

**ACADEMIC OUTCOME IN PEDIATRIC STROKE:  
A MULTIFACETED APPROACH TO EXPLORING CHALLENGES AND ACHIEVEMENTS**

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## **Abstract**

An important cause of acquired brain injury in children, pediatric stroke causes sequelae across a wide range of cognitive domains, including expressive language, attention, memory, and processing speed. As a result, survivors are especially vulnerable to academic difficulties and face unique challenges compared to their peers. Despite this knowledge, pediatric stroke remains an understudied neurological condition, and its impact on school functioning poorly understood. The present thesis addresses academic outcome in pediatric stroke with two manuscripts. The first, a systematic review, explores the tools chosen by researchers to measure academic outcome in this population. An examination of the limitations of research methodologies paves the way for discussions and recommendations for improvement. The second manuscript, a clinical research study, assesses academic outcome using a multifaceted approach. Patients in the Children's Stroke Program at the Hospital for Sick Children were recruited for participation. Results indicate that, compared to their peers, youth with stroke exhibit deficits in processing speed and basic academic skills, require more school accommodations, and are more likely to receive a learning disability diagnosis. Analyses suggest that processing speed and reading ability predict grades for youth with stroke over and above the effects of intelligence. Finally, school grades, school-related quality of life, and symptoms of Attention Deficit Hyperactivity Disorder were all comparable between groups. Ending with an overarching discussion connecting both studies, the present thesis makes a meaningful contribution to the field of pediatric stroke and promotes a more nuanced understanding of the academic struggles and achievements that survivors experience.

Key words: pediatric stroke, clinical neuropsychology, academic outcome, school

## Résumé

Les accidents vasculaires cérébraux (AVC) pédiatriques, une cause importante de lésions cérébrales acquises chez les enfants, engendrent des séquelles touchant des domaines cognitifs tels que l'expression, l'attention, la mémoire et la vitesse de traitement. Ainsi, les enfants ayant survécu un AVC sont vulnérables à des difficultés académiques uniques relativement à leurs pairs. Malgré les connaissances mentionnées précédemment, l'AVC pédiatrique est une condition neurologique sous-étudiée et son impact sur le fonctionnement scolaire peu connu. Sous forme de deux manuscrits, cette thèse adresse l'expérience académique chez les enfants ayant survécu un AVC. Le premier manuscrit, une revue systématique, explore les techniques choisies par les chercheurs pour mesurer l'expérience académique dans cette population. Une évaluation des limites de ces méthodologies est suivie par des recommandations pour les améliorer. Le second manuscrit, une étude de recherche clinique, évalue l'expérience académique d'enfants ayant survécu un AVC avec une approche multidimensionnelle. Des patients venant du Hospital for Sick Children à Toronto ont été recrutés pour y participer. Les résultats indiquent que, comparés à leurs pairs, les enfants ayant survécu un AVC ont des difficultés avec la vitesse de traitement et les compétences académiques de base, ont besoin de plus d'accommodations à l'école, et ont une plus grande chance d'être diagnostiqué avec un trouble d'apprentissage. Chez les enfants ayant survécu un AVC, la vitesse de traitement et les compétences de lecture prédisent leurs résultats scolaires au-delà des effets de l'intelligence. Enfin, les résultats scolaires, la qualité de vie à l'école, et les symptômes du trouble déficitaire de l'attention avec hyperactivité sont similaires entre les deux groupes. En terminant avec une discussion globale connectant les deux études, cette thèse contribue fondamentalement au

domaine scientifique d'AVC pédiatrique et encourage une compréhension plus fine et nuancée des luttes et succès que vivent les jeunes survivants.

Mots clés: accident cérébral vasculaire pédiatrique, neuropsychologie clinique, expérience académique, école

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## **Glossary**

Conners: Parent Clinical Index of the Conners Comprehensive Behavior Rating Scales.

Kidscreen child report: Kidscreen-52 Children and Adolescent report.

Kidscreen parent report: Kidscreen-52 Parent report.

WASI-II: Wechsler Abbreviated Scale of Intelligence – Second Edition.

WIAT-III: Wechsler Individual Achievement Test – Third Edition.

WISC-V: Wechsler Intelligence Scale for Children – Fifth Edition.

WRAT-4: Wide Range Achievement Test – Fourth Edition.

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## GENERAL INTRODUCTION

Pediatric stroke is an important cause of acquired brain injury in children, with an incidence rate of 25-37 per 100,000 infants and 1-13 per 100,000 children (deVeber, Roach, Riela, & Wiznitzer, 2000; Fuentes, Deotto, Desrocher, deVeber, & Westmacott, 2016; Härtel, Schilling, Sperner, & Thyen, 2004; Kirton, Westmacott, & deVeber, 2007; Lynch & Nelson, 2001). A stroke is deemed pediatric if it occurs perinatally (i.e., several weeks prior to an infant's birth up to 28 days after birth) or during childhood (i.e., between 29 days and 18 years of age). The resulting brain lesions cause long-term neurological problems in 50% to 80% of survivors (Cárdenas, Rho, & Kirton, 2011; Roach et al., 2008). Complex neurocognitive impairments commonly occur, rendering youth with stroke especially vulnerable to unique academic difficulties (De Schryver, Kappelle, Jennekens-Schinkel, & Peters, 2000; Ganesan et al., 2000; Jacomb, Porter, Brunson, Mandalis, & Parry, 2016). This thesis addresses academic outcome in pediatric stroke by reviewing research methodologies and providing new empirical evidence to compare academic functioning in youth with and without stroke.

Understanding the basic pathophysiology of stroke is key to appreciating its impact on a developing brain. Stroke is a focal cerebrovascular event of acute onset characterized by a significant disruption in the normal blood flow in the brain due to ischemia or hemorrhaging (Festa, Lazar, & Marshall, 2008). The population included in this thesis comprises youth who have experienced an ischemic stroke, specifically an arterial ischemic stroke (AIS) or cerebral sinovenous thrombosis (CSVT). Ischemic stroke occurs when a blood clot or narrowing artery causes a significant restriction of blood flow to a region of the brain. The deprivation of blood prevents oxygen and glucose from reaching brain tissues, causing death to the surrounding

neurons. A thrombotic stroke occurs when a blood clot – i.e., a thrombosis – forms locally on an artery or blood vessel and blocks the blood flow. In contrast, an embolic stroke occurs when an intravascular mass – i.e., an embolus, such as a blood clot or piece of tissue – has detached itself from its point of origin and travels through the vascular system, eventually lodging itself into an artery or vessel and occluding blood flow. CSVT occurs when a thrombosis within the venous system, rather than the arterial system as seen in AIS, causes obstruction. An increase in capillary hydrostatic pressure may result in edema (swelling), a reduction of arterial blood flow, and arterial ischemia. Recurrence rates of childhood ischemic stroke may reach 30% (Bernard, 2007; Lynch, Pavlakis, & Veber, 2005).

The leading risk factor for ischemic infarcts in children is arteriopathy, with studies reporting frequency rates of 50-80% in youth with stroke (Amlie-Lefond et al., 2009; Beslow & Jordan, 2010; Ganesan, Prengler, McShane, Wade, & Kirkham, 2003; Mackay et al., 2011). Other risk factors include systemic conditions (~40%), cardiac disorders (~30%), head and neck disorders (~30%), and infection (~25%) (Mackay et al., 2011). Systemic conditions range from acute conditions such as a lasting fever, shock, and dehydration, to chronic conditions, such as sickle cell disease (Mackay et al., 2011). Sickle cell disease constitutes a significant predictor of arteriopathy and of ischemic stroke; left untreated, more than 10% of pediatric patients with sickle cell disease will experience a stroke by 20 years of age (Ohene-Frempong et al., 1998). The most common cardiac disorder seen in youth with ischemic stroke is congenital heart disease, followed by acquired heart disease and heart surgery (Mackay et al., 2011). Chronic head and neck disorders that are risk factors for pediatric ischemic stroke include migraines and brain tumors, while acute disorders include trauma to these areas (Mackay et al., 2011). Previous trauma also tends to be common in children with ischemic stroke (Ganesan et al.,

2003). Major infections such as bacterial meningitis, sepsis, and endocarditis are also associated with ischemic stroke in children (Fullerton et al., 2015). Finally, between a third and a half of all pediatric stroke patients have idiopathic, or unexplained, stroke (Ganesan et al., 2003; Lynch, Hirtz, DeVeber, & Nelson, 2002; Walsh & Garg, 1997). The frequency of risk factors changes depending on the patient's age at time of stroke. Studies have found that arteriopathy is most common in children who experienced an ischemic stroke between the ages of 5 and 9, while cardiac disease, acute systemic disorders, and infections were more common in children under the age of 5, and chronic head and neck disorders were more common in youth ages 10 to 18 (Mackay et al., 2011). Nonetheless, arteriopathy remained the most common risk factor experienced by youth in all age groups, with a frequency ranging from 46% to 66%.

Presentation of neurological symptoms of pediatric stroke depend on a variety of factors, including the location and size of the lesion, the stroke mechanism, underlying cause or risk factor, and the age at time of stroke. Initial clinical presentation of stroke varies more in children than in adults, with perinatal stroke exhibiting more diverse initial symptomatology compared to childhood stroke (Cárdenas et al., 2011). Half of ischemic perinatal strokes are asymptomatic and diagnosed retrospectively upon noticing that the child has an early hand preference or motor asymmetry around 6 months of age, indicating hemiparesis. Conversely, symptomatic perinatal ischemic stroke may be diagnosed more quickly if the infant suffers from seizures within the first few weeks of life. Other symptoms of perinatal stroke include apnea spells and hypotonia. Childhood stroke symptomatology resembles that of adults. Acute hemiparesis, seizures, vertigo, lethargy, and dysphasia all commonly occur in children and adults upon onset of an ischemic stroke.

Limitations in knowledge and awareness of stroke in youth, coupled with the heterogeneity of presentation symptoms in children compared to adults, have hampered its recognition by the public and medical professionals (Cárdenas et al., 2011; Roach et al., 2008). Delays in diagnosis are common, limiting opportunities for rapid medical intervention (Braun, Kappelle, Kirkham, & DeVeber, 2006; Cárdenas et al., 2011). Data on delayed diagnosis of stroke in children are scarce (Hartman, Lunney, & Serena, 2009), but scientists agree that stroke is generally recognized later in children than in adults (Braun et al., 2006). One study reported that only a quarter to a third of children with stroke presented for medical evaluation within 6 hours of symptom onset (Gabis, Yangala, & Lenn, 2002). Researchers in Switzerland have calculated that a quarter of patients with pediatric stroke did not receive magnetic resonance imaging (MRI) within the first two weeks of presenting symptoms (Ganesan, 2010). Vascular imaging enables faster diagnosis of stroke, which can help to decrease secondary complications. Early diagnosis is critical as it gives healthcare providers more flexibility and time to determine optimal treatment and rehabilitation strategies (Braun et al., 2006).

The brain damage and lesions involved in pediatric stroke engender myriad complications for survivors, including diverse cognitive sequelae which can significantly vary from one patient to the next. Researchers have also observed that the full extent of cognitive consequences after childhood stroke may not be apparent until years after the initial injury (Anderson, Spencer-Smith, & Wood, 2011; Gordon et al., 2015), and they tend to persist over time (O’Keeffe, Ganesan, King, & Murphy, 2012). Cognitive deficits contribute to many impairments spanning academic, psychological, social, and emotional domains. Youth with stroke experience significant academic difficulties due to struggles with language, expression, executive functioning, attention, memory, visuospatial abilities, and processing speed (Allman &

Scott, 2013; Cruz, 2001; Everts et al., 2008; Härtel et al., 2004; Max, 2004; Nass & Trauner, 2004; O’Keeffe et al., 2012; Westmacott, Askalan, Macgregor, Anderson, & deVeber, 2009). Reading impairments may emerge if the structural and functional integrity of specific cerebral regions are damaged. Reading ability is a strong predictor of academic success, and, relative to their peers, children with reading difficulties have lower academic achievement and higher drop out rates in high school (Lah, Castles, & Smith, 2017). In addition, cognitive deficits can cause communication difficulties and behavioural problems (Denham, Bassett, & Wyatt, 2007). They impede socio-emotional functioning and interpersonal relationships, and may ultimately lead to social isolation (Bakopoulou & Dockrell, 2016; Mukherjee, Levin, & Heller, 2006). Children have a higher risk for social difficulties following stroke (Greenham et al., 2015; Max et al., 2002) for reasons including decreased social acceptance (Everts et al., 2008), changes in peer relationships (Neuner et al., 2011; O’Keeffe et al., 2012), reduced social participation (Anderson et al., 2014; Hurvitz, Warschausky, Berg, & Tsai, 2004), as well as problems with inhibition and emotional regulation (Gordon, Ganesan, Towell, & Kirkham, 2002), internalizing behaviours (Greenham et al., 2015), and externalizing behaviours (Steinlin, Roellin, & Schroth, 2004).

Studies have also found evidence of a higher risk for psychiatric disorders after pediatric stroke, namely Attention Deficit and Hyperactivity Disorder (ADHD) and anxiety and mood disorders (Everts et al., 2008; Max et al., 2002). However, research on the prevalence of learning disabilities in pediatric stroke populations is lacking. Findings confirm significant differences in learning skills and academic difficulties (e.g., Ballantyne, Spilkin, Hesselink, & Trauner, 2008; Chabrier et al., 2016; Jacomb et al., 2016; O’Keeffe et al., 2014), but children with specific learning disabilities due to stroke have not been distinguished from those with intellectual or behavioural challenges, who also require educational support. Thus far, only one



team of researchers has examined the prevalence of learning disabilities in youth with stroke (Williams, McDonald, et al., 2017). A third of their sample (n = 126) received a learning disability diagnosis, making it the most prevalent psychological diagnosis, followed by ADHD and intellectual disability (Williams, McDonald, et al., 2017). These findings, along with the paucity of research on learning disabilities and academic outcome in pediatric stroke, highlight the need for additional empirical evidence to shed light on post-stroke academic functioning.

Researchers have postulated that the developmental stage of the brain at the time of injury may influence outcome, but have not yet reached a consensus regarding whether age at onset correlates positively or negatively with recovery (Allman & Scott, 2013). The dominant position for many years, dubbed the *plasticity hypothesis*, supports the theory that the increased plasticity of a child's brain, compared to that of an adult, facilitates reorganization after injury (Max, Bruce, Keatley, & Delis, 2010). Studies on motor outcome and language function after brain damage were pivotal to the advocacy of the plasticity hypothesis (Max et al., 2010). For instance, scientists found that pediatric patients suffering from left hemisphere lesions showed considerable plasticity for language function compared to adults (Ballantyne et al., 2008). A number of mechanisms may be responsible for cerebral recovery after stroke, including formation of new synaptic connections, change of function of neurons, and use of pathways contralateral to the lesion site (Gordon, Wood, Tournier, & Hunt, 2012). In opposition to this theory, some researchers have uncovered increasing evidence supporting an *early vulnerability hypothesis*, which posits that younger brains may be more vulnerable to trauma (Westmacott et al., 2009). Children are less likely than adults to exhibit deficits that specifically map on to lesion location and lateralization – presumably due to their brain's increased plasticity – but research has shown that an early brain injury may lead to more widespread cognitive dysfunction

across multiple domains compared to a later brain injury (Banich, Levine, Kim, & Huttenlocher, 1990). One study uncovered patterns of poorer discourse in children with early injuries compared to children who suffered later injuries (Chapman, Levin, Wanek, Weyrauch, & Kufera, 1998), and another revealed greater adverse effects in earlier compared to later stroke affecting verbal and written language abilities (Ewing-Cobbs, Miner, Fletcher, & Levin, 1989). Some findings have suggested that the brain is most vulnerable to the effects of a focal lesion during the first two years of life, while others point to a vulnerability period ending at five years of age, and still others have found no clear relationship between age at injury and cognitive outcome (Banich et al., 1990; Goodman & Yude, 1996; Riva & Cazzaniga, 1986). Researchers have also found evidence that earlier age at insult is linked to greater impairments emerging later in development in overall cognitive functioning as well as specific cognitive domains including attention, perceptual-motor skills, spatial abilities, and higher-level aspects of language processing (Chapman, Max, Gamino, McGlothlin, & Cliff, 2003; Max et al., 2010; Stiles et al., 2008).

Despite awareness of the significant impairments it produces, pediatric stroke remains understudied, and despite the knowledge that academic skills and cognitive abilities related to learning are particularly vulnerable in youth with stroke (Gordon, 2014; Williams, McDonald, et al., 2017), research on academic outcome especially is lacking. The present thesis contains two original manuscripts representing the scope of my Master's research, centered around academic outcome in pediatric stroke. The first manuscript comprises a systematic review. Preliminary evaluation of studies on academic outcome in pediatric stroke revealed a wide discrepancy in measures utilized. In this first manuscript, I explore the tools chosen by researchers to measure academic functioning in a pediatric stroke population. I examine five central problematic

methodologies and discuss ways to improve assessment of academic outcome. In line with my findings, the second manuscript in this thesis consists of a clinical study aiming to elucidate the impact of stroke on various aspects of academic functioning. Using an extensive battery, including neuropsychological evaluations, psychoeducational assessments, school report cards, parent questionnaires, and self reports, this study seeks to improve clinical understanding of the challenges that children and adolescents with stroke encounter at school, both as independent cognitive impairments and in relation to each other. The General Discussion connects the conclusions from both studies and delves into implications for future research and clinical services for children who have had strokes and suffer from academic challenges. These studies provide a unique opportunity to study school outcomes in an understudied population.

## MANUSCRIPT 1: SYSTEMATIC REVIEW

### Literature Review

Pediatric stroke is a cerebrovascular event of acute onset, wherein a clot or ruptured vessel disrupts the normal blood flow in a child's brain, resulting in lesions (Festa et al., 2008). Pediatric stroke can occur perinatally (i.e., several weeks prior to an infant's birth up to 28 days after birth) or during childhood (i.e., between 29 days and 18 years of age). An important cause of acquired brain injury in children (Fuentes et al., 2016), childhood stroke has an annual incidence rate of 0.6 to 13 per 100,000 children while perinatal stroke has a higher prevalence of up to 37 per 100,000 live births per year, which is roughly equal to 1 per 2,700 births (deVeber et al., 2000; Härtel et al., 2004; Kirton et al., 2007; Lynch et al., 2002). Stroke can be fatal, with mortality rates reaching 40%, and potentially devastating, causing permanent neurological problems in 50% to 80% of survivors (Cárdenas et al., 2011; Roach et al., 2008). Such problems include intellectual disability, neurocognitive deficits, socio-emotional difficulties, mental health issues, seizure disorders, motor impairments, and cortical sensory problems (Greenham et al., 2015; Max et al., 2002). Due to these deficits and the secondary functional impairments they cause, stroke has been shown to adversely impact children's academic achievement, independence, psychological well-being, and quality of life (Everts et al., 2008; Härtel et al., 2004; O'Keeffe et al., 2012). Children with stroke are especially vulnerable to academic difficulties and face unique challenges compared to their peers (De Schryver et al., 2000; Ganesan et al., 2000; Jacomb et al., 2016). Furthermore, the impact of stroke is often most apparent in the area of education, and its detrimental effect on school has been reported as the greatest concern for both parents and youth (Friefeld, Yeboah, Jones, & deVeber, 2004; Gordon et al., 2002).

A majority of pediatric stroke survivors suffer from neuropsychological sequelae across a wide range of cognitive domains, including executive functioning, attention, memory, visuospatial abilities, language, and processing speed, all of which can impact school performance (Allman & Scott, 2013; Cruz, 2001; Everts et al., 2008; Härtel et al., 2004; Max, 2004; Nass & Trauner, 2004; O’Keeffe et al., 2012; Westmacott et al., 2009). Studies focused on general intellect have documented that survivors tend to score in the lower end of the average range on full scale IQ tests, typically between scales scores of 90 and 95 (Everts et al., 2008; Max et al., 2002; O’Keeffe et al., 2012). Difficulties with executive functioning are especially common, and typically span attentional control, cognitive flexibility, goal setting, and information processing (Long et al., 2011). Children suffering from reduced processing speed, impaired working memory, and difficulties with sustained and divided attention require increased cognitive effort to perform an academic task (Block, Nanson, & Lowry, 1999; Everts et al., 2008; Long et al., 2011; Max, 2004; O’Keeffe et al., 2012). In addition, children with weak working memory tend to underperform academically (Gathercole & Alloway, 2006). They experience functional difficulties in a classroom environment due to frequent errors in activities involving multi-step instructions and multi-leveled tasks such as writing (Gathercole, Tiffany, Briscoe, & Thorn, 2005). Due to these struggles, about 50% of survivors of pediatric stroke require special assistance in class; 30% need temporary remedial teaching; 20-35% are placed in special education programs; and 30% fail and/or repeat a class. In some severe cases, survivors may be unable to return to school due to significant aphasia and cognitive deficits (De Schryver et al., 2000; Ganesan et al., 2000; Hogan, Kirkham, & Isaacs, 2000; Pavlovic et al., 2006).

Preliminary evaluation of studies examining academic outcomes after pediatric stroke reveals a wide discrepancy in measures utilized. Common neuropsychological tests include the

Wide-Range Achievement Test (WRAT-R and WRAT-4) (Jastak & Wilkinson, 1984; Wilkinson & Robertson, 2006), a brief, individually administered assessment that measures reading, spelling, and arithmetic skills in youth (e.g., Ballantyne et al., 2008; Max et al., 2010); the Wechsler Individual Achievement Test (WIAT-II and III) (Wechsler, 2005, 2009), which is the comprehensive version of the WRAT (e.g., Jacomb et al., 2016; O’Keeffe et al., 2014); and the Woodcock-Johnson Test of Achievement (WJ-III ACH) (Mather & Woodcock, 2001), another full length assessment of academic achievement (e.g., Westmacott et al., 2017; Williams, Roberts, et al., 2017). Researchers who opt for neuropsychological measures to assess academic achievement typically use brief screeners (e.g., WRAT-4) or select subtests from longer tests (e.g., subtests from the WIAT-III). In rare cases, researchers have developed their own non-standardized measures to assess academic achievement, such as math or dictation exercises (e.g., Blom et al., 2003).

When assessing school functioning, researchers have also turned their attention to educational placements. Several studies include information about what kind of school participants attend, whether they require special education classes or accommodations, and if they repeated or failed a class (e.g., Rodrigues et al., 2011; Roze et al., 2009). Often, the ways in which placement information was collected are not clearly stated; authors tend to report this data without explaining how they gathered it (e.g., Chabrier et al., 2016; Dusser, Goutières, & Aicardi, 1986; Golomb, Carvalho, & Garg, 2005).

Researchers also tend to gather information about academic quality of life by asking parents about their children, usually via questionnaires or interviews. A common questionnaire is the Pediatric Quality of Life Inventory (PedsQL) (Varni, Seid, & Kurtin, 2001), which comprises both parent and child versions and asks about topics like psychosocial health and school

functioning (e.g., Bulder et al., 2011; O’Keeffe et al., 2012). Some studies have asked parents to fill out questionnaires like the PedsQL, others have asked their pediatric participants to complete questionnaires themselves, and others have used both parent and child versions for comparison and increased reliability. Measures to assess academic quality of life are sometimes unclear or unstandardized; one study crafted questions about school functioning for parents based on suggestions from an article on quality of life for oncology patients (De Schryver et al., 2000), and another mentioned parent reports as a measure, but whether interviews or questionnaires were used remains unclear (Hurvitz et al., 2004).

Overall, preliminary evaluation of studies on academic outcomes after pediatric stroke suggests that a majority assess one of three components: 1) academic achievement, typically using standardized psychoeducational tests, 2) educational placements, for which data collection measures are unclear, and 3) quality of life, often quantified with questionnaires for parents and youth. Less commonly, studies have examined behavior, social skills, and self-esteem in a school context, as well as academic abilities prior to stroke onset. To assess these variables, researchers have relied on questionnaires or on undisclosed methods.

The current systematic review explores the tools chosen by researchers to measure aspects of school functioning in a pediatric stroke population, such as achievement, satisfaction, and support in academic settings. An analysis of the methods used is necessary to gain a clear understanding of the strengths and weaknesses of research conducted thus far. Results will summarize the methods utilized, both commonly and rarely, as well as variability in quantity and types over the past decades, and specific interests of researchers (e.g., grade-based success vs. quality of life). Ending with a discussion on the effectiveness and limitations of current methods,

this review will help inform the use of valid and reliable methodologies for future studies on academic outcomes of pediatric stroke.

## **Methodology**

This study is registered with PROSPERO and follows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement guidelines (Moher, Liberati, Tetzlaff, Altman, & The PRISMA Group, 2009). The study identification number is CRD42017070532.

The following databases were searched in November 2017: PsycINFO (via ProQuest), PubMed (via Medline), and ERIC (Education Resources Information Center, via ProQuest). The following search criteria were used: [(p\*ediatic OR child\* OR youth OR perinatal OR neonatal) AND (stroke OR “cerebrovascular accident” OR hemorrhag\* OR ischemi\*) AND (academi\* OR school)]. PubMed, due to its strong medical content, yielded numerous irrelevant articles on hypoxia and encephalopathy, as well as studies on stroke movement in handwriting and letter formation. As such, for PubMed, the search terms were further restricted with the following: [NOT (hypoxic\* OR encephalopath\* OR handwriting)].

The initial literature search yielded 432 articles. In addition, manual screening of reference sections of selected manuscripts identified 11 additional relevant articles (total N = 443). After duplicates were removed, 370 articles remained for screening. To be included in the next phase, studies had to meet the following criteria:

1. The article focused on patients with stroke primarily, rather than stroke being a subgroup of medical conditions (e.g., Sickle Cell Disease);
2. The patients suffered a stroke between the ages of 0-18 years;



- The article assessed the academic experience of patients, i.e., it included findings directly related to school life, such as grades, accommodations, and academic functioning.

Two authors screened the articles by reading the abstracts, with a 50% overlap to assess interrater reliability. Comparison of screening results yielded a reliability coefficient of 0.96, indicating consistent rating. The initial screening resulted in the exclusion of 322 articles. The 48 remaining articles were evaluated for eligibility using a team-based approach. Both raters assessed the articles, reading and discussing the full texts to reach consensus. At this final stage, 7 articles were excluded, leaving a total of 41 articles for inclusion in the systematic review. See Figure 1 for details. Statistical analyses were conducted using IBM SPSS 20.

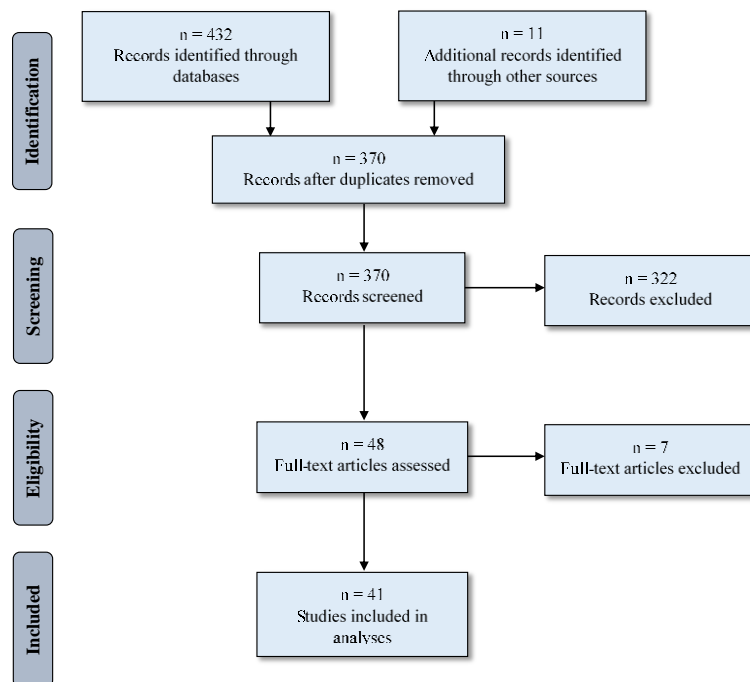


Figure 1. PRISMA flow chart of studies assessed and included.

## Results

The 41 studies included in this review are summarized in Appendix B. Studies were published between 1986 and 2017. For each article, we only examined methods that attempted to assess academic outcome, and thus ignored others (e.g., those measuring general cognitive ability or motor impairments). Researchers used between 1 and 6 measures to assess academic experience, with an average of 1.8 measures per publication, a median and a mode of 1.0 per publication, and a standard deviation of 1.2. This suggests that although some authors used several measures in their study, a majority of authors used only one measure. Specifically, in 22 articles out of 41 (53.7%), one measure was used, while 11 articles (26.8%) each used 2 measures, 5 articles (12.2%) each used 3 measures, one article (2.4%) used 4 measures, and 2 articles (4.9%) used 6 distinct measures to assess academic experience. See Figure 2.

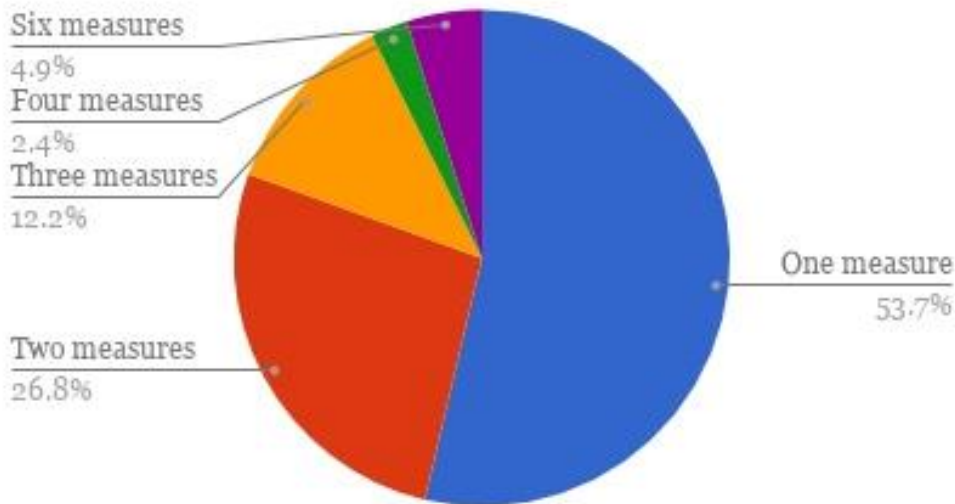


Figure 2. Number of measures used to assess academic functioning per study.

### *Method disclosure*

Methods of the examined publications were divided into 4 groups: 1) a method for which the authors stated both the actual measure (e.g., questionnaire, interview, cognitive test) and the informant (e.g., caregiver, participant, teacher); 2) a method for which the authors stated only the actual measure, but not the informant; 3) a method for which the authors stated only the informant, but not the actual measure; and 4) a method for which the authors stated neither the informant nor the measure. We provide examples for each case below.

At least one fully explained method was found in 33 out of the 41 articles (80.5%), which signifies that one fifth of all articles (19.5% or 8 out of 41) did not include a single fully explained method. A fully explained method resembles the following: “children’s academic abilities ... were examined using select subtests from the Wechsler Individual Achievement Test – Third Edition and the Woodcock-Johnson Test of Achievement – Third Edition” (Westmacott et al., 2017, p. 4). The authors communicated to readers their measures (in this case, two neuropsychological tests) and their informants (in this case, participants). As a second example, consider Hawks et al.’s (2016) explanation on how they collected data about educational placement: “For each subject, parents were asked whether the child had an individualized education plan or a 504 plan in place” (p. 47). The authors clearly stated their measure (in this case, an interview) and informants (in this case, parents).

Methods for which authors only clarified the measure but not the informant only appeared in one article (2.4%). Bulder et al. (2011) stated, “We asked whether the child attended a special or regular school” (p. 464). Without specifying who they asked, the authors indicated the measure (interview) but not the informant.

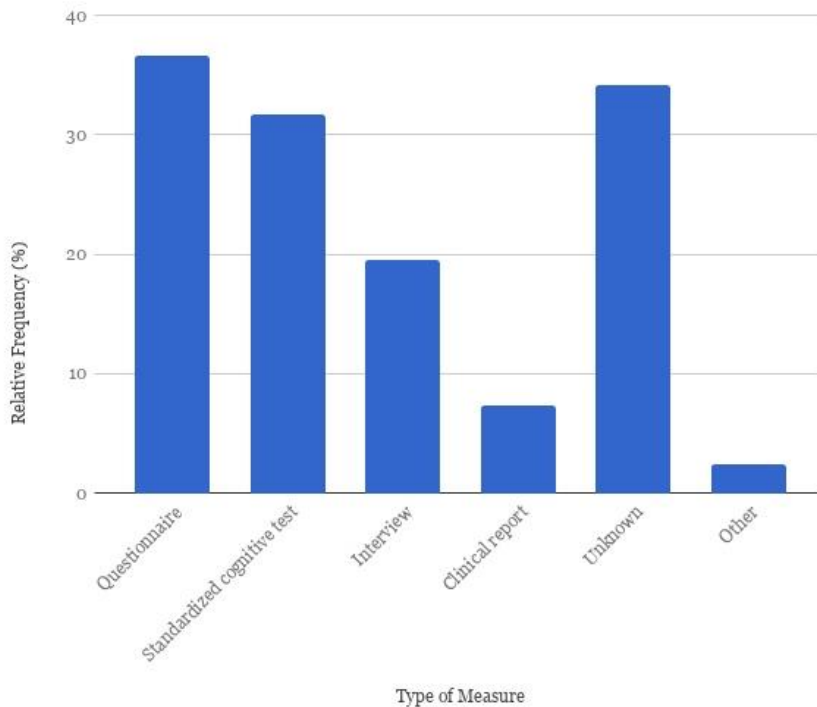
Methods for which authors mentioned the informant but failed to specify the measure were more common, appearing at least once in 4 articles (9.7%) and revolving around gaining information from parents. For instance, Cnossen et al. (2010) explained that “information concerning effect of disabilities on social participations, learning, and on the educational setting was obtained from parents” (p. 395). The informants are clear (parents) but the measure is not, with no mention of interviews or questionnaires.

Finally, 10 articles (24.4%) included at least one method for which they neither described the informant nor the actual measure. For instance, Roze et al. (2009) provided information about the educational placement of participants without clarifying how they retrieved that information: “Of 21 children, 12 attended normal education classes and 9 attended special education classes” (p. 1496). In this example, the instrument assessing educational placement is unknown (e.g., interview, clinical report) and the informant is unknown as well (e.g., parents, participant). Another example comes from Hurvitz et al. (2004), who wrote, “Current information on living situation, school placement, employment, and medical outcome were also obtained” (p. 53). Neither the actual measure nor the informant were clarified.

Overall, while most articles fully disclosed the ways in which they collected data related to academic functioning, 15 out of 41 articles (36.5%) failed to entirely disclose at least one of their methods. In other words, over a third of articles included a method with at least one unknown component. One fifth of all articles (19.5%) did not include a single fully explained method. These results suggest a noteworthy problem with lack of clarity in reporting methodology for data collection.

### *Types of measures*

Measures were divided into the following classifications: questionnaire, interview, standardized cognitive test, school report, standardized school exam, non-standardized test, telephone survey, clinical report, and unknown. The most commonly used measures are questionnaires (used in 36.6% of articles), standardized cognitive tests (31.7%), and interviews (19.5%). Clinical reports provided data on academic experience in some articles (7.3%). All other measures were used in only 1 article each (2.4%). Finally, over a third of articles included an unknown measure (34.1%). See Figure 3.



*Figure 3.* Types of measures used to assess academic functioning.

Studies using questionnaires tended to use one (7 out of 15) or two questionnaires (6 out of 15). One study used three, and one used four. The most commonly used questionnaires are the Pediatric Quality of Life Questionnaire – Self Report (PedsQL–self) (used in 4 out of 15

articles), the Pediatric Quality of Life Questionnaire – Parent report (PedsQL–parent) (used in 4 articles), and the Child Health Questionnaire (CHQ) (used in 2 articles).

Researchers using standardized cognitive tests generally used one test (9 out of 13 studies), sometimes two tests (4 studies). The most commonly selected tests were the Wide Range Achievement Test (WRAT-R, used by 6 articles), the Wechsler Individual Achievement Test (WIAT-II and -III, used by 5 articles), and the Woodcock Johnson Tests of Achievement (WJ-ACH-R and -III, used by 3 articles).

Overall, to assess academic functioning, researchers tended to opt for a questionnaire, a standardized cognitive test, or an interview. The most frequently used questionnaire was the PedsQL, while the most frequently used cognitive test was the WRAT, followed closely behind by the WIAT.

### *Informants*

A total of 15 out of 41 articles employed questionnaires, for a total of 27 questionnaires used overall. For 14 of those 27 questionnaires, the authors asked caregivers to complete them (51.9%). In 10 instances, participants were the ones asked to complete a questionnaire (37.0%). Teachers were relied upon in 3 instances (11.1%), and occupational and physical therapists were each asked to complete one questionnaire (3.7% each).

When interviews were used to assess academic experience, researchers tended to favor speaking with caregivers (4 out of 8 articles using interviews). In the remaining four articles, researchers spoke to the participants (1 out of 8 articles using interviews), stated that they interviewed participants *or* caregivers (1 out of 8 articles using interviews), stated that they

interviewed participants *and* caregivers (1 out of 8 articles using interviews), and did not specify the informant (1 out of 8 articles using interviews).

Overall, combining all measures, caregivers and participants were equally relied upon, each providing data in 20 out of 41 articles (48.8%). Caregivers were generally relied upon for questionnaires and interviews, while participants were relied upon to complete cognitive tasks. 3 articles asked teachers for information (7.3%). One article relied on information from an occupational and a physical therapist. Four articles claimed they asked for information from the caregiver *or* the participant. Lastly, 11 articles (26.8%) did not clarify who the informant was for a specific measure.

#### *Influence of publication year*

There were no significant correlations between year of publication and use of questionnaire, cognitive test, or interview. There were also no significant correlations between year of publication and use of unclear methods or fully clear methods, nor between year of publication and quantity of measures used.

#### *School-related constructs*

Our final question pertained to what researchers assessed when they sought to learn about academic experience. Over half of the articles examined educational placement (24 out of 41 articles, 58.5%) and academic achievement (23 articles, 56.1%) as measures of academic experience. 13 articles assessed school-related quality of life (31.7%), three looked at pre-stroke academic abilities (7.3%), and two evaluated social skills in academic settings (4.9%). On one

occasion, researchers assessed behavior in school as well as self-esteem in school (2.4%). See Figure 4.

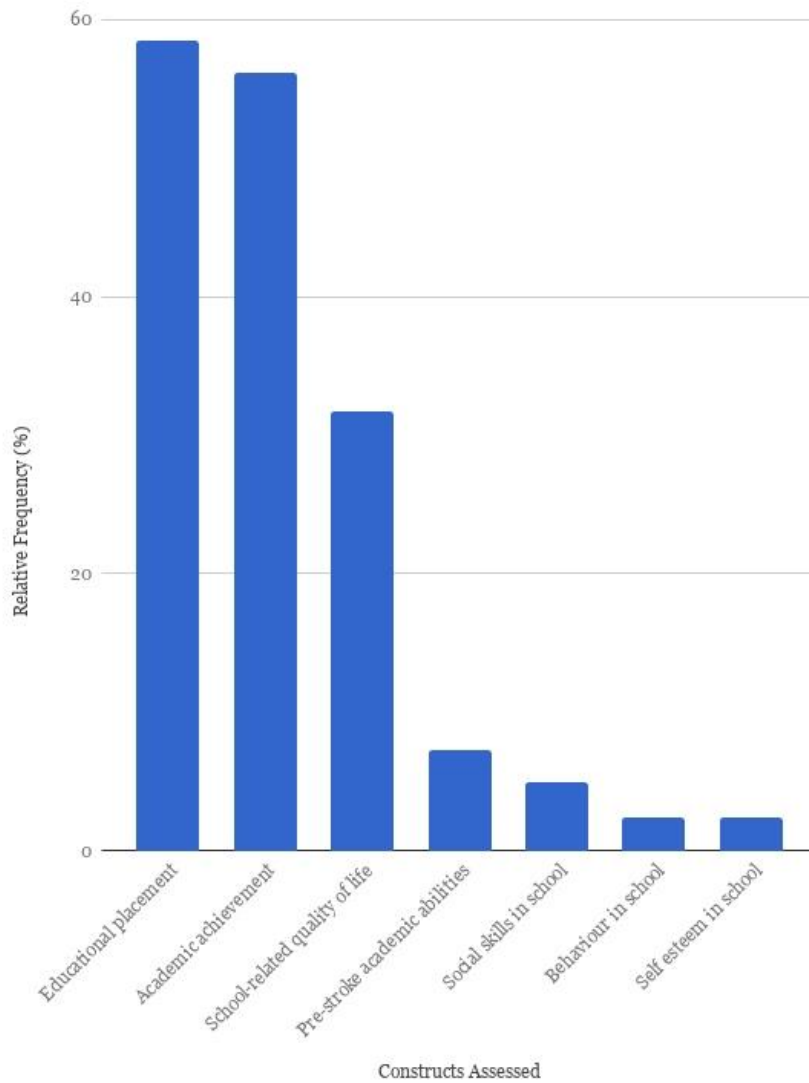


Figure 4. Types of academic constructs assessed.

Overall, about half of the articles (22 articles, 53.7%) attempted to assess only one construct of academic functioning (generally educational placement or academic achievement). One third of the articles (14 out of 41, 34.1%) attempted to assess two constructs; 3 articles



(7.3%) investigated 3 constructs; and 2 articles evaluated 4 constructs (4.9%) of school functioning. See Figure 5.

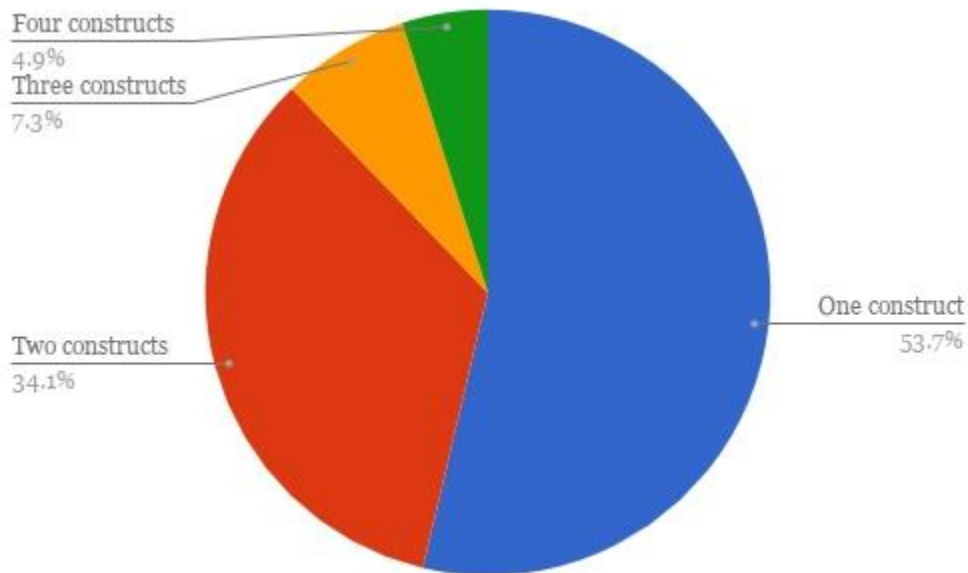


Figure 5. Number of academic constructs assessed per study.

## Discussion

The evaluation of 41 studies on academic outcome in pediatric stroke uncovered five main problematic methodology choices, and revealed some strengths in parallel. The first problem pertains to the heterogeneity of the measures used. The lack of a standardized protocol renders it difficult to compare findings across studies. In the articles examined, interviews were developed by researchers and specific questions rarely revealed. As such, another researcher would have difficulty replicating the same interview with a different sample. The most commonly used questionnaire is the Pediatric Quality of Life Questionnaire, but it was chosen by only 4 teams of researchers (9.8%). As for neuropsychological testing, the most commonly used tasks were the WRAT and the WIAT. Yet, only 6 articles employed the WRAT (14.6%) and 5 articles used the WIAT (12.2%). In short, there were no interview scripts, questionnaires, or

academic achievement tests that a majority of researchers opted to use. It should be noted that this heterogeneity of measures may be considered a strength as well. Most questionnaires and cognitive tasks generate standardized scores that can be compared across samples. Using a variety of measures causes challenges for cross-study comparisons but they also allow researchers to examine academic outcome under different lenses.

The second key problem with the methodology of the studies under review relates to the types of tools chosen to assess academic outcome. The most commonly used measure was a questionnaire (most often given to caregivers), the second was a standardized cognitive test, and the third was an interview with caregivers. These measures revolve around the opinions of parents and the performance of participants on cognitive tasks, rather than actual performance at school and personal experiences. Neuropsychological test results may not reflect every day academic functioning. Myriad factors – e.g., other stroke symptoms such as attention difficulties, mental fatigue, or headaches – may influence academic outcome for children with stroke. These factors may not appear in one-on-one testing situations, or via parent questionnaires and parent interviews. None of the studies included in the present review had included school report cards as a measure of academic outcome, yet it is a key representation of performance. One study briefly mentioned that “school performances and development were assessed by the reports from the psychologists and teachers at the respective schools as well as from parents” (Kalapurackal, Shuaib, & Lowry, 1994, p. 57), but no further details were provided. By focusing on psychoeducational tests and parent questionnaires and interviews, professionals may inadvertently underestimate or misjudge the classroom experience of these young patients.

In line with the preceding argument, the next methodology problem is the fact that researchers tended to gather information about school functioning through parents rather than the

youth under study. As previously mentioned, the most commonly used measure was a questionnaire, most often given to caregivers, and the third was an interview with caregivers. Due to the biased position of parents and the fact that they cannot exactly know their children's personal experiences in class, parent reports likely do not constitute an objective and valid measurement of academic experience. Remarkably, one team of researchers noted that six out of their sample of fifty families were unable to tell them whether their child was certified for special education (Hurvitz et al., 2004). This discrepancy highlights the key problem with using parent interviews and parent questionnaires to assess a child's academic functioning: parents may be unaware of the issues their children face as well as the resources that they benefit from or need. This issue underlines the fact that researchers should include more direct reports from participants and teachers in their investigations on academic experience. Unfortunately, only 2 out of 41 research teams interviewed the youth under study, and only 4 teams consulted with teachers. As previously mentioned, one group of researchers mentioned using teacher reports (Kalapurackal et al., 1994). Another group had asked teachers to complete a parent version of the PedsQL, as no version had been created and standardized for teachers (O'Keeffe et al., 2012). In the context of a case study, another article mentioned that the child's academic achievement had been normal prior to her stroke "according to teacher and parent reports" (Roman et al., 2003, p. 696). Finally, the fourth team of researchers that included teacher measures had asked teachers to complete two questionnaires: one unnamed questionnaire inquiring about the child's educational program, and the Social Skills Rating System, wherein teachers rate the child's social behaviors at school (Boyce, Smith, & Casto, 1999). In conclusion, most researchers focused on obtaining data from caregivers; few gathered information from teachers and youth, who likely could have provided more realistic and valid accounts of academic functioning.

The fourth problem relates to the fact that over a third of researchers did not fully explain a chosen measure. In other words, they included a measure with at least one unknown component: they failed to report the informant, the measure used, or both. One fifth of articles did not include a single fully explained method. These findings suggest a significant problem with transparency. If authors do not clarify exactly how they collected data, what measure they used, and who they asked, then their findings cannot be replicated or constructively critiqued.

Finally, the last issue pertains to the fact that a majority of researchers used only one measure to assess academic outcome, and a majority showed interest in only one construct, typically educational placement or academic achievement. In short, few researchers aimed to gain a comprehensive, multi-faceted understanding of academic functioning by examining several complementary constructs. From a more positive perspective, this indicates that researchers show a varied interest in what constitutes academic outcome, ranging from educational placement, academic achievement, school-related quality of life, pre-stroke abilities, social skills in academic settings, behavior in school, and self-esteem in school. While a valid approach for each setting, individualized selection of tasks and measures leads to separate data points that are difficult to pull together for a cross-setting picture. In summary, current methods used are varied and provide valuable data, but lack in ecological validity, transparency, and exhaustiveness.

Research teams should aim to assess academic outcome using a wider variety of measures that can capture multiple aspects of academic functioning, such as neuropsychological evaluations, questionnaires, and interviews, together. They should also include more ecologically valid measures such as school reports and teacher interviews to gain a solid idea of performance in class. In addition, and perhaps most importantly, researchers should encourage and value the

contributions of youth with stroke. They should speak directly with survivors and ask about their personal school experience, including class life, relationships with peers and teachers, and self-esteem in regard to academia. Youth should also be asked about any factors that can indirectly influence academic functioning, such as family support as well as stroke-related complications like physical impairments, headaches, and mental fatigue. By listening to these youth, researchers will be able to gain valid and authentic insight on school functioning and to unearth challenges and difficulties that they may not have predicted or looked for. Finally, researchers should be held to a higher standard regarding transparency. More accurate and complete reports of methodologies will aid other researchers to replicate their studies and to constructively critique their choices, so as to build on and improve them. With these suggestions in mind, we can aim to elucidate the academic profiles and personal school experiences of youth with stroke with inclusive, valid, and multi-dimensional research methodologies.

## MANUSCRIPT 2: CLINICAL STUDY

### Literature review

Due to neuropsychological sequelae across a wide range of cognitive domains, children and adolescents with stroke are especially vulnerable to academic difficulties and face unique challenges compared to their peers (De Schryver et al., 2000; Ganesan et al., 2000; Jacomb et al., 2016). These youth commonly suffer from neurocognitive deficits, socio-emotional difficulties, mental health issues, seizure disorders, motor impairments, and cortical sensory problems (Greenham et al., 2015; Max et al., 2002), which adversely impact academic achievement, independence, psychological well-being, and quality of life (Everts et al., 2008; Härtel et al., 2004; O’Keeffe et al., 2012).

A majority of pediatric stroke survivors experience sequelae causing impairments in domains such as language, verbal expression, executive functioning, attention, memory, visuospatial abilities, or processing speed (Allman & Scott, 2013; Cruz, 2001; Everts et al., 2008; Härtel et al., 2004; Max, 2004; Nass & Trauner, 2004; O’Keeffe et al., 2012; Westmacott et al., 2009). Studies focused on general intellect have documented that survivors tend to score in the lower end of the average range on full scale IQ tests, typically between 90 and 95 (Everts et al., 2008; Max et al., 2002; O’Keeffe et al., 2012). Difficulties with executive functioning are especially common, and typically span attentional control, cognitive flexibility, goal setting, and information processing (Long et al., 2011). Youth with reduced processing speed, impaired working memory, and difficulties with sustained and divided attention require increased cognitive effort to perform an academic task (Block et al., 1999; Everts et al., 2008; Long et al., 2011; Max, 2004; O’Keeffe et al., 2012). In addition, children with weak working memory tend to underperform academically due to frequent errors in activities involving multi-step

instructions and multi-leveled tasks such as writing (Gathercole & Alloway, 2006; Gathercole et al., 2005). Researchers have uncovered a variety of issues that survivors of pediatric stroke face specifically in school, such as needs for special assistance in class (50-60% of survivors), remedial teaching (55%), needs for special education programs (20-30%), failing and repetition of a class (40%) (De Schryver et al., 2000; Ganesan et al., 2000), and, in some severe cases, inability to return to school at all due to significant aphasia and cognitive deficits (Pavlovic et al., 2006). Finally, preliminary evidence suggests that youth with stroke are more likely than their peers to receive a diagnosis of disorders affecting learning, notably Attention-Deficit/Hyperactivity Disorder (ADHD) and learning disabilities (Max et al., 2002; Williams, McDonald, et al., 2017; Williams, Roberts, et al., 2017).

The effect of stroke on school is reported as the greatest concern for parents and youth (Friefeld et al., 2004), yet only a handful of studies have explicitly aimed to examine academic functioning after pediatric stroke. Some researchers have investigated cognitive outcomes relevant to academic success, such as language and reading disorders as well as writing and mathematics skills (Ballantyne et al., 2008; Block et al., 1999; Funnell & Pitchford, 2010; Woolpert & Reilly, 2016), and some have examined rates of psychiatric diagnoses affecting learning (Max et al., 2002; Williams, McDonald, et al., 2017; Williams, Roberts, et al., 2017). Yet, few have attempted to explicitly and comprehensively investigate academic functioning in youth with stroke. As argued in the first manuscript of this thesis, scientists who did study academic outcome typically focused on only one specific construct, such as academic achievement or school-related quality of life. Furthermore, they tended to gather data from parents rather than the youth under study, to use measures with low ecological validity, and to sometimes fail to disclose their full methodology. In addition, the high heterogeneity of

measures used across studies and the small number of measures used within studies render cross-study comparisons difficult. Further research on academic functioning in youth with stroke is required to fill a substantial gap in the scientific literature.

The current clinical study, exploratory in nature, comprised an investigation to delineate the multifaceted academic profile of youth with stroke. My research sought to answer two overarching questions. First, how does stroke affect academic functioning? To explore this topic, I investigated how stroke impacts intellectual functioning; academic skills, accommodations, and performance; psychiatric symptoms that affect learning ability; and school-related quality of life. Second, what predicts academic achievement for youth with stroke? In response, I examined the effects of stroke characteristics, processing speed, and reading ability on academic performance, over and above general intellectual skills.

I organized my hypotheses into two groups. The first comprised between groups analyses, wherein youth with stroke are compared to youth without stroke. Youth with stroke were expected to score significantly lower than youth in the control group on measures of intellectual functioning, basic academic skills, school grades, and school-related quality of life. Youth with stroke were also expected to score significantly higher than youth in the control group on measures of ADHD, language disorders, and learning disability. Additionally, youth with stroke were expected to show higher prevalence of Individualized Educational Plans, class accommodations, and access to assistive technologies. Finally, with non-directional hypotheses, I compared parent and child accounts of school-related quality of life in stroke versus non-stroke dyads. This comparison assessed parents' understandings of their children's experiences, and if these differences were more or less pronounced in families that had experienced pediatric stroke.



The second group of hypotheses comprised within group analyses, wherein I examined the stroke group more closely. I expected to find significant correlations between school grades and full scale IQ, neurological severity, age at stroke onset, processing speed, and reading ability. Using an exploratory approach, and therefore without hypotheses, I also examined the predictive power of these five variables, hierarchically, on school grades.

## **Methodology**

### *Participants*

This study evaluated 41 children ages 8 to 18 years with ( $n = 23$ ) and without ( $n = 18$ ) histories of stroke. Stroke participants were recruited within the Children's Stroke Program at The Hospital for Sick Children as a convenience sample. The minimum age of participants was selected to ensure that they have been reading and writing for at least a few years at this point in their education, and was also selected in line with chosen measures, whose norms began at age 8.

A telephone recruitment procedure was used to contact families who had indicated interest in research and had provided consent to be contacted. Participants in the control group were recruited through local advertisements posted on social media, at the Hospital for Sick Children, and at various community sites in the Greater Toronto Area (e.g., libraries, cafes), as well as word of mouth. Some participants in the control group were siblings of participating stroke patients. Recruitment criteria for the group with stroke consisted of the following: (1) one or multiple strokes, ischemic or hemorrhagic, documented on magnetic resonance imaging (MRI) or computed tomography (CT); (2) stroke before the age of 18 years; (3) between the ages of 8 and 18 years old at the time of testing; (4) at least 6 months back to school at the time of testing; and (5) fluency in English. Inclusion criteria for the control group consisted of the

following: (1) between the ages of 8 and 18 years old; and (2) fluency in English. Exclusion criteria for both stroke and control groups consisted of: (1) premature birth (less than 36 weeks gestation); (2) diagnoses that would impact neurodevelopment such as neurofibromatosis, sickle cell disease, moyo-moya disease, hypoxic-ischemic encephalopathy, or seizure disorder; (3) prenatal exposure to substances of abuse (e.g., alcohol, cocaine); (4) diagnosis of psychosis, intellectual disability, or autism spectrum disorder.

### *Procedure*

Data collection took place at the Hospital for Sick Children, at York University, or, in unique cases, in the participant's home. Informed consent was obtained from parents and participants, and assent was obtained for younger children. With the permission of the families, hospital medical records were consulted to obtain information on participant neurological status and stroke onset information. All caregivers were asked to bring in their child's one or two most recent school report cards. During testing sessions, participants in both stroke and control groups were administered the following:

1. Wechsler Abbreviated Scale of Intelligence – Second Edition (WASI-II);
2. Symbol Search subtest from the Wechsler Intelligence Scale for Children – Fifth Edition (WISC-V);
3. Wide Range Achievement Test – Fourth Edition (WRAT-4);
4. Kidscreen-52 child and adolescent self report.

If stroke patients had had a WISC-IV or a WISC-V (Wechsler Intelligence Scale for Children – Fourth and Fifth Editions) assessment within the past year, those scores were used for analyses and participants did not receive a WASI-II assessment nor Symbol Search subtest.

Similarly, stroke patients who had had a WIAT-III (Wechsler Individual Achievement Test – Third Edition) within the past year did not receive a new WRAT-4 assessment, and their recent scores were used in analyses.

During testing sessions with the child, caregivers were asked to complete the following:

1. Demographics and History Questionnaire (Appendix A);
2. Kidscreen-52 Parent version;
3. Parent Clinical Index of the Conners Comprehensive Behavior Rating Scales.

Participants and their caregivers were provided with compensation consisting of a free Cineplex movie ticket voucher, \$25 for transportation costs, a certificate for community service volunteer hours, and a brief report summarizing testing results and recommendations.

A wide majority of participants had a full data set, but there were exceptions. Two participants in the stroke group were missing an initial PSOM score in their medical records, and as such, were excluded from analyses requiring PSOM scores. In addition, all participating families were asked to provide at least one school report card. Despite multiple follow-ups, 5 participants from the stroke group and 2 participants from the control group did not provide report cards and thus lacked a grade score. As such, these participants were excluded from analyses exploring predictors of grades. Examination of these participants' scores verified that they were representative of the sample and did not have significant outlying scores compared to participants with full data sets.

### *Measures*

#### Intellectual Functioning

To assess intellectual functioning, the current study used the two-subtest version of the

Wechsler Abbreviated Scale of Intelligence – Second Edition (WASI-II; Wechsler, 1999) and the Symbol Search subtest from the Wechsler Intelligence Scale for Children – 5th Edition (WISC-V, Wechsler, 2014).

The WASI-II is an abbreviated intelligence test that consists of subtests taken from the Wechsler Intelligence Scales for Children – Fourth Edition (WISC-IV; Wechsler, 2003). It is standardized for use among individuals aged 6 to 90 years. The WASI-II produces Verbal Comprehension (Vocabulary subtest), Perceptual Reasoning (Matrix Reasoning subtest), and Full-Scale IQ scores (both subtests together). For the current study, administration of the two-subtest version of the WASI-II provided a quick and accurate estimate of Full Scale IQ, unbiased by motor functioning. In the Vocabulary subtest, participants are asked to describe the meaning of increasingly challenging words. In the Matrix Reasoning subtest, participants are asked to recognize, among an array of choices, the missing item in a series of patterned items. Internal consistency reliability coefficients of the WASI-II range from 0.88 to 0.98. Stability coefficients for test-retest reliability have been found to range from 0.87 to 0.92. A correlational study found a strong relationship between full scale IQ scores on the WASI-II and on the WAIS-III (Wechsler Adult Intelligence Scale – Third Edition), thereby demonstrating concurrent validity; the correlation coefficient for the two-subtest version of the WASI-II was 0.87 (Garland, 2005).

The Symbol Search subtest from the Wechsler Intelligence Scale for Children – 5th Edition (WISC-V, Wechsler, 2014) assessed processing speed. The WISC-V is an individually-administered intelligence scale designed for youth ages 6 to 18 years, with Canadian standardization norms. This measure was chosen because processing speed deficits are common in stroke patients and may affect school performance; as such, this cognitive skill is relevant to academic outcome. In addition, compared to most other measures of processing speed (e.g.,

Coding subtest from WISC-V), it is less affected by motor deficits. Participants are asked to grossly cross out specific symbols on a form as quickly and efficiently as possible. Internal consistency on the Symbol Search subtest ranges from 0.81 to 0.88, and inter-rater agreement ranges from 0.97 to 0.99 (Canivez & Watkins, 2016).

### Academic Functioning

Assessment of academic functioning comprised school report cards, to measure academic performance; a demographics questionnaire, to obtain information about educational placement, accommodations, and general difficulties encountered at school; and the Wide Range Achievement Test – 4<sup>th</sup> Edition (WRAT-4; Wilkinson & Robertson, 2006), to measure basic academic skills.

The WRAT-4 aims to measure abilities in reading, sentence comprehension, spelling, and arithmetic in individuals aged 5 to 94 years. In the first subtest, Word Reading, participants are asked to read a list of increasingly long and challenging words. In the second subtest, Sentence Comprehension, participants are asked to read sentences and fill in the blank with an appropriate word. A Reading Composite score is then calculated, and represents an averaged estimate based on Word Reading and Sentence Comprehension scores. Next, in the Spelling subtest, participants write words that are orally presented to them. Finally, the Math Computation subtest assesses basic computation skills with a paper and pencil math problem solving task. The WRAT-4 was chosen for this study because it provides quick and efficient assessment of academic skills, and because all tasks are untimed and therefore unbiased by processing speed ability. Split-half reliability scores range from 0.94 to 0.98 (Wilkinson & Robertson, 2006).

Caregivers were asked to complete the Demographics and History Questionnaire to

provide information regarding the participant's academic functioning as well as general family information such as family income. Caregivers were asked if their child has an Individualized Education Plan (IEP), receives special education, or has access to class accommodations and assistive technology. They also answered questions about whether their child currently has difficulties with self-confidence, fatigue/energy level, and expressing themselves. This information allowed us to understand difficulties at school that may not be brought up in report cards and may not be evident in one-on-one testing sessions.

Finally, report cards provided a measure for actual academic performance. With information about each school's grading system, grades of core courses were standardized and each participant was assigned a total score averaging class grades, on a scale of 0 to 4. See Appendix C for details about the grades-to-score conversion. The most common classes that require the academic skills of interest in this study were included in the calculation of this total score. These include English, Mathematics, Science, Social Studies, Biology, and History. The inclusion of actual school performance via report cards was key in this study; it provided an ecological and realistic measure of academic performance, which may not always be accurately reflected in psychoeducational tests such as the WRAT-4.

### Psychological Disorders

To assess symptoms of Attention Deficit/Hyperactivity Disorder (ADHD), Language Disorders, and Learning Disabilities (LD), which directly influence academic functioning, parents were asked to complete the Parent Clinical Index of the Conners Comprehensive Behavior Rating Scales, hereinafter referred to as "Conners" for short (Conners, 2008). This specific scale is commonly used as a screening tool for disorders in children. It was developed to

correspond with diagnostic criteria as outlined within the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition, Text Revision (DSM-IV-TR; American Psychiatric Association, 2000). The Conners consists of 24 statements that are rated by caregivers on a four-point Likert scale. Ratings produce scores on five subscales: ADHD Indicator, Learning and Language Disorder Indicator, Disruptive Behaviour Disorder Indicator, Mood Disorder Indicator, and Anxiety Disorder Indicator (Conners, 2008). For the purpose of this study, scores on the first two indicators were examined. Internal consistency coefficients range from 0.73 to 0.85 and test-retest reliability coefficients range from 0.83 to 0.91. Inter-rater reliability coefficients range from 0.55 to 0.90. Finally, the Conners is adept at distinguishing between clinical and non-clinical groups (Conners, 2008).

In addition, caregivers were asked to complete the Demographics and History Questionnaire, which includes questions about whether their child has even been diagnosed with ADHD, a language disorder, or a learning disability. In this way, we were able to gather information about actual diagnoses, in contrast to assessing symptoms of these disorders on a scale such as the Conners.

### School-Related Quality of Life

To assess quality of life in a school context, the current study utilized the child and parent versions of the Kidscreen-52 (Ravens-Sieberer et al., 2005). The Kidscreen is a health-related quality of life measure developed for both healthy and chronically ill youth ages 8 to 18 years, with norms obtained using a sample of over 22,000 youth. Twelve European countries collaborated to create this questionnaire, ensuring cross-cultural validity. The current study used the most comprehensive version of the Kidscreen which comprises 52 items and provides a

detailed profile on ten dimensions: Physical Well-Being, Psychological Well-Being, Moods & Emotions, Self-Perception, Autonomy, Parent Relations & Home Life, Financial Resources, Social Support & Peers, School Environment, and Social Acceptance & Bullying. The subscales of interest in the current study were the following three: Social Support & Peers, School Environment, and Social Acceptance & Bullying. The Social Support & Peers dimension examines the nature of the participant's relationships with other children and adolescents. It assesses the extent to which the participant feels accepted, respected, and supported by friends and other peers. The School Environment dimension explores participant perception about their own learning capacities as well as satisfaction with their ability and performance at school. This subscale also explores overall feelings about school and teachers. Finally, the Social Acceptance & Bullying subscale covers the extent to which a participant feels rejected or bullied by school peers. Each subscale yields a T-value for the participant, with population norms indicating a mean of 50 and standard deviation of 10. Analyses regarding psychometric properties yielded internal consistency reliability scores ranging from 0.77 to 0.90, and satisfactory item internal consistency and item discriminant validity (Ravens-Sieberer et al., 2004, 2005).

### Stroke Characteristics

The current study investigated the impact of stroke severity on academic outcome. Medical records were used to gain information about neurological status as assessed by the Pediatric Stroke Outcome Measure (PSOM; deVeber et al., 2000). The PSOM is administered to all patients within the Stroke Program to assess neurological deficits covering five domains: left sensorimotor function, right sensorimotor function, language production, language comprehension, and cognitive functioning. Each child is assigned a value indicating degree of



deficit within each domain ranging from 0 to 2, where 0 = normal, 0.5 = mild deficit, 1 = moderate deficit, and 2 = severe deficit. The sum of these five scores is the final PSOM score for the patient, ranging from 0 to 10. PSOM scores are used within the current study to quantify stroke neurological severity.

Next, neuroimaging data and medical records at the Hospital for Sick Children provided information about each patient's stroke type and lesion location. Team neurologists reviewed neuroimaging scans of stroke patients and coded lesion location in the following way:

1) subcortical lesion: an infarct restricted to the basal ganglia and/or thalamus; 2) cortical lesion: an infarct localized to the cortex with no subcortical involvement; 3) combined lesion: an infarct involving both the cortex and basal ganglia and/or thalamus; 4) white matter: an infarct restricted to white matter only. Information on lesion location and stroke type was collected in this study for descriptive purposes only; the small sample size precluded inferential statistical tests.

## **Results**

All analyses were performed using IBM SPSS Statistics Software Version 20. Variables were examined to ensure that parametric assumptions were met. Levene's test of equality of variances assessed homogeneity of variance across groups. An inspection of score distribution by group, using the Shapiro-Wilk test of normality, observation of histograms and Q-Q plots, as well as calculation of z-scores for skewness and kurtosis, informed data normality. One-tailed *p*-values were used for statistical test results when hypotheses were directional, with  $\alpha = .025$ . Two-tailed *p*-values were used for tests results when hypotheses were non-directional, with  $\alpha = .05$ . Adjusted partial eta squared values were reported for effect sizes, where 0.20 = small, 0.50 = medium, and 0.80 = large (Cohen, 1988).

Pearson chi-square tests were conducted to compare groups on categorical variables. When too many cells had an expected count less than 5, likelihood ratio statistics were reported. Independent and paired samples t-tests were used to compare group means on separate continuous variables. Multivariate analyses of variance (MANOVAs) were conducted to assess group differences on dependent variables that represent theoretically related constructs. In contrast to conducting multiple univariate analyses of variance, this approach protects against Type I errors. In addition, MANOVAs consider the relationship between the dependent variables and therefore have the power to detect whether groups differ along a combination of dimensions. Relationships between potential predictors and grades were investigated using scatterplot correlation matrices and Pearson correlational analyses. Finally, hierarchical linear regression analyses were carried out to examine predictors of school performance.

Results are presented in the following order: firstly, group characteristics are given, including demographic data for both groups as well as clinical data for participants in the stroke group. Next, an overview of general concerns, as reported by parents, provides a preliminary idea of differences between groups. Parametric assumptions of the data are then examined. Inferential statistics are conducted to study differences between groups on measures related to or affecting academic outcome: 1) intellectual functioning; 2) academic skills, accommodations, and performance; 3) psychological disorders; and 4) school-related quality of life. Finally, hierarchical linear regressions are performed to evaluate whether stroke characteristics and certain cognitive and academic skills are significant predictors of school grades.

### *Group Characteristics*

Demographic characteristics of participants were determined from the Demographics and

History Questionnaire and clinical characteristics of youth in the stroke group were collected using their health records at the Hospital for Sick Children. The average age of the 23 youth with stroke at the time of the study session was 13.25 years old, while the average age of the 18 participants in the control group was 12.55. See Table 1 for demographic characteristics of stroke and control groups.

Table 1

*Demographic Characteristics of Participants.*

	<b>Stroke group</b>	<b>Control group</b>
Number of participants	23	18
Age at assessment, M and SD	13.25 (2.82)	12.55 (2.74)
School level, number and %		
Elementary school	14 (60.9%)	13 (72.2%)
High school	9 (39.1%)	5 (27.8%)
Gender, number and %		
Females	11 (47.8%)	8 (44.4%)
Males	12 (52.2%)	10 (55.6%)

An independent samples t-test indicated no significant difference between groups in age [ $t(39) = .807, p = .425$ ]. A Pearson chi-square test indicated no significant difference between groups in gender [ $\chi^2(1) = .046, p = .829$ ]. The likelihood ratio statistic was used to assess differences in family income because several cells had an expected count less than 5. Results indicated no significant difference between groups in family income [ $\chi^2(6) = 9.866, p = .130$ ].

Five out of 23 stroke patients were classified as presumed perinatal; their stroke likely occurred shortly prior or after birth but was diagnosed retrospectively upon the appearance of emerging deficits such as hemiparesis. Seven patients were classified as neonatal stroke, indicating that they incurred their stroke at birth and were diagnosed quickly, often due to seizures. Eight patients incurred their stroke during early childhood, and three patients had their stroke during middle to late childhood. The mean age at stroke onset was 2.36 years old. On average, patients had incurred their stroke 10.91 years prior to the testing date. Twenty patients

suffered an Arterial Ischemic Stroke (AIS), while the three others suffered a Cerebral Sinus Venous Thrombosis (CVST). None of the patients experienced a hemorrhagic stroke nor secondary hemorrhaging after their stroke. Sixteen patients were diagnosed with hemiparesis after their stroke. In terms of lesion location, ten patients had a subcortical stroke and six had a cortical stroke. Three participants had a stroke affecting both cortical and subcortical areas, and four had a stroke affecting white matter only. Overall, white matter was affected in thirteen participants. Finally, the average initial PSOM score after stroke was 1.5 out of 10. Two thirds of patients had a PSOM score equal to or lower than 1.5. The highest score in the stroke group was a 5 out of 10. See Table 2 for further information on clinical characteristics of participants with stroke.

Table 2

*Clinical Characteristics of Participants in the Stroke Group.*

Age at stroke onset, M and SD	2.36 (3.36)
Years since stroke, M and SD	10.91 (3.71)
Stroke onset age group <sup>1</sup> , participants and %	
Presumed perinatal	5 (21.7%)
Neonatal	7 (30.4%)
Early childhood	8 (34.8%)
Middle to late childhood	3 (13.0%)
Type of stroke, participants and %	
Arterial Ischemic Stroke (AIS)	20 (87.0%)
Cerebral Sinus Venous Thrombosis (CSVT)	3 (13.0%)
Lesion location, participants and %	
Cortical	6 (26.1%)
Subcortical	10 (43.5%)
Combined cortical-subcortical	3 (13.0%)
White matter only	4 (17.4%)
White matter affected, participants and %	13 (56.5%)
Secondary hemorrhage, participants and %	0 (0.0%)
Hemiparesis, participants and %	16 (69.6%)
Neurological severity <sup>2</sup> M (SD)	1.50 (1.50)

<sup>1</sup> As per the stroke literature, age groups are stratified as follows: presumed perinatal = retrospective diagnosis, stroke presumed to have occurred shortly before or after birth, neonatal = acute diagnosis, stroke occurred between birth and 1 month of age, early childhood = 1 month – 5 years, middle and late childhood = 6 – 18 years. <sup>2</sup> Neurological outcome is measured by the Pediatric Stroke Outcome Measure (PSOM).

### *Preliminary Observations*

Prior to conducting formal analyses, an examination of general concerns revealed that the youth with stroke in our study tended to exhibit certain difficulties more commonly than their healthy peers. According to parent reports on the Demographics and History Questionnaire, 30.4% of children in the stroke group had problems with anxiety compared to 16.7% of children in the control group. In addition, children with a history of stroke had problems with self-confidence (30.4%), making friends (26.1%), and regulating emotions (43.5%). In comparison, on all three of these questions, only 11.1% of parents in the control group reported such difficulties for their children. See Table 3 for results.

Table 3

#### *Parent Responses on General Concerns in Stroke and Control Groups.*

<b>Does your child currently have trouble with...<sup>1</sup></b>	<b>Stroke group (% yes)</b>	<b>Control group (% yes)</b>
Anxiety	30.4%	16.7%
Low Mood	13.0%	0.0%
Self-Confidence	30.4%	11.1%
Making Friends	26.1%	11.1%
Interacting with Peers	17.4%	16.7%
Understanding Social Cues	4.3%	5.6%
Fatigue/Energy Level	21.7%	16.7%
Understanding Humour	17.4%	5.6%
Complying with Rules & Requests	4.3%	16.7%
Frustration Tolerance	26.1%	22.2%
Regulating Emotions	43.5%	11.1%
Disinhibited or Inappropriate Behaviour	4.3%	0.0%
Being Teased or Bullied	8.7%	5.6%

<sup>1</sup> Questions posed to parents in the Demographics and History Questionnaire.

Parents were then asked about their child's difficulties in an academic context. Notable differences in reports were observed. For instance, 47.8% of parents in the stroke group reported that their child had difficulties with reading, and the same number of parents reported problems with expressing ideas when speaking. Only one parent in the control group (5.6%) indicated problems with reading and problems with expressing ideas. Youth with stroke also seem to

show more difficulties with spelling (30.4%), printing and handwriting (34.8%), remembering information for tests (39.1%), and reasoning (30.4%). Youth in both groups did not significantly differ on reports of attention and hyperactivity, and 27.8% of parents in the control group reported that their child had problems with following classroom rules, compared to none of the parents in the stroke group. See Table 4 for further information about academic concerns.

Table 4

*Parent Responses on Academic Concerns in Stroke and Control Groups.*

<b>Does your child currently have difficulties at school with...<sup>1</sup></b>	<b>Stroke group (% yes)</b>	<b>Control group (% yes)</b>
Attention	21.7%	22.2%
Hyperactivity	4.3%	11.1%
Math	26.1%	22.2%
Reading	47.8%	5.6%
Spelling	30.4%	16.7%
Expressing ideas when speaking (e.g., finding words, organizing thoughts)	47.8%	5.6%
Printing / Handwriting	34.8%	11.1%
Following instructions	17.4%	11.1%
Remembering information on tests	39.1%	16.7%
Reasoning / Problem solving	30.4%	11.1%
Getting along with others	4.3%	5.6%
Following classroom rules and routines	0.0%	27.8%

<sup>1</sup> Questions posed to parents in the Demographics and History Questionnaire.

*Inferential Statistics: Parametric Assumptions*

Variables were examined to ensure that parametric assumptions were met. An inspection of score distribution by group was conducted using the Shapiro-Wilk test of normality, observation of histograms and Q-Q plots, and calculation of z-scores for skewness and kurtosis, wherein absolute values over 1.96 were considered indicative of normality violation. Data in both groups was distributed similarly, with a few exceptions.

The stroke group scores in the Math Computation subtest of the WRAT-4 exhibited a significantly leptokurtic distribution compared to scores in the control group. In other words,

more participants in the stroke group scored in the extremes compared to participants in the control group. In addition, participants in the stroke group tended to score on the lower end in Math Computation as well as in Symbol Search, as illustrated by a significantly positive skewness. Next, the stroke group scores on the Social Support & Peers subscale of the Kidscreen Parent version exhibited significantly positive kurtosis compared to the control group. This indicates that more parents of children in the stroke group indicated extreme scores compared to parents in the control group. Finally, youth in the control group unexpectedly showed a significant positive kurtosis in the distribution of their scores on the Conners Learning and Language Disorder subscale, and a significant positive skewness in the distribution of their scores on the Conners ADHD subscale. As such, our control group may not be accurately representative of the general population regarding psychiatric symptoms for these disorders. The distribution of their scores was heavy-tailed (i.e., more participants scored in the extremes) in learning and language disorder symptoms, and participants tended to show fewer symptoms of ADHD than expected in a normal distribution.

#### *Between Groups Analyses: Intellectual Functioning*

Groups were compared on three measures of intellectual functioning: verbal reasoning, nonverbal reasoning, and processing speed. Due to the exploratory nature of the study, t-tests were chosen to allow investigation of each variable, rather than grouping variables into full scale intellectual quotients. Levene's test of equality of variance indicated that the assumption of homogeneity of variances was met for between group comparisons of each subtest. One-tailed independent samples t-tests indicated no significant difference between groups on measures of verbal and nonverbal reasoning, as measured by the Vocabulary and Matrix Reasoning subtests,

respectively. However, analyses revealed that the stroke group scored significantly lower on the processing speed task, measured with the Symbol Search subtest, compared to the control group.

See Table 5 for results.

Table 5

*Independent Samples T-Test Results on Differences in Intellectual Functioning in Stroke and Control Groups.*

<b>Subtest</b>	<b>Stroke M (SD)</b>	<b>Control M (SD)</b>	<b>t-value</b>	<b>df</b>	<b>p-value<sup>3</sup></b>
Vocabulary <sup>1</sup>	51.65 (11.51)	58.67 (10.92)	-1.980	39	.028
Matrix Reasoning <sup>1</sup>	52.04 (11.65)	55.72 (8.94)	-1.108	39	.138
Symbol Search <sup>2</sup>	9.22 (3.40)	11.83 (2.88)	-2.614	39	.007*

<sup>1</sup> Performance measured in t-scores. <sup>2</sup> Performance measured in standard scores. <sup>3</sup> One-tailed *p*-values (directional hypotheses).

\* Significant at the .025 level.

*Between Groups Analyses: Academic Skills & Performance*

Chi squares were first conducted to compare groups on categorical variables. Parents had been asked three yes or no questions: whether their child received 1) an Individualized Education Plan (IEP) at school, 2) accommodations, an educational assistant, or extra help at school, and 3) access to assistive technology at school. One-tailed *p*-values were used because hypotheses were directional. Results indicated that, as predicted, children in the stroke group were significantly more likely to have received an IEP [ $\chi^2(1) = 9.664, p = .001$ ], accommodations [ $\chi^2(1) = 4.360, p = .019$ ], and access to assistive technologies [ $\chi^2(1) = 7.572, p = .003$ ] compared to their peers in the control group.

A MANOVA was conducted to assess group differences on the WRAT-4 subtests: Word Reading, Sentence Comprehension, Spelling, and Math Computation. Box's test of equality of covariance matrices and Levene's test of equality of variance indicated that the assumptions of sphericity and homogeneity of variances were met for between group comparisons of each subtest. One-tailed *p*-values were used because hypotheses were directional. Results indicated a



significant group difference and a small effect size, [ $F(4,36) = 3.369, p = .010, \text{Wilk's } \Lambda = 0.728, \text{partial } \eta^2 = .272$ ]. Tests of between-subjects effects indicated significant differences between groups in all subtests, with small effect sizes. See Table 6 for descriptive and inferential statistics.

Table 6

*MANOVA Results on Differences in Academic Skills in Stroke and Control Groups.*

<b>WRAT-4 subtest<sup>1</sup></b>	<b>Stroke M (SD)</b>	<b>Control M (SD)</b>	<b>F-value</b>	<b>df</b>	<b>p-value<sup>2</sup></b>	<b>Adjusted partial eta squared</b>
Word Reading	97.70 (19.88)	114.17 (13.54)	9.045	1,39	.003*	.167
Sentence Comprehension	94.78 (14.29)	112.06 (16.16)	13.153	1,39	<.001*	.233
Spelling	98.65 (16.69)	116.28 (16.10)	11.615	1,39	.001*	.210
Math Computation	92.26 (16.01)	107.56 (19.54)	7.596	1,39	.005*	.142

<sup>1</sup> Academic subtests are in standard scores. <sup>2</sup> One-tailed *p*-values (directional hypotheses).

\* Significant at the .025 level.

Finally, school grades were compared between groups using a two-tailed independent samples *t*-test, as hypotheses were non-directional and this analysis exploratory. Levene's test indicated that the assumption of homogeneity of variances was met. Results indicated that groups did not significantly differ, [ $t(32) = -1.133, p = .266$ ]. In other words, youth in the stroke group obtained similar grades ( $M = 3.11, SD = .53$ ) to youth in the control group ( $M = 3.37, SD = .81$ ).

#### *Between Groups Analyses: Psychological Disorders*

Examination of differences in diagnoses were conducted using Pearson chi squares and likelihood ratio statistics to compare groups on categorical variables. Parents had been asked three yes or no questions: whether their child had ever been diagnosed with 1) ADHD, 2) language difficulties/disorder, and 3) a learning disability. One-tailed *p*-values were used, as hypotheses were directional. Results indicated that groups did not differ in respect to diagnoses of ADHD [ $\chi^2(1) = .150, p = .349$ ] and language disorders [ $\chi^2(1) = 1.067, p = .151$ ]. However,

youth with stroke were significantly more likely to be diagnosed with a learning disability compared to youth in the control group [ $\chi^2(1) = 5.487, p = .010$ ]. In fact, 12 out of 23 participants in the stroke group had a learning disability, indicating a prevalence rate of 52.17%, compared to 3 out of 18 participants in the control group, indicating a prevalence rate of only 16.67% for comparison.

Next, group differences in symptoms were investigated using continuous variables, as measured by scores on two Conners subscales: 1) ADHD, and 2) Learning and Language Disorder. Again, one-tailed  $p$ -values were used. Levene's test indicated that the assumption of homogeneity of variances was met for the ADHD scale, but was violated on the Learning and Language Disorder subscale. As such, we reported the results with equal variances not assumed for the latter subscale. Results indicated that groups did not differ in respect to symptoms of ADHD [ $t(39) = -.410, p = .342$ ]; however, the stroke group reported significantly more symptoms of Learning and Language Disorders [ $t(38.121) = 2.138, p = .020$ ].

#### *Between Groups Analyses: School-Related Quality of Life*

A MANOVA was conducted to assess group differences on the three Kidscreen subscales of the self report version: Social Support & Peers, School Environment, and Social Acceptance & Bullying. Box's test of equality of covariance matrices indicated that the assumption of sphericity was met. Levene's test of equality of variance was non-significant for two of the three subscales; homogeneity of variance was violated for the Social Acceptance & Bullying subscale. Because MANOVA tends to be robust to non-normal distribution and because group sizes are nearly equal, the decision was made to conduct a MANOVA. Results indicated non-significant group differences [ $F(3,37) = .992, p = .407, \text{Wilk's } \Lambda = 0.926, \text{partial } \eta^2 = .074$ ]. Youth with

stroke and youth without stroke provided similar answers on school-related quality of life subscales.

Next, a MANOVA was conducted to assess group differences on the same three Kidscreen subscales of the parent version. Box’s test and Levene’s test indicated that the assumptions of sphericity and homogeneity of variance were met. Results indicated non-significant group differences [ $F(3,37) = .288, p = .833, \text{Wilk's } \Lambda = 0.977, \text{partial } \eta^2 = .023$ ]. Parents of youth with and without stroke provided similar responses about their children’s school-related quality of life.

Finally, paired samples t-tests were used to examine the differences between parent and child reports, in both groups separately. Results indicate that, on the Social Support & Peers and the School Environment subscales, youth with stroke and their parents reported similar levels of quality of life. However, on the Social Acceptance & Bullying subscale, youth with stroke tended to respond significantly more negatively than their parents did [ $t(22) = -2.246, p = 0.035$ ]. See Table 7 for descriptive and inferential statistics.

Table 7

*T-Test Results on Differences in Responses to QoL in Youth and Their Parents in the Stroke Group.*

<b>Kidscreen scale</b>	<b>Youth M (SD)</b>	<b>Parent M (SD)</b>	<b>t-value</b>	<b>df</b>	<b>p-value<sup>1</sup></b>
Social Support & Peers	49.67 (12.02)	44.89 (11.17)	1.814	22	.083
School Environment	54.24 (9.06)	51.83 (8.73)	1.419	22	.170
Social Acceptance & Bullying	45.99 (12.21)	51.30 (9.70)	-2.246	22	.035*

<sup>1</sup> Two-tailed *p*-values (non-directional hypotheses).

\*  $p < .05$ , \*\*  $p < .01$ , \*\*\*  $p < .001$ .

In contrast, youth and parents in the control group responded similarly on subscales of School Environment and Social Acceptance & Bullying but gave different responses when asked about Social Support & Peers [ $t(17) = 4.515, p < 0.001$ ]. Youth tended to respond significantly more positively than their parents. See Table 8 for descriptive and inferential statistics.

Table 8

*T-Test Results on Differences in Responses to QoL in Youth and Their Parents in the Control Group.*

<b>Kidscreen scale</b>	<b>Youth M (SD)</b>	<b>Parent M (SD)</b>	<b>t-value</b>	<b>df</b>	<b>p-value<sup>1</sup></b>
Social Support & Peers	54.33 (8.59)	45.91 (6.76)	4.515	17	<.001***
School Environment	53.76 (9.57)	49.34 (11.09)	1.534	17	.143
Social Acceptance & Bullying	49.90 (8.63)	50.11 (10.39)	-0.081	17	.936

<sup>1</sup> Two-tailed *p*-values (non-directional hypotheses).

\* \* *p* < .05, \*\* *p* < .01, \*\*\* *p* < .001.

*Within Group Analysis: Predictors of Grades*

Based on examination of the literature, variables were selected to examine their relationship with, and potential predictive power of, school performance as assessed by grades. The variables chosen for this analysis were the following: intellectual functioning (FSIQ), age at stroke onset (in decimal years), neurological severity (PSOM score), processing speed (Symbol Search score), and reading ability (Reading Composite score). For this group of analyses, stroke participants required scores for all predictors to be included. Using listwise deletion, wherein cases are dropped if they have at least one value missing, our sample size was decreased from 23 to 17 participants. Participants were excluded either because they had failed to provide school reports or there was no initial PSOM score in their medical records.

To evaluate goodness-of-fit of the variables of interest, correlational matrix scatterplots with regression lines were examined and bivariate Pearson correlations were conducted. Scatterplots indicated that three of the five predictors – FSIQ, Symbol Search score, and Reading Composite score – had reasonably linear relationships with the outcome (grades). See Appendix D for graphs. Furthermore, Pearson correlations showed significant relationships between grades and FSIQ, Symbol Search score, and Reading Composite score, but not between grades and PSOM scores or age at stroke. See Table 9 for inferential correlation results.

Table 9

*Inferential Correlations Between Variables and Grades in the Stroke Group.*

<b>Independent variable</b>	<b>r coefficient<sup>3</sup></b>	<b>Significance<sup>4</sup></b>
Full Scale IQ <sup>1</sup>	.563	.019*
Age at stroke <sup>2</sup>	.067	.797
Initial PSOM score	-.254	.326
Symbol Search score <sup>1</sup>	.721	.001**
Reading Composite score <sup>1</sup>	.640	.006*

<sup>1</sup> In standard scores. <sup>2</sup> In decimal years. <sup>3</sup> Pearson correlation coefficient with grade scores. <sup>4</sup> Two-tailed *p*-values.  
*Note.* *N* = 17; \* *p* < .05, \*\* *p* < .01, \*\*\* *p* < .001

Based on these preliminary results, the decision was made to include those variables that are most likely to predict grades: FSIQ, Symbol Search score, and Reading Composite score. Because PSOM scores were no longer part of the analyses, our sample size gained an extra participant who had been previously excluded due to a missing PSOM score.

Data was assessed to ensure it met assumptions for hierarchical regressions. The Shapiro-Wilk test and z-scores for skewness and kurtosis showed that the assumption of normality was met. The Durbin-Watson statistic confirmed that the assumption of independent errors was met. Tolerance and variance inflation values indicated no multicollinearity. Based on a scatterplot and P-P plot of standardized residuals against standardized predicted values, the assumptions of linearity and homogeneity of variance were met. See Appendix E for graphs.

Three outlying scores belonging to two participants were detected using boxplots, on measures of FSIQ and Reading Composite. Calculations showed that both participant scored less than 2.5 standard deviations above or below the group mean. Because this is a clinical sample, these may represent natural variation in the scores. In addition, our sample size is somewhat small, and excluding more participants would have critically affected the power of the hierarchical regression. Moreover, scores within 2.5 standard deviations of the mean are not abnormally different in a clinical sample. For these reasons, the decision was made to keep these participants in our analyses.

A four-stage hierarchical multiple regression was conducted to examine if processing speed and reading ability were significant predictors of grades in the stroke group, over and above the effect of intelligence. In step one, Full Scale IQ was entered into the regression model to control for intelligence. Intelligence accounted for 34.4% of the variation in grades, making it a significant predictor, [ $F(1,16) = 8.391, p = .011$ ]. In step two, Symbol Search scores, representing processing speed, were entered into the model. Together, FSIQ and Symbol Search scores accounted for 59.6% of the variation in grades. Processing speed was a significant predictor of grades, over and above the effects of intelligence, [ $F(1,15) = 9.370, p = .008$ ], and uniquely accounted for 25.2% of the variability in grades. In step three, Reading Composite scores were added to the model. Together, all three independent variables accounted for 70.0% of variance in grades. Controlling for the effects of intelligence and processing speed, reading ability uniquely accounted for 10.3% of the variation in grades, and was a significant predictor of grades [ $F(1,14) = 4.814, p = .046$ ]. See Table 10 for results.

Table 10

*Four-Step Hierarchical Multiple Regression Results for Variables Predicting Grades in the Stroke Group.*

<b>Variable<sup>1</sup></b>	<b><math>\beta</math></b>	<b>t</b>	<b>sr<sup>2</sup></b>	<b>R</b>	<b>R<sup>2</sup></b>	<b><math>\Delta R^2</math></b>	<b>R<sup>2</sup> change</b>
Model 1:				.587	.344	.303	.344*
FSIQ	.587	2.897*	.587				
Model 2:				.772	.596	.542	.252**
FSIQ	.309	1.646	.270				
Symbol Search	.574	3.061**	.502				
Model 3:				.836	.700	.635	.103*
FSIQ	-.137	-.521	-.076				
Symbol Search	.596	3.554**	.521				
Reading Composite	.541	2.194*	.321				

1. All independent variables in standard scores.

Note.  $N = 18$ ; \*  $p < .05$ , \*\*  $p < .01$ , \*\*\*  $p < .001$

Overall, results of the hierarchical multiple regression analysis suggest that, in patients with stroke, reading ability and processing speed both uniquely significantly predict grades, over and above the effects of intelligence.

## Discussion

This clinical study sought to explore the academic profile of youth with stroke through two overarching questions: *How does stroke affect academic outcome?* and *What predicts academic performance for youth with stroke?* To answer the first question, the impact of stroke on academic outcome was examined through a multitude of pathways: intellectual abilities, basic academic skills, need for special accommodations, academic performance, psychiatric disorders that impact learning capacity, and school-related quality of life. Youth with stroke were expected to score significantly lower on measures of intellectual and academic skills, school performance, and quality of life; to score significantly higher on measures assessing psychiatric symptoms; and to receive significantly more special accommodations in school compared to their peers. Overall, results suggested that hypotheses regarding differences in academic skills and accommodations were supported. Hypotheses regarding intellectual functioning and diagnoses were partly supported, depending on the cognitive skill and psychological disorder assessed. Hypotheses about differences in grades and school-related quality of life were not supported by our data. The current discussion delves deeper into these findings.

Parent responses about behavioural, socio-emotional, and academic concerns for their child provided a preliminary idea of differences between groups. The widest gap was found on difficulties with reading and oral expression; nearly 50% of parents of youth with stroke indicated these concerns compared to under 6% of parents of youth without stroke. Striking differences were also uncovered on problems with regulating emotions; 44% of the parents in the stroke group indicated these struggles compared to 11% of the control group. Remembering information on tests was a concern for 39% of parents in the stroke group, in contrast to 17% of parents in the control group. Other noteworthy differences between groups were found on

concerns about problem solving, self-confidence, anxiety, and ability to make friends.

In terms of intellectual functioning, youth with stroke exhibited slower processing speed than their peers. This impairment is in line with previous research (e.g., Allman & Scott, 2013; Block et al., 1999; Bosenbark, 2015), which also suggests that low performance in processing speed tends to be sustained over the years for stroke survivors (Murphy, Compas, Gindville, Reeslund, & Jordan, 2017). In an academic context, slow processing speed could make it difficult to keep up with the class pace and to absorb information throughout the day. In this way, impairments in processing speed likely impact performance at school. Verbal and nonverbal reasoning were also examined to assess potential differences between groups. Although the stroke group scored lower than the control group on both measures, differences were not significant. Research on cognitive functions has been conflicting thus far, but generally errs towards suggesting that deficits in verbal and nonverbal reasoning are common in youth with stroke (e.g., Allman & Scott, 2013; Max et al., 2010; Westmacott et al., 2009). As such, results on these measures went against original expectations. It is possible that youth with stroke in the current study were higher functioning than the general population of youth with stroke, however, reaching a conclusion is challenging due to low sample size.

Academic skills, performance, and need for special accommodations were examined as our next key question about outcome. Results showed that children with stroke were more likely to receive an Individualized Education Plan (IEP); accommodations, an educational assistant, or extra help at school; and access to assistive technology, compared to their peers. In line with these findings, researchers have uncovered similar needs in their samples, ranging from requiring help in class to placement in a special education program (De Schryver et al., 2000; Ganesan et al., 2000). In fact, a recent systematic review examining psychosocial outcome after childhood



stroke calculated that, across 36 studies, approximately half of patients required extra educational help (O’Keeffe et al., 2017). Although our results highlight academic struggles, they also illustrate a positive finding: that youth are receiving assistance. On basic academic skills, participants in the stroke group scored significantly lower than their peers on all four measures: reading, sentence comprehension, spelling, and math. These results are in line with previous research findings (e.g., Allman & Scott, 2013; Jacomb et al., 2016; Max et al., 2010). Finally, school report cards were standardized to calculate differences in grades between groups. Counter to expectations, youth with and without stroke received similar grades, despite youth with stroke scoring significantly lower on measures of basic academic skills. It is posited that the range of accommodations offered to youth with stroke positively contributes to their grades, helping them learn academic material despite measurable difficulties with reading, writing, and math. Alternatively, it is possible that youth with stroke who have an IEP benefit from a modified curriculum. Their normative grades may therefore not be comparable to the grades of their peers because their IEP goals could be significantly different from the general education goals of those peers. Finally, perhaps youth with stroke work significantly more hours than their peers do to earn the same grades.

Next, psychiatric symptoms and diagnoses that particularly impact learning ability were evaluated in both groups. Prevalence rates of ADHD and language disorders were similar between groups. In addition, on a scale assessing symptoms of ADHD, no differences were found. Secondary psychiatric disorders represent a new area in pediatric stroke, and little research has been published thus far. Recent findings generally suggest a higher prevalence of ADHD in survivors of pediatric stroke (Max et al., 2002; Williams, Roberts, et al., 2017). In this sample, youth with stroke were significantly more likely to have received a learning disability

diagnosis; the prevalence rate reached 52% compared to 17% in the control group. In addition, on a scale measuring symptoms of language and learning disabilities, youth with stroke scored significantly higher than the control group. Although this scale merged both disorders, it is hypothesized, based on findings regarding diagnosis, that the true difference lies in symptoms of learning disability rather than language disorders. These results are in line with the only study that has examined rates of learning disability following pediatric stroke, to our knowledge (Williams, McDonald, et al., 2017).

Analyses of differences in school-related quality of life, as reported by youth and parents separately, indicated that youth with and without stroke seem to experience similar levels of satisfaction with their school environment, peer support, and social acceptance. Hypotheses had posited significant differences based on the literature; namely, a recent systematic review concluded that childhood stroke significantly affects quality of life, including domains relating to school (O’Keeffe et al., 2017). Although negative outcomes in quality of life were consistently found in the literature, some studies have focused on positive outcomes after stroke. One such study stated that 93% of children in their sample reported “feeling as happy as other children” (De Schryver et al., 2000, p. 316). Another team of researchers found that children with stroke had significantly higher self-esteem than healthy controls (Christerson & Strömberg, 2010). These findings, along with the current study’s indication that youth with stroke experience similar school-related quality of life as their peers, underline the need for further research on resilience and positive outcome after stroke.

The second major question the clinical study sought to answer pertained to elucidating which factors predict academic performance in youth with stroke. Based on the literature and on previous results, the predictive values of processing speed and reading ability were examined.

Results suggest that both processing speed and reading ability are significant predictors of grades over and above the effects of intelligence. Processing speed showed the larger effect, uniquely accounting for about 25% of the variability in grades, while reading ability accounted for approximately 10% of variance, and intellectual functioning alone had originally accounted for about 34% of variance. Further research is needed to establish the newfound importance of processing speed in relation to academic success; if this effect is replicated, then neuropsychologists should examine processing speed in patients more closely, knowing that it plays a role in their academic success.

### **Strengths, Limitations, and Future Directions**

The current study provided an original and important contribution to knowledge in the field of pediatric stroke. Academic outcome in this population has largely been overlooked, with most studies focusing on motor and cognitive sequelae. This project addressed the academic experiences of youth with stroke with a comprehensive and multifaceted methodology. It was designed to take into account results from a thorough systematic review on methodologies in this field (cf. manuscript 1). The review underlined the problematic practice of assessing outcome from parent measures and neglecting to collect data from the youth under study. Accordingly, the current study involved youth to a larger extent. Another problem uncovered in the systematic review pertains to the fact that many research teams failed to fully disclose all measures in their study. A lack of transparency proves problematic for both ethical and practical reasons; if methodologies are unclear, replication is not possible. Conscious efforts were made to meticulously describe all methods in this study, how data was collected, and from which measures data points came from. Finally, research studies tend to focus on one aspect of

academic outcome, such as academic skills or educational placement alone. Accordingly, the current study gained information from multiple angles, examining general academic concerns, cognitive abilities, academic skills, school placement and services, grades, school-related quality of life, and disorders that affect learning. This approach is novel because of its wide range of measures devoted to the assessment of academic outcome and because it is the first study in pediatric stroke to include school report cards. Grades represent an ecologically valid measure of academic performance and provide key information about school functioning that cannot be captured in questionnaires and one-on-one testing situations.

Despite benefitting from the constructive critiques expressed in the systematic review, the current study is not without limitations. A critical flaw plaguing research involving uncommon conditions is the low sample size, which translates to low statistical power, limited analyses, and limited generalizability. Due to a lack of clinical diversity and equal stratification in terms of age at stroke onset, lesion location, and stroke etiology, analyses with these variables were not feasible. For instance, all patients in the stroke group had an arterial ischemic stroke or a cerebral sinus venous thrombosis (CSVT) stroke; as such, results cannot be generalized to patients who have incurred a hemorrhagic stroke. Another limitation pertains to the fact that teachers were not called upon to participate in this study, despite their being a key figure in children's school lives and having valuable insight into students' academic struggles. Future research should include teachers in addition to youth and their parents to gain a clearer picture of academic outcome. Finally, lesser known factors affecting academic outcome in pediatric stroke may have not been considered due to simple lack of knowledge. For instance, it is possible that youth with stroke experience anxiety due to stroke-related impairments, such as physical disabilities, and therefore show decreased focus or enthusiasm at school. Adult survivors have

been found to experience post-stroke fatigue as well as debilitating headaches (Eilertsen, Ormstad, & Kirkevold, 2013; Hansen et al., 2015; Kirkevold, Christensen, Andersen, Johansen, & Harder, 2012). In children, these symptoms could cause significant impairments in a class context or in testing situations due to cognitive exertion. Qualitative research is therefore warranted to shed light on issues that researchers may not yet be aware of. In line with these concerns, the next phase of my research project is dedicated to amplifying the voices of youth with stroke. Semi-structured interviews have been conducted and thematic analysis using a phenomenological approach will bring to light the concerns of patients regarding school success and enjoyment.

The current study provided multifold new information about academic outcome after pediatric stroke, allowing for a better understanding of the struggles that these patients encounter, what deficits they tend to experience compared to their peers, and how these impairments impact their grades. Future research should continue to explore academic outcome and give weight to the narratives of patients, as these could point researchers towards unexplored avenues to delve into.

## GENERAL DISCUSSION

The present thesis comprised a systematic review on methodologies used in research on academic outcome in pediatric stroke as well as a clinical research study examining academic outcome in this population. This complementary approach was chosen such that the systematic review informed the methodological design of the clinical study. The first manuscript unearthed problematic practices including the heterogeneity of methods used across studies; tools that measure few and miscellaneous facets of school functioning, some of which may not be ecologically valid; emphases on parent reports at the expense of the self-reports of youth under study; and low transparency regarding method disclosure. Taking these shortcomings into consideration, the second study examined academic outcome using a comprehensive and multi-dimensional approach. It explored the academic profile of youth with stroke through two overarching themes: how stroke affects academic outcome and which variables predict grades for these youth. Findings indicated that youth with stroke received similar grades to their peers, yet they exhibited deficits in academic skills spanning reading, writing, and math, and significantly slower processing speed. Possible explanations for these normative grades include: youth with stroke receive more accommodations in school than their healthy peers; youth with stroke may have IEPs which allow them to follow a modified curriculum with different goals; youth with stroke work significantly more than their peers to earn similar grades. Both processing speed and reading ability accounted for a significant portion of variability in grades for youth with stroke, over and above the effects of intellectual functioning. Unexpectedly, age at stroke onset and initial stroke neurological severity did not play a role in predicting grades. Youth with stroke were also more likely to receive a diagnosis of learning disability, with a prevalence rate reaching 52% compared to 17% in the control group. No differences in ADHD symptomatology

and diagnoses were found. Finally, youth with stroke performed similarly to their peers on tasks assessing verbal and nonverbal reasoning, and both groups responded similarly on questionnaires evaluating school-related quality of life.

These results carry both research and clinical implications. In a research context, the systematic review provides crucial information about limitations of methodologies as well as recommendations and guidelines to improve research protocols, with the goal of designing more solid and valid studies on academic outcome. The clinical study makes valuable contributions to the field of pediatric stroke by building on the scarce knowledge existing on academic outcome. Findings suggest that youth with stroke do exhibit significant difficulties compared to their healthy peers, but results have conflicted when it comes to verbal and nonverbal reasoning skills. The current study adds to this debate, supporting the possibility that these specific cognitive skills may not be typically affected. In addition, this study highlights the importance of processing speed; researchers have demonstrated that youth with stroke typically score lower on this measure, and this study is the first to suggest that processing speed, as a unique factor separate from intelligence, significantly impacts school performance. Current findings have also underlined the significance of reading ability in predicting school performance, which warrants further investigation.

From a clinical perspective, present findings provide medical teams and families with some reassurance. Notably, youth with stroke tend to receive similar grades as their peers; they do not show a wide disadvantage when it comes to school report cards and grade point averages. In addition, youth with stroke may experience similar school-related quality of life as their peers; they have not indicated major differences in their feelings about their school environment, support from their peers, and social acceptance. However, youth with stroke scored significantly

higher on measures assessing learning disabilities. Research on mental health and diagnoses after pediatric stroke has just begun to grow, and the clinical study is the second study that has examined prevalence rates of learning disability in this population. Findings should encourage clinicians to consider learning disabilities when working with youth with stroke, and neuropsychologists to keep this possibility in mind when assessing patients. Uncovering learning disabilities would not only give a label and explanation for a child's difficulties at school, but would also give reason for further accommodations or an IEP if beneficial. Finally, for youth struggling in school, attention should be given to their processing speed and reading abilities. Neuro-rehabilitation sessions and at-home practice targeting these impairments may prove useful in improving school performance and grades, although these would be exploratory treatment options; research in these domains should be conducted to confirm efficacy.

The projects in this thesis provide stepping stones to major topics of interest in the field of pediatric stroke. Steered by these results, future researchers should conduct studies exploring academic outcome in further depth and breadth. Recognizing the influence of core skills such as processing speed and reading ability should urge researchers to further scrutinize these constructs and their roles in academic success. In line with general concerns expressed by parents in our clinical study, researchers should examine potential struggles for youth with stroke regarding oral expression, emotion regulation, memory, problem-solving, self-confidence, anxiety, and forming friendships. In addition, the discrepancy between impaired basic academic skills and normative grades should be further explored; notably, the validity of grades in representing academic proficiency should be assessed. Perhaps youth with stroke receive grades similar to those of their peers thanks to beneficial accommodations and IEPs. Conversely, perhaps youth with stroke are obliged to work significantly harder to attain the same grades as their peers, due



to impaired academic skills and cognitive deficits. If research findings support this notion, then youth with stroke may require additional or different accommodations and neuro-rehabilitation strategies to help them master class material. At such a young age, overwork and overextension could prove exceedingly stressful and adversely affect quality of life and mental health. Finally, researchers should explore the academic experiences of youth with stroke using qualitative approaches. Scientists might brainstorm efficiently and make professionally wise decisions about research questions, but these will never attain the precious value of a first-person account. Youth with stroke know best what they struggle with at school and their parents and teachers possess a unique and nuanced understanding of their difficulties. Researchers should recognize the worthiness inherent in personal experiences and listen to the stories of stroke survivors, so that we pursue studies and clinical work in directions that truly matter to our patients.

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## Appendix A

### DEMOGRAPHICS AND HISTORY QUESTIONNAIRE

Please note that you can skip any questions that you do not want to answer.

#### SECTION 1: GENERAL INFORMATION

In your own words, describe any concerns that you may have about your child's physical or cognitive development, school (e.g., reading, writing, math), behaviour, or social/emotional development:

- a. \_\_\_\_\_
- b. \_\_\_\_\_
- c. \_\_\_\_\_
- d. \_\_\_\_\_

#### SECTION 2: DEVELOPMENTAL HISTORY

1. What is your child's handedness?                      LEFT                      RIGHT                      BOTH
2. Has your child ever had or been diagnosed with (if yes, please provide more information):
- |                          |                             |   |
|--------------------------|-----------------------------|---|
| ADHD                     | <input type="checkbox"/> no | <input type="checkbox"/> yes – explain: _____ |
| Anxiety                  | <input type="checkbox"/> no | <input type="checkbox"/> yes – explain: _____ |
| Autism Spectrum Disorder | <input type="checkbox"/> no | <input type="checkbox"/> yes – explain: _____ |
| Depression               | <input type="checkbox"/> no | <input type="checkbox"/> yes – explain: _____ |
| Diabetes                 | <input type="checkbox"/> no | <input type="checkbox"/> yes – explain: _____ |
| Epilepsy                 | <input type="checkbox"/> no | <input type="checkbox"/> yes – explain: _____ |
| Febrile Convulsion       | <input type="checkbox"/> no | <input type="checkbox"/> yes – explain: _____ |
| Gifted and Talented      | <input type="checkbox"/> no | <input type="checkbox"/> yes – explain: _____ |
| Head Injury              | <input type="checkbox"/> no | <input type="checkbox"/> yes – explain: _____ |
| Hearing Problems         | <input type="checkbox"/> no | <input type="checkbox"/> yes – explain: _____ |

- Hospitalization [ ] no [ ] yes – explain: \_\_\_\_\_
- Language Difficulties / Disorder [ ] no [ ] yes – explain: \_\_\_\_\_
- Learning Disability [ ] no [ ] yes – explain: \_\_\_\_\_
- Operations [ ] no [ ] yes – explain: \_\_\_\_\_
- Other Chronic Illness [ ] no [ ] yes – explain: \_\_\_\_\_
- Other Psychiatric Illness [ ] no [ ] yes – explain: \_\_\_\_\_
- Premature Birth [ ] no [ ] yes – explain: \_\_\_\_\_
- Sensory Difficulties [ ] no [ ] yes – explain: \_\_\_\_\_
- Thyroid Dysfunction [ ] no [ ] yes – explain: \_\_\_\_\_
- Vision Problems [ ] no [ ] yes – explain: \_\_\_\_\_
- Other [ ] no [ ] yes – explain: \_\_\_\_\_

3. Did / Does your child have trouble with any of the following? Please circle any problems and check off if they were from the past or are current concerns:

	<b>Problem in the past that has resolved</b>	<b>Ongoing problem currently</b>
Anxiety		
Low mood		
Self- Confidence		
Making Friends		
Interacting with Peers		
Understanding Social Cues		
Fatigue/Energy Level		
Understanding Humour		
Complying with Rules & Requests		
Frustration Tolerance		
Regulating Emotions		
Disinhibited or Inappropriate Behaviour		
Being Teased or Bullied		

If yes, please explain: \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

4. Has your child, either now or in the past, received psychological help or therapy? If yes, please describe the type of therapy, when it was received, and for how long:

\_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

**SECTION 3: SCHOOL HISTORY**

1. Current Grade: \_\_\_\_\_ Placement: Regular \_\_\_\_\_ Resource: \_\_\_\_\_ Special Ed.: \_\_\_\_\_

2. Any difficulties at school with the following?

	<b>Problem in the past that has resolved</b>	<b>Ongoing problem currently</b>
Attention		
Hyperactivity		
Math		
Reading		
Spelling		
Expressing ideas when speaking (e.g. finding words, organizing thoughts)		
Printing / Handwriting		
Following instructions		
Remembering information on tests		
Reasoning / Problem solving		
Getting along with others		
Following classroom rules and routines		

3. Has your child ever had an Individual Education Plan (IEP) at school? YES NO

4. Does/did your child receive any accommodations, EA support or extra help at school? YES NO

5. Does/did your child receive access to assistive technology (e.g., laptop, iPad provided by school)? YES NO

Please describe the types of accommodations or extra help that your child receives at school (describe any special placements, extra time given, assistive devices, technology, EA support etc):

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**SECTION 4: FAMILY HISTORY**

1. What is your child's ethnicity? (please circle):

- Aboriginal (Inuit, Métis, North American Indian)
- Arab/West Asian (e.g., Armenian, Egyptian, Iranian, Lebanese, Moroccan)
- Asian American / Asian Pacific Islander
- Black (e.g., African, Haitian, Jamaican, Somali)
- Latino-a/Hispanic
- South Asian
- European Origin / White
- Bi-racial/Multi-racial
- Other: \_\_\_\_\_

2. Parents' Marital Status:

- Single \_\_\_\_\_
- Married/Common-Law \_\_\_\_\_
- Separated \_\_\_\_\_
- Divorced \_\_\_\_\_
- Widowed \_\_\_\_\_

3. Do any members of the family (or extended family) have a history of **intellectual, academic, learning, or attention difficulties**? If yes, who? What type of difficulties?

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4. Does anyone in the family (or extended family) have a history of **emotional or psychiatric illnesses** (e.g., depression, anxiety, schizophrenia)? If yes, who? What type of mental illness?

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5. What is your child's native (first) language? \_\_\_\_\_

6. If not English, at what age did your child start speaking English? \_\_\_\_\_

7. What other languages are used in your home? \_\_\_\_\_

8. What is the highest educational level of the mother? (please circle a number below)

1 = some elementary school;

2 = completed elementary school;

3 = some high school;

4 = completed high school;

5 = some college;

6 = completed college;

7 = university degree;

8 = postgraduate degree

9. What is the mother's job? \_\_\_\_\_

Currently employed? Yes/No

Full-time or Part-time?

10. What is the highest educational level of the father? (please circle a number below)

1 = some elementary school;

2 = completed elementary school;

3 = some high school;

4 = completed high school;

5 = some college;

6 = completed college;

7 = university degree;

8 = postgraduate degree

11. What is the father's job? \_\_\_\_\_

Currently employed? Yes/No

Full-time or Part-time?

12. Does your child have a job? Yes/No

If yes, what is the job? \_\_\_\_\_

How many hours per week on average? \_\_\_\_\_

13. Household Income: (please circle)

- < \$30,000
- \$30,000 - \$49,999
- \$50,000 - \$89,999
- \$90,000 - \$139,999
- \$140,000 - \$199,999
- \$200,000 - \$299,999
- Over \$300,000



## Appendix B

Compilation of studies that assessed academic outcome in pediatric stroke until November 2017.

<b>Authors (year)</b>	<b>Number of measures</b>	<b>Constructs assessed</b>	<b>Type of measure (specific name), informant</b>
Aguas, S.J., Ampudia, M.S., Macaya, A., Molina, J., & Tomas, J. (1999)	3	Placement, achievement	Interview, caregiver; cognitive test (WISC-R), participant; cognitive test (Luria DNI), participant
Ballantyne, A.O., Spilkin, A.M., Hesselink, J., & Trauner, D.A. (2008)	2	Placement, achievement	Cognitive test (WRAT-R), participant; unknown measure, unknown informant
Blom, I., De Schryver, E. L., Kappelle, L. J., Rinkel, G. J., Jennekens-Schinkel, A., & Peters, A. B. (2003)	6	Placement, achievement, QoL, pre-stroke academic abilities	Non-standardized test, participant; non-standardized test, participant; non-standardized test, participant; interview, caregiver; unknown measure, unknown informant; questionnaire (Child Health Questionnaire-Parent), caregiver
Boyce, G. C., Smith, T. B., & Casto, G. (1999)	4	Placement, achievement, social skills	Interview, caregiver; cognitive test (WJTA-R), participant; questionnaire, teacher; questionnaire, teacher
Bulder, M. M. M., Hellmann, P. M., Van Nieuwenhuizen, O., Kappelle, L. J., Klijn, C. J. M., & Braun, K. P. J. (2011)	3	Placement, QoL	Interview, unknown informant; questionnaire (PedsQL-parents), caregiver; questionnaire (PedsQL-child), participant
Chabrier, S., Peyric, E., Drutel, L., Deron, J., Kossorotoff, M., Dinomais, M., ... & Fluss, J. (2016)	1	Placement	Unknown measure, caregiver
Christerson, S., & Strömberg, B. (2010)	1	QoL, achievement, placement	Interview, caregiver and participant
Cnossen, M. H., Aarsen, F. K., Akker, S. L. V. D., Danen, R., Appel, I. M., Steyerberg, E. W., & Catsman-Berrevoets, C. E. (2010)	1	Placement, social skills, QoL	Unknown measure, caregiver
Daseking, M., & Petermann, F. (2007)	1	Achievement	Unknown measure, unknown informant
Daseking, M., Petermann, F., & Simonis, A. (2008)	1	QoL, placement	Questionnaire (CBCL), caregiver
De Schryver, E. L., Kappelle, L. J., Jennekens-Schinkel, A., & Peters, A. B. (2000)	2	QoL	Questionnaire, caregiver; questionnaire, participant

Dusser, A., Goutières, F., & Aicardi, J. (1986)	1	Placement	Unknown measure, unknown informant
Fiori, A., Huber, W., Dietrich, T., Schnitker, R., Shah, J., Herpertz-Dahlmann, B., & Konrad, K. (2006)	1	Achievement, placement	Clinical report, psychologist
Friefeld, S. J., Yeboah, O., & Jones, J. E. (2004)	2	QoL	Questionnaire (PedsQL child self-report), participant; questionnaire (PedsQL parent report), caregiver
Friefeld, S. J., Westmacott, R., MacGregor, D., & deVeber, G. A. (2011)	1	QoL	Questionnaire (Centre for Health Promotion's QoL Profile), caregiver
Ganesan, V., Hogan, A., Shack, N., Gordon, A., Isaacs, E., & Kirkham, F. J. (2000)	3	Placement	Questionnaire (developed by authors), caregiver; questionnaire (same), occupational therapist; questionnaire (same), physical therapist
Goeggel Simonetti, B., Cavelti, A., Arnold, M., Bigi, S., Regényi, M., Mattle, H. P., ... & Steinlin, M. (2015)	1	Placement	Interview, caregiver or participant
Golomb, M. R., Carvalho, K. S., & Garg, B. P. (2005)	1	Placement, achievement	Unknown measure, unknown informant
Gordon, A. L., Ganesan, V., Towell, A., & Kirkham, F. J. (2002)	2	QoL	Interview, caregiver; questionnaire (Child Health Questionnaire-Parent), caregiver
Hawks, C., Jordan, L. C., Gindville, M., Ichord, R. N., Licht, D. J., & Beslow, L. A. (2016)	1	Placement	Interview, caregiver
Hurvitz, E. A., Linda, B., Ried S., Nelson, V. S. (1999)	1	Placement, achievement	Telephone survey, participant or caregiver
Hurvitz, E., Warschausky, S., Berg, M., & Tsai, S. (2004).	1	Placement	Unknown measure, unknown informant
Jacomb, I., Porter, M., Brunson, R., Mandalis, A., & Parry, L. (2016)	1	Achievement	Cognitive test (WIAT-II), participant
Kalapurackal, M., Shuaib, A., & Lowry, N. J. (1994)	3	Achievement	Clinical report, psychologist; school report, teacher; unknown measure, caregiver
Koegel, L. K., & Koegel, R. L. (1986)	3	Placement, achievement	Standardized school exam, participant; cognitive test (Peabody Individualized Achievement Test), participant; cognitive test (WRAT-I), participant

Lo, W. D., Hajek, C., Pappa, C., Wang, W., & Zumberge, N. (2013)	2	QoL	Questionnaire (PedsQL parent proxy-report), caregiver; questionnaire (PedsQL child self-report), participant
Max, J. E., Mathews, K., Lansing, A. E., Robertson, B. A., Fox, P. T., Lancaster, J. L., ... & Smith, J. (2002)	1	Achievement	Cognitive test (WRAT-R), participant
Max, J. E., Mathews, K., Manes, F. F., Robertson, B. A., Fox, P. T., Lancaster, J. L., ... & Collings, N. (2003)	1	Achievement	Cognitive test (WRAT-R), participant
Max, J. E., Bruce, M., Keatley, E., & Delis, D. (2010)	1	Achievement	Cognitive test (WRAT-R), participant
Neuner, B., von Mackensen, S., Krümpel, A., Manner, D., Friefeld, S., Nixdorf, S., ... & Nowak-Göttl, U. (2011)	2	QoL	Questionnaire (KINDL-R self-report), participant; questionnaire (KINDL-R parent proxy-report), caregiver
O’Keeffe, F., Liégeois, F., Eve, M., Ganesan, V., King, J., & Murphy, T. (2014)	2	Placement, achievement	Cognitive test (WIAT-II), participant; unknown measure, unknown informant
O’Keeffe, F., Ganesan, V., King, J., & Murphy, T. (2012)	6	QoL, achievement, placement, self-esteem	Questionnaire (PedsQL-self), participant; questionnaire (PedsQL-parent), caregiver; questionnaire (PedsQL-parent), teacher; cognitive test (WIAT-II), participant; questionnaire (Culture-Free Self-Esteem Inventory 3rd Edition), participant; unknown measure, unknown informant
Pavlovic, J., Kaufmann, F., Boltshauser, E., Mori, A. C., Mercati, D. G., Haenggeli, C. A., ... & Perez, E. R. (2006)	1	Placement	Questionnaire, participant and caregiver
Rodrigues, S. D., Ciasca, S. M., Guimaraes, I. E., Elias, K. M., Oliveira, C. C., & Moura-Ribeiro, M. V. (2011)	2	Placement, achievement	Cognitive test, participant; unknown measure, unknown informant
Roman, F., Salgado-Pineda, P., Bartrès-Faz, D., Sánchez-Navarro, J. P., Martínez-Lage, J., López-Hernández, F., ... & Junquè, C. (2003)	2	Pre-stroke abilities, achievement	Unknown measure, caregiver; unknown measure, teacher
Roze, E., Van Braeckel, K. N., van der Veere, C. N., Maathuis, C. G., Martijn, A., & Bos, A. F. (2009)	1	Placement	Unknown measure, unknown informant

Steinlin, M., Roellin, K., & Schroth, G. (2004)	1	Achievement, QoL	Questionnaire, participant and caregiver
Trauner, D. A., Panyard-Davis, J. L., & Ballantyne, A. O. (1996).	1	Behaviour, achievement	Questionnaire (Personality Inventory for Children), caregiver
Westmacott, R., McDonald, K. P., deVeber, G., MacGregor, D., Moharir, M., Dlamini, N., ... & Williams, T. S. (2017)	2	Achievement	Cognitive test (WIAT-III), participant; cognitive test (WJ-III ACH), participant
Williams, T. S., Roberts, S. D., Coppens, A. M., Crosbie, J., Dlamini, N., & Westmacott, R. (2017)	2	Achievement	Cognitive test (WIAT-III), participant; cognitive test (WJ-III ACH), participant
Yvon, E., Lamotte, D., Tiberghien, A., Godard, I., Mardaye, A., Laurent-Vannier, A., ... & Chevignard, M. (2016)	2	Pre-stroke abilities, placement	Clinical report, psychologist

## Appendix C

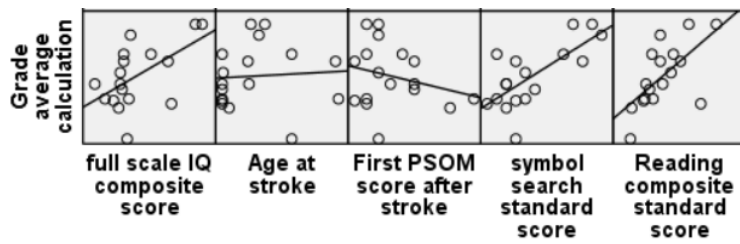
Based on the Guide to the Provincial Report Card published by the Ontario Ministry of Education and Training, the following system was developed to standardize grades across participants in public and private schools on a 4-point scale.

*School Grade 4-Point Standardization Scale.*

<b>Letter grade</b>	<b>Percentage grade</b>	<b>Standardized score</b>
A- to A+	80-100%	4
B- to B+	70-79%	3
C- to C+	60-69%	2
D- to D+	50-59%	1
< D-	< 50%	0

## Appendix D

Below is the correlation scatterplot matrix with linear regression fit lines, for the purpose of assessing potential linear relationships between the independent variable (grades) and dependent variables in consideration for the hierarchical linear regression.



## Appendix E

Scatterplot and P-P plot of standardized residuals against standardized predicted values to assess the assumptions of linearity and homogeneity of variance for the hierarchical linear regression.

