inclusion of more participants. Responses to the feasibility questionnaires are mainly anecdotal and will be discussed in greater detail in the discussion section; the average levels of support necessary via the Communicative Support Hierarchy are summarized in Table 9. The results exhibit that a very low level of support was necessary on average across participants on each of the four self-report questionnaires.

Table 9. Summary of Average Level of Support Necessary by Test Bank (Tucker et al. 2012)

Test	Average Level of Support Necessary
PROMIS-SD	0.0529
PROMIS-SRI	0.0625
PROMIS-Fatigue	0.0376
PHQ-8	0.3571

4.0 Discussion

This study aimed to investigate two main questions. The first aim was to determine the association between self-reported sleep disturbance and self-reported depression symptoms while accounting for demographic, stroke, and language variables that may also impact depression severity. This aim builds upon previous research (Pompon & Cohen 2018) and was addressed utilizing pre-existing data collected from 72 PWA. In the present study, the only statistically significant and meaningful predictor of PHQ-8 responses in the multiple regression model was PROMIS-SD Short Form 8a responses. Specifically, the positive coefficient value suggests that higher PROMIS-SD scores (and therefore, greater sleep dysfunction) were associated with higher PHQ-8 scores (and therefore, greater depressive symptoms). The remaining variables (age in years, time post-onset in months, education in years, and CAT comprehension scores) were not statistically significant and did not display a meaningful relationship with the dependent variable, PHQ-8 score. While the results suggested these coefficient values were not statistically significant, consideration of the weak negative correlations may be of value.

The second aim was to explore preliminary relationships among self-reported sleep disturbance, sleep related impairment, fatigue, and depression in individuals with chronic post-stroke aphasia. This aim was addressed utilizing data collected recently from seven PWA. The sample size used to address the second aim is small and results are preliminary; specifically, early exploration revealed positive correlations between self-reported sleep disturbance and depression (though modest), self-reported sleep related impairment and depression, self-reported fatigue and sleep disturbance, self-reported fatigue and sleep related impairment, and self-reported sleep

disturbance and sleep related impairment. There was a weak negative correlation found between self-reported fatigue and depression.

Finally, while not considered a specific aim of the study and not statistically analyzed in the results section, it is important to discuss preliminary evidence related to feasibility of using the PROMIS Sleep and Fatigue banks with PWA. Evidence regarding this discussion topic is anecdotal, drawn from the feasibility questionnaires given to the seven PWA who participated in this study, and based upon independence and support hierarchy created by Tucker et al., (2012). Overall, it appears that the PROMIS-SD, PROMIS-SRI, and PROMIS-Fatigue were feasible measures of sleep disturbance, sleep related impairments, and fatigue for the individuals with aphasia included in the study sample. Additional interpretations of Aim 1 and 2 results and PROMIS bank feasibility are provided below.

4.1 Aim 1: The association between self-reported sleep disturbance and self-reported depression symptoms

It was hypothesized that PWA self-reporting worse sleep disturbance would also self-report greater depression symptoms. Given the results of Aim 1, this hypothesis was confirmed, as the only significant predictor of depression in the multiple regression model was PROMIS-SD Short Form 8a. Notably, the model coefficient suggests that for each one z-score unit increase in PROMIS-SD score, the PHQ-8 z-score increased by 0.49 units. The explanation for this result is rooted in the known bidirectional relationship between sleep and depression; poor sleep quality is a potential predictive factor of depressive symptoms (and vice-versa). Therefore, it is unsurprising

that scores indicative of worse sleep disturbance on the PROMIS-SD Short Form 8a are associated within scores indicative of worse depression symptoms on the PHQ-8.

It was also found that there were several factors that did not result in statistically significant relationships when predicting PHQ-8 scores: time post-onset in months, age in years, education in years, and CAT comprehensions scores. It was interesting to note that these factors did not play a significant role in PHQ-8 scores, as they each reasonably could be related to depression severity. Notably, when examining the sample distribution for these variables, CAT language comprehension scores of the sample appeared to be left-skewed suggesting lower severity; furthermore, sample distribution for time post-onset of stroke in months exhibited a mean of 81 months post-stroke, which is over six years following stroke. Considering this, it is possible that individuals with greater language deficits may self-report greater feelings of depression, consistent with the (statistically insignificant) negative model coefficient. Furthermore, it can be posited that individuals with post-stroke aphasia who are several years post-onset may be better equipped to understand and manage their stroke and related disorders, resulting in lower presence of depressive symptoms as compared to someone who was recently diagnosed with aphasia following stroke.

There was one participant in particular within this data set that self-reported a raw score of 37 (out of a possible 40 points) on the PROMIS-SD Short Form 8a. This score is relatively high (therefore, indicating greater sleep disturbance) compared to their peers. In fact, the second highest PROMIS-SD Short Form 8a score was a 31. Other information regarding this participant includes as follows: 139 months (11.5 years) post-stroke onset, 19 years of education, 63 years of age, a raw CAT comprehension score of 102 (out of a possible 128; when z-scored, this score fell right around the sample mean at 0.11) and a raw PHQ-8 score of 6 (out of a possible 24; when z-scored, this is slightly above the sample mean). With analysis of these specific values, a robust positive

relationship displaying PROMIS-SD Short Form 8a scores as a predictor of PHQ-8 scores was not established, contrary to the overall results of this aim. This lack of relationship suggests that sleep disturbance can occur in absence of depression in the post-stroke aphasia population, which inspires interesting questions such as what might sleep disturbance in this particular individual with stable, chronic, post-stroke aphasia be impacting, if anything?

While there is a known bidirectional relationship between depression and sleep, there are many factors other than depression that can contribute to sleep disturbances as well, especially when one does not exhibit clinically diagnosed major depression, but instead, a milder depression characterized by inconsistent minor depressive symptoms lasting for less than two weeks or occurring irregularly. Stress or anxiety levels at the time of the study could also be separate and contributing factors impacting sleep length, amount and quality. With great intensity, anxiety and stress can constitute their own mental health disorder (e.g., generalized anxiety disorder). Measures of stress and anxiety were collected by Pompon and Cohen (2018); however, they were not factored into this study's analyses for Aim 1. A future direction could include exploring how the influence of PROMIS-SD short form scores on PHQ-8 scores changes when measures of stress and anxiety are also included.

4.2 Aim 2: Preliminary relationships between PROMIS-SD, SRI, Fatigue, and PHQ-8

It was hypothesized that there would be a significant ($r > 0.50$) positive correlation between depressive symptoms and fatigue, due to major depression being a major indicator of higher levels of fatigue. This hypothesis was not proven to be true. The main reason for this lack of relationship

is most likely related to the small sample size collected (n = 7), as there is a known relationship between fatigue and symptoms of depression, given the mental strain the fatigue and depression both have on the energy levels of the body as a whole. Thus, the weak negative correlation was surprising, though it is suspected that with more participants, this relationship between PROMIS-Fatigue and PHQ-8 scores will strengthen; analyses of the full sample size in the future (target n = 100) . Another reason that this weak negative relationship may have been observed could be due to the very "loose" definition of fatigue itself; because fatigue is more of a subjective construct, anecdotal interactions with the seven participants highlighted difficulty parsing out what was considered "sleepiness" versus what was considered "fatigue." In future studies, it would be interesting to provide a solid definition of fatigue and how it manifests prior to administration of the PROMIS-Fatigue so that participants can accurately differentiate fatigue versus sleepiness in their own lives. Finally, another reason that this weak negative relationship might have occurred was because of the length of time post-stroke onset; the range of time post-stroke onset in months for the set of seven participants was 75 months to 396 months. With a greater length of time post-stroke, it is possible that some of these participants have learned to manage their symptoms of depression and fatigue; several participants commented on this fact as well, noting that their fatigue and overall feelings of depression were greater in the first year following their stroke.

It was also hypothesized that there would be a significant ($r > 0.50$) positive correlation between depression symptoms and sleep disturbance. This hypothesis was somewhat supported by this preliminary data, with a weak positive correlation highlighted between PROMIS-SD and PHQ-8 and a moderate positive correlation highlighted between the PROMIS-SRI and PHQ-8. These moderate and weak positive correlations can be explained by the types of questions asked during both self-report questionnaires. Recall that the PROMIS-SD asks about sleep disturbances,

whereas the PROMIS-SRI asks about the impact of these sleep disturbances on day-to-day function. Even though we found a strong positive correlation between the PROMIS-SD and PROMIS-SRI, they related to the PHQ differently. Specifically, it is not the sleep disturbances themselves that could be impacting depression but instead their impact on day-to-day function; however, this correlation is fairly weak and additional data is needed to further explore these relationships. Both of these relationships exhibiting positive correlation in general can, once again, be explained with previous studies underlying the bidirectional relationship between sleep and depression, with one impacting the other and vice versa. Thus, lower PROMIS-SD and PROMIS-SRI scores should result in lower PHQ-8 scores, representing decreased severity of both sleep dysfunction and depressive symptoms; at the same time higher PROMIS-SD and PROMIS-SRI scores should result in higher PHQ-8 scores, representing increased severity of both sleep dysfunction and depressive symptoms.

It is also instrumental to confirm the strong positive correlation between the PROMIS-SD and PROMIS-Fatigue, the PROMIS-SRI and PROMIS-Fatigue, and the PROMIS-SD and PROMIS-SRI in individuals with post-stroke aphasia. As previously mentioned, these PROMIS subtests have not been utilized in full with PWA in previous studies; all post-stroke studies involving the full versions of these self-report questionnaires have purposefully excluded individuals with aphasia due to potential deficits in language comprehension. The strong correlation existing across these relationships between PROMIS Sleep and Fatigue questionnaires among individuals with post-stroke aphasia is important to note, as it provides preliminary evidence for their validity in PWA.

4.3 Preliminary Feasibility

The Tucker et al. (2012) Communicative Support Hierarchy Scale as well as a feasibility questionnaire were utilized in order to begin to answer questions related to the feasibility of the PROMIS self-report measures for the population of individuals with aphasia. Based on the preliminary data collected, it was found that little to no support was needed across these questionnaires for the current sample population. Infrequently, individuals required a verbal re-read of the question as well as repetition of choices, which related to Step 1 of the Communicative Support Hierarchy Scale. Also, infrequently with questions that could be considered more syntactically complex, a simplification and restatement of the question was needed, which related to Step 2 of the Communicative Support Hierarchy Scale. However overall, this sample of PWA required minimal support following the initiation question presentation.

The Feasibility Questionnaire revealed valuable feedback in relation to the PROMIS and PHQ-8 self-report measures administered. Several participants relayed that some items were more difficult to comprehend as compared to others; some participants relayed that they felt questions on both were too simplistic or oversimplified what they were feeling. One participant in particular stated that they felt that "seven days is not always [their] normal;" given that a majority of these questionnaires ask to rate feelings regarding sleep and depression within the last one to two weeks, it makes sense that individuals who face fluctuations in sleep or depression would have a more difficult time responding to these questionnaires. Finally, many individuals commented on the severity rating scale itself; sometimes the number "5" related to "Very much," whereas other times it corresponded to "Not at all" (i.e., the scale sometimes switched directions numerically). This has to do with the severity scoring of the PROMIS questionnaires; with lower scores corresponding

to lower severity and higher scores corresponding to higher severity, the scale must switch when someone is responding “Very Much” to a statement in a more positive light or responding “Not at all” to a statement in a more negative light. This was confusing to some of the participants of the study.

It should be noted that written and auditory comprehension scores of the CAT revealed that written comprehension deficits were less severe than auditory comprehension deficits, with auditory comprehension t-scores being lower. This is an interesting finding, especially given the virtual administration of the PROMIS Sleep and Fatigue test banks because reduced auditory comprehension could have impacted verbal administration of test bank items. Lower auditory comprehension t-scores could have been heavily related to the virtual nature of this study for several reasons. First, specific tasks can be more difficult when presented virtually rather than in-person. For instance, there is a specific subtest on the CAT where the investigator verbally reads a word; then the participant selects one picture out of four that shows the verbally stated word. For each item, a phonological distractor picture is also presented (e.g., if the target word is “mouse,” a picture of a “house” is also presented). It is arguably more difficult to differentiate the target from the phonological distractor when the words are presented virtually rather than in-person, as visual and perceptual cues allowing for differentiation of sounds can be more evident in person as compared to over Zoom. Second, the participants of this study were middle age to older adults; with age, hearing tends to decline due to noise exposure throughout the lifespan. It may be the case that some of these participants have experienced undiagnosed hearing loss, which might have impacted their performance on auditory comprehension measures. Third, while it is possible for the investigator to control the volume of the Zoom session on their end, it is impossible to control the volume of the Zoom session on the participant’s end. It may have been the case that volume

was too low on the computer of the participant; as well as this, the participant may have been experiencing a lot of background noise from their environment. It will be interesting to further consider what other person-specific factors (e.g., language deficit severity) impacted feasibility ratings when the full sample is collected.

4.4 Study Limitations

There are several limitations that should be noted for this study. First, across both participant groups, it should be noted that individuals potentially experiencing greater depression or other psychosocial symptoms are less likely to volunteer to participate in research studies; this is because it is likely that those with greater depression or other symptoms may have less motivation to seek out studies such as this one. Thus, the sample population collected may not be representative of the population of individuals with aphasia as a whole. Second, the second participant group collected was a very small sample, only consisting of seven individuals with post-stroke aphasia. It is anticipated that results for Aim 2 would vary if there was an increase in sample population. Thus, the results discussed for Aim 2 should be viewed only as preliminary at this time. Third, PWA who participated in the second group participated in this study virtually; virtual participation could impact administration of self-report questionnaires and the potential feasibility of these questionnaires among this population, as evidenced by lower CAT auditory comprehension scores. This is a factor that should continue to be explored given the new-found role of telehealth in our everyday healthcare system. Fourth, there are not currently scoring guidelines enabling raw score to t-score conversation for the full PROMIS Sleep and Fatigue test

banks; currently, conversions exist for the PROMIS short forms and for the computerized version of these test banks. As this study includes a preliminary sample, future aims should look at comparing scores from the full sample to normative data. Finally, it would be worthwhile to explore psychometric properties such as test-retest reliability in order to account for day-to-day fluctuations in depressive symptoms or sleep dysfunction that could occur. The PROMIS Sleep and Fatigue Test Banks and the PHQ-8 offer only snapshots from a specific moment of time, which cannot allow for comprehensive judgements related to levels of sleep disturbance, fatigue, or depression.

5.0 Conclusion and Future Directions

This study aimed to shed light on three underexplored factors that are likely highly prevalent in individuals with aphasia: sleep dysfunction, fatigue, and depression. With a bidirectional relationship existing between sleep dysfunction and depressive symptoms, it was found that PROMIS-SD scores meaningfully predicted PHQ-8 scores; furthermore, it was found that PROMIS-SD and PROMIS-SRI scores positively correlated with PHQ-8 scores. Examining these relationships as well as preliminary information related to the feasibility of these self-report questionnaires among the post-stroke aphasia population are important steps in initiating important future research related to sleep, depression, and its role in individuals with post-stroke aphasia, as these factors—given limited findings—could impact the post-stroke aphasia population's ability to respond to rehabilitation as well as their overall quality of life and life participation.

Future studies should focus on collection of more participants in order to confirm or deny the preliminary findings related to sleep, fatigue, and depression exhibited in this study. As well as this, future studies could focus on collecting information regarding sleep, fatigue, and depression longitudinally, in order to examine fluctuations that could occur amongst PWA, especially throughout treatment of aphasia. Furthermore, future studies should continue to focus on determining the feasibility of the PROMIS Sleep and Fatigue subtests for individuals with post-stroke aphasia; once feasibility is confirmed, validating these measures for individuals with post-stroke aphasia should be the next step in order to emphasize the importance of utilization of valid and reliable measures among the post-stroke aphasia population. Finally, future studies should explore depressive symptoms, fatigue, and sleep dysfunction at different points in time following

a stroke, given the heightened sleep dysfunction and feelings of depression that one may face due to stressors and neurochemical and neurophysiological changes that can occur in the stages following acute stroke. Participants in aphasia research are commonly individuals who are well-past their time in the hospital and are mostly recovered; however, perhaps research should instead turn its head towards individuals who are in the early stages of recovery, where lack of sleep and presence of mental health have a high probability of negatively impacting the early stages of recovery. Examining this as well pathophysiological factors contributing to depression and sleep dysfunction following stroke can help healthcare professionals mitigate these issues in the long-term following stroke as well as inform speech-language pathologists of the referrals that they may possibly need to make depending on the needs of their patients.

Finally, it is vitally important for speech-language pathologists to address issues of mental health when poor mental health is observed in a patient. With few resources available regarding treatment of depression within the post-stroke aphasia community, the speech-language pathologist has the opportunity to be their patient's strongest ally and advocate and can play a necessary role in the diagnosis of depression and other mental health disorders. While it may feel uncomfortable for the speech-language pathologist to take on this role in aiding in the diagnostic process of mental health disorders, depression and other mental health disorders are heavily prevalent in the aphasia community and should not simply be ignored due to discomfort.

Appendix A Feasibility Questionnaires

PROMIS-Fatigue Feasibility Questions

Were the instructions provided to you clear (easy to understand)? (circle one)

YES NO

If NO, how difficult for you was it to understand the instructions?

☐ 1 – Barely

☐ 2 – A little

☐ 3 – Moderately

☐ 4 – Very

Additional Feedback About Instructions:

Was it difficult for you to answer these questions? (circle one)

YES NO

If YES, how difficult for you was it to understand the questions?

☐ 1 – Barely

☐ 2 – A little

☐ 3 – Moderately

☐ 4 – Very

Additional Feedback About Questions:

Did you feel that the questionnaire accurately described your fatigue?

YES NO

If NO, please explain: (e.g. what was missing?)

PROMIS-Sleep Related Impairment (SRI) Feasibility Questions

Were the instructions provided to you clear (easy to understand)? (circle one)

YES NO

If NO, how difficult for you was it to understand the instructions?

☐ 1 – Barely

☐ 2 – A little

☐ 3 – Moderately

☐ 4 – Very

Additional Feedback About Instructions:

Was it difficult for you to answer these questions? (circle one)

YES NO

If YES, how difficult for you was it to understand the questions?

☐ 1 – Barely

☐ 2 – A little

☐ 3 – Moderately

☐ 4 – Very

Additional Feedback About Questions:

3.Did you feel that the questionnaire accurately described your sleep?

YES NO

If NO, please explain: (e.g. what was missing?)

PROMIS-Sleep Disturbance (SD) Feasibility Questions

Were the instructions provided to you clear (easy to understand)? (circle one)

YES NO

If NO, how difficult for you was it to understand the instructions?

☐ 1 – Barely

☐ 2 – A little

☐ 3 – Moderately

☐ 4 – Very

Additional Feedback About Instructions:

Was it difficult for you to answer these questions? (circle one)

YES NO

If YES, how difficult for you was it to understand the questions?

☐ 1 – Barely

☐ 2 – A little

☐ 3 – Moderately

☐ 4 – Very

Additional Feedback About Questions:

Did you feel that the questionnaire accurately described your sleep?

YES NO

If NO, please explain: (e.g. what was missing?)

PHQ-8 Feasibility Questions

Were the instructions provided to you clear (easy to understand)? (circle one)

YES NO

If NO, how difficult for you was it to understand the instructions?

☐ 1 – Barely

☐ 2 – A little

☐ 3 – Moderately

☐ 4 – Very

Additional Feedback About Instructions:

Was it difficult for you to answer these questions? (circle one)

YES NO

If YES, how difficult for you was it to understand the questions?

☐ 1 – Barely

☐ 2 – A little

☐ 3 – Moderately

☐ 4 – Very

Additional Feedback About Questions:

Did you feel that the questionnaire accurately described your feelings?

YES NO

If NO, please explain: (e.g. what was missing?)

Bibliography

Acciarresi, M., Bogousslavsky, J., & Paciaroni, M. (2014). Post-Stroke Fatigue: Epidemiology, Clinical Characteristics and Treatment. *European Neurology*, *72*(5–6), 255–261. https://doi.org/10.1159/000363763

Alajbegovic, A., Djelilovic-Vranic, J., Alajbegovic, S., Nakicevic, A., Todorovic, L., & Tiric-Campara, M. (2014). Post Stroke Depression. *Medical Archives*, *68*(1), 47–50. https://doi.org/10.5455/medarh.2014.68.47-50

Anderson, K. N., & Bradley, A. J. (2013). Sleep disturbance in mental health problems and neurodegenerative disease. *Nature and Science of Sleep*, *5*, 61–75. https://doi.org/10.2147/NSS.S34842

Angelelli, P., Paolucci, S., Bivona, U., Piccardi, L., Ciurli, P., Cantagallo, A., Antonucci, G., Fasotti, L., Di Santantonio, A., Grasso, M. G., & Pizzamiglio, L. (2004). Development of neuropsychiatric symptoms in poststroke patients: A cross-sectional study. *Acta Psychiatrica Scandinavica*, *110*(1), 55–63. https://doi.org/10.1111/j.1600-0447.2004.00297.x

Barrett, A., Convoy-Hellmann, J., Loring, D., Saurman, J., Benameur, K., Goldstein, F., Krishnan, S., & Nahab, F. (2022). Cognitive disorder and depression screening in acute stroke. (P7-6.002). *Neurology*, *98*(18 Supplement). https://n.neurology.org/content/98/18_Supplement/2291

Berger, R. J., & Phillips, N. H. (1995). Energy conservation and sleep. *Behavioural Brain Research*, *69*(1), 65–73. https://doi.org/10.1016/0166-4328(95)00002-B

Boyce, R., Williams, S., & Adamantidis, A. (2017). REM sleep and memory. *Current Opinion in Neurobiology*, *44*, 167–177. https://doi.org/10.1016/j.conb.2017.05.001

Buysse, D. J., Yu, L., Moul, D. E., Germain, A., Stover, A., Dodds, N. E., Johnston, K. L., Shablesky-Cade, M. A., & Pilkonis, P. A. (2010). Development and Validation of Patient-Reported Outcome Measures for Sleep Disturbance and Sleep-Related Impairments. *Sleep*, *33*(6), 781–792. https://doi.org/10.1093/sleep/33.6.781

CDC. (2022, December 14). *Key Sleep Disorders—Sleep and Sleep Disorders*. Centers for Disease Control and Prevention. https://www.cdc.gov/sleep/about_sleep/key_disorders.html

Cella, D., Lai, J.-S., Jensen, S. E., Christodoulou, C., Junghaenel, D. U., Reeve, B. B., & Stone, A. A. (2016). PROMIS Fatigue Item Bank had Clinical Validity across Diverse Chronic Conditions. *Journal of Clinical Epidemiology*, *73*, 128–134. https://doi.org/10.1016/j.jclinepi.2015.08.037

Chapey, R., Duchan, J. F., Elman, R. J., Garcia, L. J., Kagan, A., Lyon, J. G., & Mackie, N. S. (2000, February 1). *Life Participation Approach to Aphasia: A Statement of Values for the Future* (world) [Review-article]. The ASHA Leader; American Speech-Language-Hearing Association. https://doi.org/10.1044/leader.FTR.05032000.4

Conte, F., Arzilli, C., Errico, B. M., Giganti, F., Iovino, D., & Ficca, G. (2014). Sleep Measures Expressing 'Functional Uncertainty' in Elderlies' Sleep. *Gerontology*, *60*(5), 448–457. https://doi.org/10.1159/000358083

Deak, M. C., & Stickgold, R. (2010). Sleep and cognition. *WIREs Cognitive Science*, *1*(4), 491–500. https://doi.org/10.1002/wcs.52

Dignam, J., Copland, D., O, 'Brien Kate, Burfein, P., Khan, A., & Rodriguez, A. D. (2017). Influence of Cognitive Ability on Therapy Outcomes for Anomia in Adults With Chronic Poststroke Aphasia. *Journal of Speech, Language, and Hearing Research*, *60*(2), 406–421. https://doi.org/10.1044/2016_JSLHR-L-15-0384

Duss, S. B., Seiler, A., Schmidt, M. H., Pace, M., Adamantidis, A., Müri, R. M., & Bassetti, C. L. (2017). The role of sleep in recovery following ischemic stroke: A review of human and animal data. *Neurobiology of Sleep and Circadian Rhythms*, *2*, 94–105. https://doi.org/10.1016/j.nbscr.2016.11.003

Everson, C. A. (1997). *Sleep deprivation and the immune system*.

Fang, H., Tu, S., Sheng, J., & Shao, A. (2019). Depression in sleep disturbance: A review on a bidirectional relationship, mechanisms and treatment. *Journal of Cellular and Molecular Medicine*, *23*(4), 2324–2332. https://doi.org/10.1111/jcmm.14170

Fishbein, A. B., Lor, J., Penedo, F. J., Forrest, C. B., Griffith, J. W., & Paller, A. S. (2020). Patient-Reported Outcomes for Measuring Sleep Disturbance in Pediatric Atopic Dermatitis: Cross sectional study of PROMIS Pediatric Sleep Measures and Actigraphy. *Journal of the American Academy of Dermatology*, *0*(0). https://doi.org/10.1016/j.jaad.2020.05.138

Flowers, H. L., Skoretz, S. A., Silver, F. L., Rochon, E., Fang, J., Flamand-Roze, C., & Martino, R. (2016). Poststroke Aphasia Frequency, Recovery, and Outcomes: A Systematic Review and Meta-Analysis. *Archives of Physical Medicine and Rehabilitation*, *97*(12), 2188-2201.e8. https://doi.org/10.1016/j.apmr.2016.03.006

Franzen, P. L., & Buysse, D. J. (2008). Sleep disturbances and depression: Risk relationships for subsequent depression and therapeutic implications. *Dialogues in Clinical Neuroscience*, *10*(4), 473–481. https://doi.org/10.31887/DCNS.2008.10.4/plfranzen

Full, K. M., Malhotra, A., Crist, K., Moran, K., & Kerr, J. (2019). Assessing psychometric properties of the PROMIS Sleep Disturbance Scale in older adults in independent-living and continuing care retirement communities. *Sleep Health*, *5*(1), 18–22. https://doi.org/10.1016/j.sleh.2018.09.003

Gaete, J. M., & Bogousslavsky, J. (2008). Post-stroke depression. *Expert Review of Neurotherapeutics*, *8*(1), 75–92. https://doi.org/10.1586/14737175.8.1.75

Galski, T., Bruno, R. L., Zorowitz, R., & Walker, J. (1993). Predicting length of stay, functional outcome, and aftercare in the rehabilitation of stroke patients. The dominant role of higher-order cognition. *Stroke*, *24*(12), 1794–1800. https://doi.org/10.1161/01.STR.24.12.1794

Greenberg, R., & Dewan, E. M. (1969). Aphasia and Rapid Eye Movement Sleep. *Nature*, *223*(5202), Article 5202. https://doi.org/10.1038/223183a0

Hackett, M. L., Yapa, C., Parag, V., & Anderson, C. S. (2005). Frequency of depression after stroke: A systematic review of observational studies. *Stroke*, *36*(6), 1330–1340. https://doi.org/10.1161/01.STR.0000165928.19135.35

Hanish, A. E., Lin-Dyken, D. C., & Han, J. C. (2017). PROMIS Sleep Disturbance and Sleep-Related Impairment in Adolescents: Examining Psychometrics Using Self-Report and Actigraphy. *Nursing Research (New York)*, *66*(3), 246–251. https://doi.org/10.1097/NNR.0000000000000217

HOUSE, A., DENNIS, M., HAWTON, K., & WARLOW, C. (1989). Methods of Identifying Mood Disorders in Stroke Patients: Experience in the Oxfordshire Community Stroke Project. *Age and Ageing*, *18*(6), 371–379. https://doi.org/10.1093/ageing/18.6.371

Iddagoda, M. T., Inderjeeth, C. A., Chan, K., & Raymond, W. D. (2020). Post-stroke sleep disturbances and rehabilitation outcomes: A prospective cohort study. *Internal Medicine Journal*, *50*(2), 208–213. https://doi.org/10.1111/imj.14372

Inoué, S., Honda, K., & Komoda, Y. (1995). Sleep as neuronal detoxification and restitution. *Behavioural Brain Research*, *69*(1), 91–96. https://doi.org/10.1016/0166-4328(95)00014-K

Jason, L. A., Evans, M., Brown, M., & Porter, N. (2010). What is Fatigue? Pathological and Nonpathological Fatigue. *PM&R*, *2*(5), 327–331. https://doi.org/10.1016/j.pmrj.2010.03.028

Jaussent, I., Bouyer, J., Ancelin, M.-L., Akbaraly, T., Peres, K., Ritchie, K., Besset, A., & Dauvilliers, Y. (2011). Insomnia and Daytime Sleepiness Are Risk Factors for Depressive Symptoms in the Elderly. *Sleep*, *34*(8), 1103–1110. https://doi.org/10.5665/SLEEP.1170

Jensen, R. E., Moinpour, C. M., Potosky, A. L., Lobo, T., Hahn, E. A., Hays, R. D., Cella, D., Smith, A. W., Wu, X.-C., Keegan, T. H. M., Paddock, L. E., Stroup, A. M., & Eton, D. T. (2017). Responsiveness of 8 Patient-Reported Outcomes Measurement Information System (PROMIS) measures in a large, community-based cancer study cohort. *Cancer*, *123*(2), 327–335. https://doi.org/10.1002/cncr.30354

Joa, K.-L., Kim, W.-H., Choi, H.-Y., Park, C.-H., Kim, E.-S., Lee, S.-J., Kim, S.-Y., Ko, S.-H., & Jung, H.-Y. (2017). The Effect of Sleep Disturbances on the Functional Recovery of

Rehabilitation Inpatients Following Mild and Moderate Stroke. *American Journal of Physical Medicine & Rehabilitation*, *96*(10), 734–740. https://doi.org/10.1097/PHM.0000000000000744

Jones, J., Nielson, S. A., Trout, J., Swenson, M., Reiley, J., Tanner, J., Bowers, D., & Kay, D. B. (2021). A Validation Study of PROMIS Sleep Disturbance (PROMIS-SD) and Sleep Related Impairment (PROMIS-SRI) Item Banks in Individuals with Idiopathic Parkinson's Disease and Matched Controls. *Journal of Parkinson's Disease*, *11*(2), 877–883. https://doi.org/10.3233/JPD-202429

Karni, A., Tanne, D., Rubenstein, B. S., Askenasy, J. J. M., & Sagi, D. (1994). Dependence on REM Sleep of Overnight Improvement of a Perceptual Skill. *Science*, *265*(5172), 679–682. https://doi.org/10.1126/science.8036518

Katzan, I. L., Thompson, N. R., Walia, H. K., Moul, D. E., & Foldvary-Schaefer, N. (2020a). Sleep disturbance predicts future health status after stroke. *Journal of Clinical Sleep Medicine*, *16*(11), 1863–1870. https://doi.org/10.5664/jcsm.8700

Katzan, I. L., Thompson, N. R., Walia, H. K., Moul, D. E., & Foldvary-Schaefer, N. (2020b). Sleep-related symptoms in patients with mild stroke. *Journal of Clinical Sleep Medicine*, *16*(1), 55–64. https://doi.org/10.5664/jcsm.8122

Kauhanen, M. L., Korpelainen, J. T., Hiltunen, P., Määttä, R., Mononen, H., Brusin, E., Sotaniemi, K. A., & Myllylä, V. V. (2000). Aphasia, depression, and non-verbal cognitive impairment in ischaemic stroke. *Cerebrovascular Diseases (Basel, Switzerland)*, *10*(6), 455–461. https://doi.org/10.1159/000016107

Khot, S. P., & Morgenstern, L. B. (2019). Sleep and Stroke. *Stroke*, *50*(6), 1612–1617. https://doi.org/10.1161/STROKEAHA.118.023553

Kim, J., Kim, Y., Yang, K. I., Kim, D., & Kim, S. A. (2015). The Relationship Between Sleep Disturbance and Functional Status in Mild Stroke Patients. *Annals of Rehabilitation Medicine*, *39*(4), 545–552. https://doi.org/10.5535/arm.2015.39.4.545

Klerman, E. B., & Dijk, D.-J. (2008). Age-Related Reduction in the Maximal Capacity for Sleep—Implications for Insomnia. *Current Biology*, *18*(15), 1118–1123. https://doi.org/10.1016/j.cub.2008.06.047

Krachman, S. L., D'Alonzo, G. E., & Criner, G. J. (1995). Sleep in the intensive care unit. *Chest*, *107*(6), 1713–1720. https://doi.org/10.1378/chest.107.6.1713

Kroenke, K., Strine, T. W., Spitzer, R. L., Williams, J. B. W., Berry, J. T., & Mokdad, A. H. (2009). The PHQ-8 as a measure of current depression in the general population. *Journal of Affective Disorders*, *114*(1), 163–173. https://doi.org/10.1016/j.jad.2008.06.026

Krueger, J. M., Frank, M. G., Wisor, J. P., & Roy, S. (2016). Sleep function: Toward elucidating an enigma. *Sleep Medicine Reviews*, *28*, 46–54. https://doi.org/10.1016/j.smrv.2015.08.005

Landolt, H.-P., Dijk, D.-J., Achermann, P., & Borbély, A. A. (1996). Effect of age on the sleep EEG: Slow-wave activity and spindle frequency activity in young and middle-aged men. *Brain Research*, *738*(2), 205–212. https://doi.org/10.1016/S0006-8993(96)00770-6

Laures-Gore, J. S., Dotson, V. M., & Belagaje, S. (2020). Depression in Poststroke Aphasia. *American Journal of Speech-Language Pathology*, *29*(4), 1798–1810. https://doi.org/10.1044/2020_AJSLP-20-00040

Léger, D., Debellemaniere, E., Rabat, A., Bayon, V., Benchenane, K., & Chennaoui, M. (2018). Slow-wave sleep: From the cell to the clinic. *Sleep Medicine Reviews*, *41*, 113–132. https://doi.org/10.1016/j.smrv.2018.01.008

Lei, D. K., Yousaf, M., Janmohamed, S. R., Vakharia, P. P., Chopra, R., Chavda, R., Gabriel, S., Sacotte, R., Patel, K. R., Singam, V., Kantor, R., Hsu, D. Y., Cella, D., & Silverberg, J. I. (2020). Measurement Properties of 4 Patient-Reported Outcome Measures to Assess Sleep Disturbance in Adults With Atopic Dermatitis. *Dermatitis®*, *31*(5), 321–327. https://doi.org/10.1097/DER.0000000000000625

Mander, B. A., Winer, J. R., & Walker, M. P. (2017). Sleep and Human Aging. *Neuron*, *94*(1), 19–36. https://doi.org/10.1016/j.neuron.2017.02.004

Marquez-Romero, J. M., Morales-Ramírez, M., & Arauz, A. (2014). Non-breathing-related sleep disorders following stroke. *Neurología (English Edition)*, *29*(9), 511–516. https://doi.org/10.1016/j.nrleng.2013.04.005

McGinty, D., & Szymusiak, R. (1990). Keeping cool: A hypothesis about the mechanisms and functions of slow-wave sleep. *Trends in Neurosciences*, *13*(12), 480–487. https://doi.org/10.1016/0166-2236(90)90081-K

Morrison, M. (2016). I Would Tell You If I Could: Language Loss, Depression, and the Challenge of Treatment with Aphasia. *UBC Medical Journal*, *8*(1), Article 1.

Neu, D., Kajosch, H., Peigneux, P., Verbanck, P., Linkowski, P., & Le Bon, O. (2011). Cognitive impairment in fatigue and sleepiness associated conditions. *Psychiatry Research*, *189*(1), 128–134. https://doi.org/10.1016/j.psychres.2010.12.005

Patel, A. K., Reddy, V., Shumway, K. R., & Araujo, J. F. (2022). Physiology, Sleep Stages. In *StatPearls*. StatPearls Publishing. http://www.ncbi.nlm.nih.gov/books/NBK526132/

Pompon, R. H., Fassbinder, W., McNeil, M. R., Yoo, H., Kim, H. S., Zimmerman, R. M., Martin, N., Patterson, J. P., Pratt, S. R., & Dickey, M. W. (2022). Associations among depression, demographic variables, and language impairments in chronic post-stroke aphasia. *Journal of Communication Disorders*, *100*, 106266. https://doi.org/10.1016/j.jcomdis.2022.106266

Rasch, B., & Born, J. (2013). About Sleep's Role in Memory. *Physiological Reviews*, *93*(2), 681–766. https://doi.org/10.1152/physrev.00032.2012

Riley, E. A. (2017). Patient Fatigue during Aphasia Treatment: A Survey of Speech-Language Pathologists. *Communication Disorders Quarterly*, *38*(3), 143–153. https://doi.org/10.1177/1525740116656330

Riley, E. A., Hart, E., Preston, J. L., Wu, Y., & Ashaie, S. (2021). Pervasiveness of speech-language disorders and fatigue in stroke: A systematic scoping review. *Journal of Communication Disorders*, *93*, 106145. https://doi.org/10.1016/j.jcomdis.2021.106145

Robinson, R. G., Kubos, K. L., Starr, L. B., Rao, K., & Price, T. R. (1984). Mood disorders in stroke patients. Importance of location of lesion. *Brain: A Journal of Neurology*, *107 (Pt 1)*, 81–93. https://doi.org/10.1093/brain/107.1.81

Sarasso, S., Määttä, S., Ferrarelli, F., Poryazova, R., Tononi, G., & Small, S. L. (2014). Plastic Changes Following Imitation-Based Speech and Language Therapy for Aphasia: A High-Density Sleep EEG Study. *Neurorehabilitation and Neural Repair*, *28*(2), 129–138. https://doi.org/10.1177/1545968313498651

Schönauer, M. (2018). Sleep Spindles: Timed for Memory Consolidation. *Current Biology*, *28*(11), R656–R658. https://doi.org/10.1016/j.cub.2018.03.046

Siengsukon, C. F., & Boyd, L. A. (2008). Sleep Enhances Implicit Motor Skill Learning in Individuals Poststroke. *Topics in Stroke Rehabilitation*, *15*(1), 1–12. https://doi.org/10.1310/tsr1501-1

Skidmore, E. R., Whyte, E. M., Holm, M. B., Becker, J. T., Butters, M. A., Dew, M. A., Munin, M. C., & Lenze, E. J. (2010). Cognitive and Affective Predictors of Rehabilitation Participation After Stroke. *Archives of Physical Medicine and Rehabilitation*, *91*(2), 203–207. https://doi.org/10.1016/j.apmr.2009.10.026

Smith, C., & Rose, G. M. (1996). Evidence for a paradoxical sleep window for place learning in the Morris water maze. *Physiology & Behavior*, *59*(1), 93–97. https://doi.org/10.1016/0031-9384(95)02054-3

Snaphaan, L., van der Werf, S., & de Leeuw, F.-E. (2011). Time course and risk factors of post-stroke fatigue: A prospective cohort study. *European Journal of Neurology*, *18*(4), 611–617. https://doi.org/10.1111/j.1468-1331.2010.03217.x

Steiger, A., & Pawlowski, M. (2019). Depression and Sleep. *International Journal of Molecular Sciences*, *20*(3), Article 3. https://doi.org/10.3390/ijms20030607

Strong, K. A., & Randolph, J. (2021). How Do You Do Talk Therapy With Someone Who Can't Talk? Perspectives From Mental Health Providers on Delivering Services to Individuals With Aphasia. *American Journal of Speech-Language Pathology*, *30*(6), 2681–2692. https://doi.org/10.1044/2021_AJSLP-21-00040

Suni, E., & Singh, A. (2021, March 9). *How Much Sleep Do We Really Need?* Sleep Foundation. https://www.sleepfoundation.org/how-sleep-works/how-much-sleep-do-we-really-need

Terzoudi, A., Vorvolakos, T., Heliopoulos, I., Livaditis, M., Vadikolias, K., & Piperidou, H. (2009). Sleep Architecture in Stroke and Relation to Outcome. *European Neurology*, *61*(1), 16–22. https://doi.org/10.1159/000165344

Towfighi, A., Ovbiagele, B., El Husseini, N., Hackett, M. L., Jorge, R. E., Kissela, B. M., Mitchell, P. H., Skolarus, L. E., Whooley, M. A., & Williams, L. S. (2017). Poststroke Depression: A Scientific Statement for Healthcare Professionals From the American Heart Association/American Stroke Association. *Stroke*, *48*(2), e30–e43. https://doi.org/10.1161/STR.0000000000000113

Tucker, F. M., Edwards, D. F., Mathews, L. K., Baum, C. M., & Connor, L. T. (2012). Modifying health outcome measures for people with aphasia. *The American Journal of Occupational Therapy: Official Publication of the American Occupational Therapy Association*, *66*(1), 42–50. https://doi.org/10.5014/ajot.2012.001255

Vallila-Rohter, S., & Kiran, S. (2013). Non-linguistic learning and aphasia: Evidence from a paired associate and feedback-based task. *Neuropsychologia*, *51*(1), 79–90. https://doi.org/10.1016/j.neuropsychologia.2012.10.024

Van Cauter, E., Leproult, R., & Plat, L. (2000). Age-Related Changes in Slow Wave Sleep and REM Sleep and Relationship With Growth Hormone and Cortisol Levels in Healthy Men. *JAMA*, *284*(7), 861–868. https://doi.org/10.1001/jama.284.7.861

van Dijk, M. J., de Man-van Ginkel, J. M., Hafsteinsdóttir, T. B., & Schuurmans, M. J. (2016). Identifying depression post-stroke in patients with aphasia: A systematic review of the reliability, validity and feasibility of available instruments. *Clinical Rehabilitation*, *30*(8), 795–810. https://doi.org/10.1177/0269215515599665

Walker, M. P., & van der Helm, E. (2009). Overnight therapy? The role of sleep in emotional brain processing. *Psychological Bulletin*, *135*, 731–748. https://doi.org/10.1037/a0016570

Wallace, D. M., Ramos, A. R., & Rundek, T. (2012). Sleep disorders and stroke. *International Journal of Stroke*, *7*(3), 231–242. https://doi.org/10.1111/j.1747-4949.2011.00760.x

Weinhouse, G. L., & Schwab, R. J. (2006). Sleep in the Critically ill Patient. *Sleep*, *29*(5), 707–716. https://doi.org/10.1093/sleep/29.5.707

What Is Sleep Quality? (2020, October 28). National Sleep Foundation. https://www.thensf.org

Wilson, M. A., & McNaughton, B. L. (1994). Reactivation of Hippocampal Ensemble Memories During Sleep. *Science*, *265*(5172), 676–679. https://doi.org/10.1126/science.8036517

Xie, L., Kang, H., Xu, Q., Chen, M. J., Liao, Y., Thiyagarajan, M., O'Donnell, J., Christensen, D. J., Nicholson, C., Iliff, J. J., Takano, T., Deane, R., & Nedergaard, M. (2013). Sleep Drives

Metabolite Clearance from the Adult Brain. *Science*, *342*(6156), 373–377. https://doi.org/10.1126/science.1241224

Yang, G., Lai, C. S. W., Cichon, J., Ma, L., Li, W., & Gan, W.-B. (2014). Sleep promotes branch-specific formation of dendritic spines after learning. *Science*, *344*(6188), 1173–1178. https://doi.org/10.1126/science.1249098

Yu, L., Buysse, D. J., Germain, A., Moul, D. E., Stover, A., Dodds, N. E., Johnston, K. L., & Pilkonis, P. A. (2011). Development of short forms from the PROMIS™ sleep disturbance and Sleep-Related Impairment item banks. *Behavioral Sleep Medicine*, *10*(1), 6–24. https://doi.org/10.1080/15402002.2012.636266

Zunzunegui, C., Gao, B., Cam, E., Hodor, A., & Bassetti, C. L. (2011). Sleep Disturbance Impairs Stroke Recovery in the Rat. *Sleep*, *34*(9), 1261–1269. https://doi.org/10.5665/SLEEP.1252