





Barriers and facilitators to the assessment of cognitive-communication disorders in children and adolescents after traumatic brain injury: a survey of Australian clinical practice

L. Crumlish^{A,*} , A. Copley^A , S. J. Wallace^{A,B}  and T. A. Rose^{A,B} 

For full list of author affiliations and declarations see end of paper

***Correspondence to:**

L. Crumlish
School of Health and Rehabilitation
Sciences, The University of Queensland,
Brisbane, Qld 4072, Australia
Email: lauren.crumlish@uqconnect.edu.au

Handling Editor:

Petrea Cornwell

Received: 6 September 2023

Accepted: 19 September 2023

Published: 19 January 2024

Cite this:

Crumlish L *et al.* (2024)
Brain Impairment 25, IB23075.
doi:[10.1071/IB23075](https://doi.org/10.1071/IB23075)

© 2024 The Author(s) (or their employer(s)). Published by CSIRO Publishing on behalf of the Australasian Society for the Study of Brain Impairment.

This is an open access article distributed under the Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License ([CC BY-NC](https://creativecommons.org/licenses/by-nc/4.0/))

OPEN ACCESS

ABSTRACT

Background. There is a lack of comprehensive clinical guidance for the measurement of paediatric cognitive-communication disorders (CCDs) following traumatic brain injury (TBI). This study aimed to (1) explore Australian speech-language pathologists' (SLPs') measurement practices when assessing CCDs in children and adolescents with TBI; and (2) to understand the barriers and facilitators to optimal assessment using the Theoretical Domains Framework. **Methods.** This study used an online, cross-sectional survey design, comprising both quantitative and qualitative questions, informed by behaviour change theory. Results were analysed using descriptive statistics and qualitative content analysis. **Results.** This study reports data from 111 Australian SLPs. SLPs reported measuring a range of constructs with 52 unique measurement instruments. SLPs' professional role, identity and optimism were the primary facilitators, whereas clinicians' behavioural regulation and emotion were found to be primary barriers. SLPs identified the need for greater tertiary training and professional development opportunities, regardless of workplace sector or years of experience. **Conclusions.** Australian SLPs considered themselves key professionals in the assessment of CCDs in children and adolescents with TBI and reported optimism for the value and benefits of this clinical activity. There was, however, a lack of consistency in measurement practices, as well as feelings of nervousness and difficulty associated with CCD assessment, which may further compound the under-diagnosis already prevalent in this population. Results from this study support the need for comprehensive guidance regarding best practice.

Keywords: assessment, clinimetrics, clinical practice, cognitive-communication, measurement, outcome measurement, paediatric, traumatic brain injury.

Background

Traumatic brain injuries (TBIs) place a significant burden on Australia's economy and health services (Bierbaum *et al.* 2019), as well as on the children, adolescents and families affected (Brenner *et al.* 2021). Paediatric TBIs are a major cause of morbidity and mortality (Leo and McCrea 2016), impacting more than 3 million children and adolescents globally each year (Dewan *et al.* 2016). Within Australia, 356 per 100 000 children (≤ 16 years) are hospitalised with head injuries annually (Bierbaum *et al.* 2019). Given that most TBIs are mild and unreported (Leo and McCrea 2016), these international and national statistics likely under-estimate true prevalence. The financial burden of TBI in Australia is considerable, with paediatric hospitalisations costing \$468.9 million over a 10-year time frame (Bierbaum *et al.* 2019). TBI is a significant public health burden, with often long-term consequences (e.g. Babikian *et al.* 2011; Anderson *et al.* 2012; Rosema *et al.* 2015) that require multi-disciplinary intervention from a range of health professionals (e.g. speech-language pathologists, neuropsychologists) across sectors (e.g. education, disability, private practice) through the acute and chronic stages of recovery. Paediatric TBIs are considered to be chronic health conditions (Kurowski *et al.* 2023),

and the children, adolescents and families impacted experience a range of neurobehavioural (e.g. Ewing-Cobbs *et al.* 1994; Massagli *et al.* 1996; Levin and Hanten 2005), communicative (e.g. Hanten *et al.* 2009; Chapman *et al.* 1995, 2016) and psychosocial outcomes (e.g. Anderson *et al.* 2005; Yeates *et al.* 2010; Gregório *et al.* 2014) and experience unmet therapeutic needs within Australia (Brenner *et al.* 2021) and internationally (Dollman *et al.* 2017; Lyons *et al.* 2017; Fuentes *et al.* 2018). Although a range of communication disorders can arise following TBIs (e.g. Safaz *et al.* 2008), cognitive-communication disorders (CCDs) are arguably the most commonly occurring (MacDonald 2017) and complex.

CCDs in paediatric populations and ‘silent’ sub-populations

CCDs are defined by the American Speech-Language Association (ASHA) as being, ‘disorders encompass(ing) difficulty with any aspect of communication that is affected by disruption of cognition’ (ASHA 2005, p. 2). CCDs can impact any mode of a child or adolescents’ reading, writing, listening or speaking (Chapman *et al.* 2016). Onset may be delayed (Ylvisaker 1993; Chapman *et al.* 2016), and outcomes can be measured months or even years after initial injury, regardless of whether a child sustains a moderate to severe (e.g. Mateer and Williams 1991; Eslinger *et al.* 1992; Ylvisaker 1993) or mild (concussive) injury (e.g. McKinlay *et al.* 2002; Bernard *et al.* 2017; Stockbridge and Newman 2019; Tuerk *et al.* 2020). Importantly, not all Australian children experience the same risk of brain injury. Emerging evidence highlights the existence of ‘silent’ paediatric TBI sub-populations (Maas *et al.* 2017), which experience increased rates of brain injury and/or poorer long-term outcomes compared to the general population, including Indigenous children/adolescents (Esterman *et al.* 2018; Peterson *et al.* 2019), those with pre-existing developmental disabilities/disorders (McKinlay *et al.* 2012; Kang *et al.* 2013; Martin *et al.* 2022), individuals with mental health disorders (Fann *et al.* 2002), juvenile offenders (Linden *et al.* 2020), those who have experienced abuse (Cusimano *et al.* 2021), non-white minority youth (Haider *et al.* 2007; Jimenez *et al.* 2013) and youth athletes (Kimble *et al.* 2011). Problematically, within Australia such sub-populations may also experience barriers in accessing healthcare (Gilbert and Partridge 2012; Elkington *et al.* 2019; Department of Social Services 2021; Green *et al.* 2021; Nolan-Isles *et al.* 2021). Thus, a substantial proportion of children and adolescents that live with undiagnosed brain injuries (and secondary communicative, behavioural and psychosocial impairments) may be from these sub-populations. Whether a child or adolescent has received an official diagnosis of TBI or not, assessment of their cognitive-communication abilities is important for diagnosis, prognostication, treatment delivery and coordination of services.

Assessing CCDs in clinical practice

Assessment happens in clinical practice for a variety of purposes, for example to diagnose, set goals, evaluate treatment outcomes and prognosticate (Laver-Fawcett and Cox 2021). Assessment refers to the process of collecting data that can be interpreted and used to inform clinical decision making (Intercollegiate Stroke Working Party 2012). Despite assessment being foundational to health service delivery, it is considered to be a complex clinical skill due to the requirement of ‘creativity, experience, knowledge, and original thought’ (Laver-Fawcett and Cox 2021, p. 30). However, assessment may also be complex in part due to the careful consideration that clinicians must give to their measurement practices (i.e. the selection of constructs to measure, the timing of measurement post-injury, and determining how measurement will occur through the selection of measurement instruments and potentially interdisciplinary practice). Resources such as those produced by the Allied Health Professions (AHP) Outcome Measures UK Working Group (2019) outline key considerations for clinicians to ensure the validity and reliability of their measurement practices. Clinical guidelines exist to support the assessment and treatment of speech, language and swallowing outcomes for children and adolescents with TBI during their first year of recovery (Mei *et al.* 2018). These guidelines, although comprehensive in scope, do not provide in-depth guidance with regards to clinical assessment practices for CCDs. This is not surprising given that significant knowledge gaps still exist for paediatric CCDs, for example in understanding the most important constructs to measure for diagnosis or to determine treatment success, and the optimal timing of measurement (particularly in the chronic stage of recovery). Indeed, the need for ongoing research in this area, particularly for guidelines that support cognitive impairments underlying communication disorders, is recognised by Mei *et al.* (2018). Decisions about what to measure, when and using which measurement instruments are critical, having implications for accurate and timely identification of paediatric CCDs, appropriate intervention, and optimal health and life outcomes. Given the individual and societal imperative for high quality assessment following TBI, particularly for children and adolescents in ‘silent’ populations, there is a need to understand how measurement currently occurs in clinical practice and the factors that encourage or impede optimal practice.

Theoretical Domains Framework

The Theoretical Domains Framework (TDF) is a framework that may be used to understand the factors influencing health professional behaviours in clinical practice (Atkins *et al.* 2017). In its refined form, the TDF integrates 14 domains (Michie *et al.* (2005): (1) knowledge; (2) skills; (3) social/professional role and identity; (4) beliefs about capabilities; (5) optimism; (6) beliefs about consequences;

(7) reinforcement; (8) intentions; (9) goals; (10) memory, attention and decision processes; (11) environmental context and resources; (12) social influences, (13) emotions; and (14) behavioural regulation (Cane *et al.* 2012). Huijg *et al.* (2014) developed a reliable and valid questionnaire to evaluate the determinants of health care professionals' behaviour based upon the TDF domains. The TDF has preceded use in communication research (Arnold *et al.* 2020; Wallace *et al.* 2021; Kwok *et al.* 2022) and the implementation of evidence-based guidelines in TBI management (Tavender *et al.* 2015; Silverberg *et al.* 2021). An additional benefit of the TDF is that it not only enables the identification of factors influencing implementation, but it can be used to inform future behavioural change interventions (Cane *et al.* 2012). In this study, the TDF has been used to identify the positive and negative factors influencing Australian SLPs' measurement practices when assessing CCDs in children and adolescents with TBI.

Therefore, this study aimed to explore Australian SLPs' measurement practices when assessing CCDs in children and adolescents with TBI. The specific research questions were,

- (1) Which case history questions do SLPs ask to (i) identify children and adolescents with TBI in general clinical practice and (ii) inform their measurement practices when supporting children and adolescents with documented TBI?
- (2) When SLPs assess CCDs in children and adolescents with documented TBI, (i) what are the clinical purposes of measurement, (ii) which constructs are measured, (iii) when are constructs measured and (iv) how are constructs measured (through interdisciplinary practices and using which measurement instruments)?
- (3) What are the facilitators and barriers to Australian SLPs' assessment of CCDs in clinical practice?

Method

Ethical approval was received from the National Health and Medical Research Council (NHMRC) registered Human Research Ethics Committee of The University of Queensland (approval number: 2020000103).

Study design

This study employed a cross-sectional, online survey design and collected qualitative and quantitative data. This design was undertaken not only as a time- and cost-effective approach (Wang and Cheng 2020) but to also enable the convenient participation of a large number of geographically diverse respondents (Evans and Mathur 2005). The web-based survey platform Qualtrics (www.qualtrics.com) was used to develop the survey in accordance with the Checklist for Reporting Results of Internet E-Surveys reporting guidelines

(Eysenbach 2004; refer to Supplementary File S1 for an overview of the survey design and reporting).

The survey included 34 questions with Likert rating scales, multiple-choice, open-ended response and yes/no response formats in four sections: (1) participant demographics (six questions) (see Table 1), (2) case history practices (12 questions) (see Figs 1 and 2), (3) measuring CCD outcomes (20 questions) (see Tables 2 and 3), and (4) facilitators and barriers to the measurement of CCD outcomes in clinical practice (32 questions) (see Table 4, Fig. 3). All SLPs were presented with questions in survey sections 1, 2 and 4. However, only SLPs who reported having children and adolescents with TBI on their current caseload were presented with survey section 3. The number of respondents to each question is available upon request from the corresponding author. Question skip logic was employed to create custom paths for each participant.

Topic areas included in the survey were based on important considerations of measurement outlined by Williamson *et al.* (2012, 2017); the role of SLPs in the identification, diagnosis and treatment of CCDs described by ASHA (2005); and existing guidelines, models, literature and recommendations describing paediatric CCD measurement (McCauley *et al.* 2012; Turkstra *et al.* 2015; MacDonald 2017; Mei *et al.* 2018). Questions concerning measurement instrument use were also informed by a previous scoping review undertaken by the research team (Crumlish *et al.* 2022).

Questions in section 4 were developed in alignment with the Determinants of Implementation Behaviour Questionnaire (Huijg *et al.* 2014). Based upon the TDF (Michie *et al.* 2005), this questionnaire been used to assess factors that influence SLP behaviours in research (e.g. Wallace *et al.* 2021) and clinical practice (e.g. Chang *et al.* 2018; Shrubsole *et al.* 2019; Arnold *et al.* 2020). Participants rated their agreement (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree) with 28 TDF positively and negatively phrased statements. Such statements reflected the 14 validated domains outlined by Cane *et al.* (2012).

A mixture of positive and negative phrasing was used to control for the possibility of acquiescence response bias (Lavrakas 2008). Positively phrased statements with higher response ratings were considered to represent facilitators, whereas positively phrased statements with lower ratings were considered to reflect barriers. Conversely, higher response ratings to negatively phrased statements were considered to reflect barriers, whereas lower ratings reflected facilitators (Young *et al.* 2018). Pilot testing of the survey occurred with five experienced SLPs and led to amendments to the wording of some questions to improve overall clarity.

Participants

Australian SLPs were eligible to participate if they were supporting children or adolescents in clinical practice at

Table 1. Participant demographics.

Variable	No. of participants N (%)
State or territory (n = 111)	
Queensland	45 (40.5%)
New South Wales	26 (23.4%)
Victoria	20 (18.0%)
Tasmania	8 (7.2%)
South Australia	5 (4.5%)
Western Australian	5 (4.5%)
Australian Capital Territory	1 (0.9%)
Northern Territory	1 (0.9%)
Workplace/service delivery (n = 111)	
Private practice	40 (36%)
Department of Education	18 (16.2%)
Hospital – acute	11 (10.0%)
Non-governmental organisation	10 (9.0%)
Hospital – inpatient rehabilitation service	9 (8.1%)
Other	7 (6.3%)
Community rehabilitation – day hospital or outpatients	5 (4.5%)
Child Development Service	4 (3.6%)
Juvenile Justice Service	3 (2.7%)
Community rehabilitation – home-based	2 (1.8%)
Profit for Purpose	2 (1.8%)
Years of professional experience (n = 111)	
Less than 1 year	10 (9.0%)
1–3 years	17 (15.3%)
4–6 years	34 (30.6%)
7–10 years	16 (14.4%)
More than 10 years	34 (30.6%)
Time working with children/adolescents with TBI (n = 111)	
I have not worked with children or adolescents with TBI	43 (38.7%)
Less than 1 year	18 (16.2%)
1–3 years	16 (14.4%)
4–6 years	12 (10.8%)
7–10 years	11 (10.0%)
More than 10 years	11 (10.0%)
Caseload (n = 107)	
I have children or adolescents with documented TBI on my current caseload	57 (53.3%)
I do not have children or adolescents with documented TBI on my current caseload	50 (46.7%)

the time of the survey's completion. SLPs did not need to be supporting children or adolescents with documented TBI to participate, as (1) most brain injuries are mild and unreported (Leo and McCrea 2016) and (2) the experiences of both specialist (i.e. SLPs with clinical experience) and generalist SLPs (i.e. those without/little TBI experience) were sought in this study. There were no other inclusion or exclusion criteria.

A total of 134 SLPs commenced the survey. However, 23 surveys were excluded, as the participant did not complete past survey section 1 (participant demographics) (n = 23). Therefore, 111 responses were included in the final analysis. The majority of SLPs were located within Queensland (n = 45; 40.5%) and worked within a private practice setting (n = 40; 36%). Most SLPs had either 4–6 years (n = 34; 30.6%) or more than 10 years (n = 34; 30.6%) of clinical experience. Forty-three (38.7%) SLPs had no experience working with children or adolescents with TBI (n = 43; 38.7%). Just over half of the SLPs within this study reported having children and adolescents with TBI in their current caseload (n = 57; 53.3%) (See Table 1). Results are reported as a proportion of the respondents completing each question, as not all participants completed all questions.

Procedures

Convenience and snowball sampling (Gill 2020) were used to recruit Australian SLPs. During a 1-month period (August–September 2020), a link to the online survey was disseminated through Speech Pathology Australia's National eNews newsletter, social media networks (e.g. Twitter, Facebook, LinkedIn), Australian Special Interest Brain Injury groups and professional networks. SLPs were required to provide informed consent via Qualtrics prior to being presented with survey questions. All data were collected in a de-identified manner.

Data analysis

The survey results were exported into Apple Pages, and close-ended questions were analysed descriptively using frequency distribution and percentages. Qualitative data were analysed using content analysis, with broad concepts and categories being inductively generated (Graneheim and Lundman 2004). Analysis involved (1) reading and clarifying participants' responses to open-ended questions, (2) dividing responses into meaning units (words/phrases that were related based upon their meaning and context), (3) refining meaning units while still ensuring their original meaning and context, (4) grouping meaning units with others that were most closely related and (5) grouping content codes into subcategories and higher-level categories. Agreement was achieved through author discussion when discrepancies in coding arose.

In survey section 4, facilitators and barriers to assessment approaches were analysed by calculating an average score

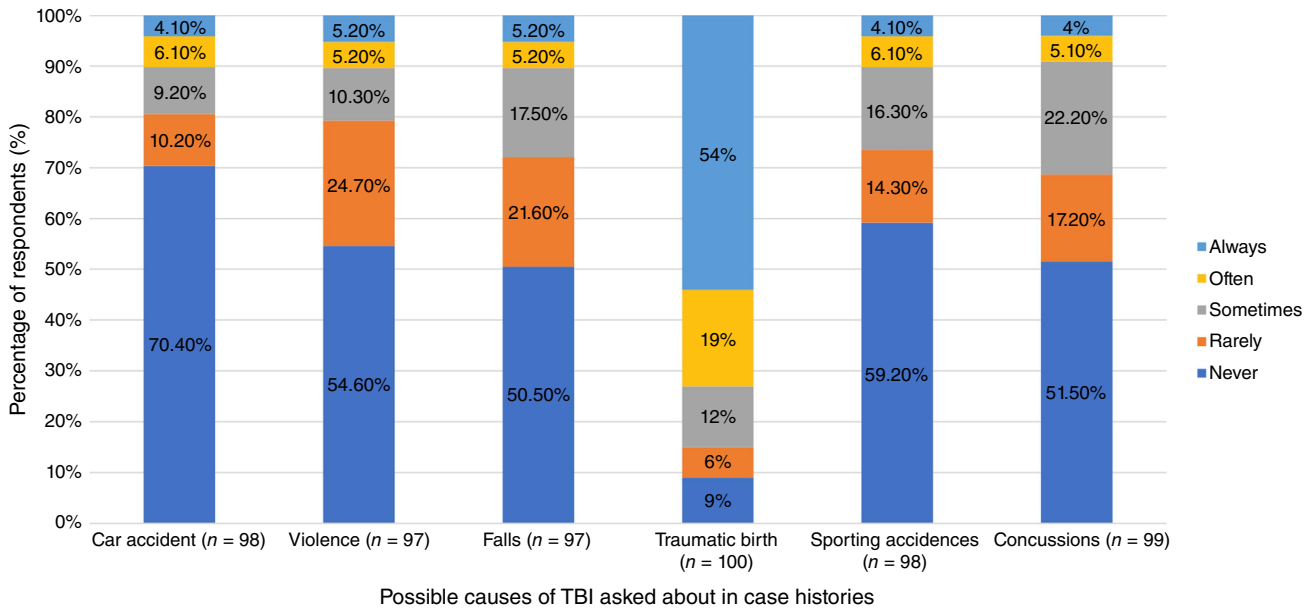


Fig. 1. Case history questions asked by Australian SLPs to identify children and adolescents with TBI in general clinical practice.

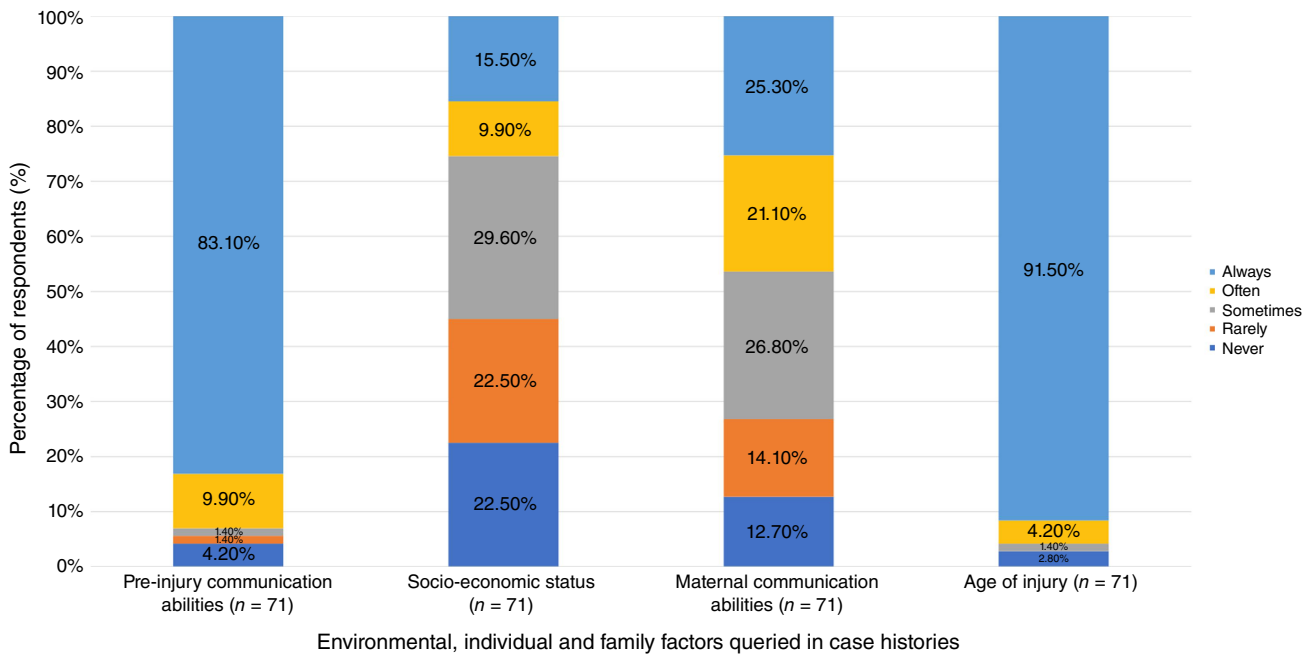


Fig. 2. Case history questions asked by Australian SLPs when supporting children and adolescents with documented TBI.

(between 1 and 5) for each TDF statement and domain based upon published precedence (Young et al. 2018). Based upon work by Arnold et al. (2020) and Young et al. (2018), the scoring system was reversed for negative statements to ensure consistency in the scoring approach. A score of less than three (i.e. < 3) reflected a barrier, whereas a score of more than or equal to three (i.e. ≥ 3) reflected a facilitator. Mean scores for TDF statements were summed and then divided by the number of statements in the domain to

calculate the domain score. Facilitators were domains with the highest average score, whereas barriers were domains with the lowest average score.

As outlined by Koch (2006), an audit trail was also maintained by the lead author (LC) throughout the data analysis process (i.e. when extracting raw data, prioritising the most relevant questions for the study’s aims, and completing quantitative and qualitative analysis) to further increase rigour.

Table 2. Measurement practices of Australian SLPs assessing children and adolescents with TBI.

Measurement practices	No. of participants N (%)
Why do SLPs undertake assessments with children and adolescents that have experienced TBI? (n = 52) ^A	
Inform goal setting	52 (100%)
Guide intervention	50 (96.2%)
Screen	35 (67.3%)
Diagnose	35 (67.3%)
Measure therapy outcomes	35 (67.3%)
Other	7 (13.5%)
School supports	5 (9.6%)
Guide referrals	1 (1.9%)
Support funding applications	1 (1.9%)
Are SLPs completing cognitive-communication assessments with children or adolescents that have a documented history of TBI? (n = 52) ^A	
Yes	38 (73.0%)
No	14 (27.0%)
Combined (language/pragmatics/speech/swallowing) assessments	5 (9.6%)
Developmental language assessments	4 (7.7%)
Social (pragmatic) assessments	3 (5.8%)
Swallowing assessments	1 (1.9%)
Informal communication assessments	1 (1.9%)
Do SLPs include measures for measuring quality of life or psychosocial impacts when assessing children/adolescents who have experienced a TBI? (n = 50)	
Yes	10 (20%)
No	40 (80%)
When do SLPs assess children or adolescents that have experienced a TBI? (n = 52) ^A	
Following hospital discharge and in the first 12 months following a TBI	19 (36.5%)
More than 12 months following a TBI	36 (69.2%)
In the acute phase after injury (i.e. the initial hospital admission and stay)	15 (28.8%)
When assessing children or adolescents with a history of TBI, do SLPs recommend reviews or ongoing monitoring? (n = 50)	
Yes	46 (92%)
No	4 (8%)
When do SLPs recommend that reviews and monitoring occur? (n = 50) ^A	
When/if more parental- or child-based concerns arise	29 (58%)
When a client reaches a new developmental, transitional time period	28 (56%)
Ahead of funding reviews	20 (40%)

(Continued on next column)

Table 2. (Continued)

Measurement practices	No. of participants N (%)
Yearly	18 (36%)
Other	12 (24%)
How do SLPs work with other health professionals when assessing CCDs? (n = 37)	
In a multi-disciplinary capacity (working with other health professionals, drawing upon their speech pathology-related knowledge and experience)	18 (48.6%)
In an intradisciplinary capacity (individually as a speech pathologist)	5 (13.5%)
In an interdisciplinary capacity (working with other health professionals to integrate and synthesise information from different disciplines)	9 (24.3%)
In a transdisciplinary capacity (integrating information and knowledge across health professionals and working in a way that transcends traditional roles)	5 (13.5%)
When completing cognitive-communication assessments SLPs work with	
Occupational therapists (n = 37)	Always = 12 (32.4%) Sometimes = 22 (59.5%) Never = 3 (8.1%)
Neuropsychologists (n = 37)	Always = 11 (29.7%) Sometimes = 20 (54.1%) Never = 6 (16.2%)
Clinical psychologists (n = 32)	Always = 6 (18.8%) Sometimes = 21 (65.6%) Never = 5 (15.6%)
Others (n = 6) ^A	Physiotherapists = 4 Neurologists = 1 Paediatricians = 1 Music therapists = 1

^AQuestions that allowed respondents to select more than one answer.

Results

Which case history questions do SLPs ask to (i) identify children and adolescents with TBI when injury has not been reported and (ii) inform their measurement practices when supporting children and adolescents with documented TBI?

Just over half of the SLPs (54.0%, n = 54/100) reported that they 'always' ask if their clients experienced a traumatic birth when completing a case history. However, more than half of the SLPs reported 'never' including questions in their case history about other possible causes of TBI, including car

Table 3. Measurement instruments used by Australian SLPs when assessing CCD outcomes with children and adolescents with TBI.

Measurement instrument	Reported use N (%)	Construct(s) measured by the reported measurement instrument ^B
Measurement instruments used by Australian SLPs assessing cognitive-communication abilities/outcomes in children and adolescents with TBI (n = 37) ^A		
Clinical Evaluation of Language Fundamentals Australian and New Zealand Fifth Edition (CELF-5 A&NZ)	32 (86.5%)	Oral language (Semel et al. 2014)
Language Sampling (Narrative Retell or Generation based tasks)	31 (83.8%)	Narrative (Retell/Generation)
Language Sampling (Play-based observation)	28 (75.7%)	Language
Clinical Evaluation of Language Fundamentals Preschool – Second Edition, Australian and New Zealand Standardised Edition (CELF P-2 Australian and New Zealand)	25 (67.6%)	Oral language (Semel et al. 2004)
Preschool Language Scales, Fifth Edition – Australian and New Zealand Language Adapted Edition (PLS-5)	21 (56.8%)	Oral Language (Zimmerman et al. 2011)
Test of Problem Solving (TOPS) – Elementary/Adolescent	18 (48.6%)	Language-based thinking, reasoning, and problem-solving (Bowers et al. 2005)
Renfrew Bus Story Test	16 (43.2%)	Narrative (Retell) (Pankratz et al. 2007)
Bayley Scales of Infant Development Mental Scale	11 (29.7%)	Memory, habituation, problem solving, early number concepts, generalisation, classification, vocalisations, language, social skills (Koseck 1999)
Boston Naming Test (BNT)	11 (29.7%)	Naming (Kaplan et al. 1983)
Hundred Pictures Naming Test (HPNT)	10 (27.0%)	Naming (Fisher and Glenister 1992)
La Trobe Communication Questionnaire (LCQ)	8 (21.6%)	Perceived Communication (Douglas et al. 2000)
The Functional Independence Measure and Functional Assessment Measure (FIM + FAM)	8 (21.6%)	Functional disability (Hall et al. 2010)
Test of Language Competence – Expanded Edition (TLC-Expanded)	7 (18.9%)	Language (Wiig and Secord 1989)
Pediatric Test of Brain Injury (PTBI)	7 (18.9%)	Neurocognition, language, and literacy (Hotz et al. 2009)
Vineland Adaptive Behaviour Scales (VABS)	5 (13.5%)	Adaptive Behaviour (Sparrow et al. 1984)
Pediatric Evaluation of Disability Inventory (PEDI)	4 (10.8%)	Functional status (Haley et al. 1991)
Test of Language Development – Intermediate	4 (10.8%)	Oral language (Hammill and Newcomer 2008)
Test of Language Development – Primary	3 (8.1%)	Oral language (Newcomer and Hammill 1997)
Adaptive Behaviour Assessment System (ABAS)	3 (8.1%)	Adaptive Behaviour (Harrison and Oakland 2003)
Test for Reception of Grammar (TROG-2)	3 (8.1%)	Understanding of grammar (Bishop 2003)
Test of Adolescent and Adult Language (TOAL-4)	2 (5.4%)	Language (Hammill et al. 2007)
Social Language Development Test	2 (5.4%)	Language-based social skills (Bowers et al. 2008)
Expressive Vocabulary Test, Third Edition (EVT-3)	2 (5.4%)	Expressive vocabulary (Williams 2019)
Peabody Picture Vocabulary Test, Fifth Edition (PPVT-5)	2 (5.4%)	Receptive vocabulary (Dunn 2019)
Sutherland Phonological Awareness Test (SPAT-R)	2 (5.4%)	Phonological awareness (Neilson 2003)
The Functional Assessment of Verbal Reasoning and Executive Strategies for Students (S-FAVRES)	2 (5.4%)	Cognitive-communication (MacDonald 2016)
Home and Community Social Behaviour Scales	1 (2.7%)	Social behaviour (Merrell et al. 2001)
The Disability Rating Scale (DRS)	1 (2.7%)	Disability (Rappaport et al. 1982)
Bracken Basic Concept Scale Revised	1 (2.7%)	Concept knowledge, receptive language (Bracken 1998)
Comprehensive Assessment of Spoken Language (CASL 2)	1 (2.7%)	Language (Rehfeld and Padgett 2019)
CELF 5 Metalinguistics	1 (2.7%)	Higher-level language (Semel et al. 2014)
Expression, Reception and Recall of Narrative Instrument (ERRNI)	1 (2.7%)	Narrative (Retell) (Bishop 2014)

(Continued on next page)

Table 3. (Continued)

Measurement instrument	Reported use N (%)	Construct(s) measured by the reported measurement instrument ^B
The Functional Assessment of Verbal Reasoning and Executive Strategies (FAVRES)	1 (2.7%)	Cognitive-communication (Macdonald and Johnson 2005)
Measure of Cognitive Linguistic Abilities (MCLA)	1 (2.7%)	Cognitive linguistic impairments (Ellmo et al. 1995)
Montreal Evaluation of Communication	1 (2.7%)	Communication (Joanette et al. 2004)
Preschool Language Assessment Instrument (PLAI-2)	1 (2.7%)	Discourse (Blank et al. 2003)
Renfrew Action Picture Test (RAPT)	1 (2.7%)	Language (Renfrew 2010)
Receptive-Expressive Emergent Language Test, Third Edition (REEL-3)	1 (2.7%)	Language (Bzoch et al. 2003)
Symbolic Play Test	1 (2.7%)	Symbolic play (Doswell et al. 1994)
The Awareness of Social Inference Test (TASIT)	1 (2.7%)	Social perception (McDonald et al. 2003)
Test of Integrated Language and Literacy Skills (TILLS)	1 (2.7%)	Oral/written language (Nelson et al. 2016)
Wechsler Individual Achievement Test (WIAT- III)	1 (2.7%)	Listening, speaking, reading, writing, and mathematics skills (Breux 2009)
Western Aphasia Battery	1 (2.7%)	Language (Kertesz 2022)
Woodcock-Johnson Tests of Cognitive Abilities	1 (2.7%)	Cognitive ability (Bulut et al. 2021)
York Assessment of Reading for Comprehension (YARC)	1 (2.7%)	Reading (comprehension) (Snowling et al. 2012)
Measurement instruments used by Australian SLPs assessing quality of life or psychosocial impacts in children and adolescents with TBI ($n = 10$) ^A		
The Paediatric Quality of Life Inventory	4 (40%)	Health-related quality of life (Varni et al. 1999)
Sydney Psychosocial Reintegration Scale (SPRS)	2 (20%)	Everyday living (occupational activities, interpersonal relationships, independent living skills) (Tate et al. 1999)
Independently developed set of questionnaires/checklist	2 (20%)	–
Satisfaction With Life Scale (SWLS)	1 (10%)	Global life satisfaction (Diener et al. 1985)
Family Functioning Questionnaire (FFQ)	1 (10%)	Family functioning (P. Noller unpubl. data)
Goal Attainment Scale	1 (10%)	–
TOMS	1 (10%)	–

^AQuestions that allowed respondents to select more than one answer.

^BAs reported by published manual or psychometric research literature.

accidents, sporting accidents, family violence, concussions or falls (see Fig. 1).

When undertaking case history analysis with children and adolescents with documented TBI, the majority of Australian SLPs reported ‘always’ asking about a child’s or adolescent’s age of injury and pre-injury communication abilities respectively ($n = 65/71$; 91.5%; $n = 59/71$; 83.1%). Maternal communication abilities ($n = 18/71$; 25.3%) and socio-economic status ($n = 11/71$; 15.5%) were ‘always’ asked by a smaller proportion of respondents (see Fig. 2).

When SLPs assess CCDs in children and adolescents with documented TBI, (i) what are the clinical purposes of measurement, (ii) which constructs are measured, (ii) when are constructs measured and (iii) how are constructs measured?

Australian SLPs reported undertaking assessments with children and adolescents with TBI primarily for the purposes of

informing goal setting ($n = 52$; 100%) and guiding intervention ($n = 50$; 96.2%). Other purposes included screening ($n = 35$; 67.3%), diagnosing ($n = 35$; 67.3%) and measuring therapy outcomes ($n = 35$; 67.3%).

Of the clinicians who reported working with children and adolescents with TBI, 73% ($n = 38$) reported assessing the cognitive-communication abilities of children and adolescents with TBI. Clinicians who were not assessing cognitive-communication abilities in children and adolescents with a documented history of TBI ($n = 14$; 27.0%), primarily reported assessing some combination of language, pragmatics, speech and/or swallowing outcomes ($n = 5$; 9.6%) instead (see Table 2).

Australian SLPs who reported assessing the cognitive-communication abilities of children and adolescents with TBI specifically, reported measuring a variety of constructs through their measurement instrument selection. The five most frequently reported measurement instruments (each reported by more than 50% of participants) measured

Table 4. Australian SLPs' agreement levels (and respective means and medians) with statements within TDF domains.

Domain	Survey statements	No. of participants (n = 90)						Mean	Median	
		1 s.d.	2 D	3 N	4 A	5 SA	Less than Agreement (1–3)			Agreement (4–5)
1. Knowledge	1.1 I know what cognitive-communication disorders are and how they differ from both developmental communication disorders and aphasia in children and adolescents	0 (0)	12 (13.3)	17 (18.8)	44 (48.9)	17 (18.8)	29 (32.2)	61 (67.8)	3.73	4.00
	1.2 I know how to undertake cognitive-communication assessments with children and adolescents who have a history of TBI	6 (6.7)	29 (32.2)	18 (20)	29 (32.2)	8 (8.9)	53 (58.8)	37 (41.2)	3.04	3.00
	Average domain score						(45.5)	(54.5)	3.40	–
2. Skills	2.1 I have been trained in selecting appropriate assessments/tools to use when assessing cognitive-communication disorders in children and adolescents who have a history of TBI	14 (15.5)	36 (40)	19 (21.1)	14 (15.5)	7 (7.8)	69 (76.7)	21 (23.4)	2.60	2.00
	2.2 I have the skills to generate a clear assessment plan when assessing cognitive-communication disorders in children and adolescents who have a history of TBI	8 (8.9)	26 (28.9)	21 (23.3)	27 (30)	8 (8.9)	55 (61.1)	35 (38.9)	3.01	3.00
	Average domain score						(68.9)	(31.1)	2.81	–
3. Social/professional role and identity	3.1 As a speech pathologist, it is not my job to assess cognitive-communication disorders (R)	56 (62.2)	26 (28.9)	5 (5.6)	1 (1.1)	2 (2.2)	82 (91.1)	8 (8.8)	4.48 ^A	5.00 ^A
	3.2 It is my responsibility to work collaboratively with other healthcare professionals to complete cognitive-communication assessments for children and adolescents following TBI	0 (0)	0 (0)	3 (3.3)	38 (11.5)	49 (54.4)	3 (3.3)	87 (96.6)	4.51	5.00
	Average domain score						(6.1)	(93.9)	4.51	–
4. Beliefs about capabilities	4.1 I am confident that I can undertake cognitive-communication assessments with children and adolescents	5 (5.5)	21 (23.3)	24 (26.7)	30 (33.3)	10 (11.1)	50 (55.6)	40 (44.4)	3.21	3.00
	4.2 I feel that I received adequate knowledge and training in my tertiary speech pathology training to assess cognitive-communication disorders in paediatric/adolescent populations following TBIs	23 (25.6)	39 (43.3)	19 (21.1)	7 (7.8)	2 (2.2)	81 (90)	9 (10)	2.18	2.00
	Average domain score						(72.7)	(27.2)	2.71	–
5. Optimism	5.1 I believe that undertaking cognitive-communication assessments with children and	0 (0)	0 (0)	4 (4.4)	48 (53.3)	38 (42.2)	4 (4.4)	86 (95.6)	4.38	4.00

(Continued on next page)

Table 4. (Continued)

Domain	Survey statements	No. of participants (n = 90)						Less than Agreement (1–3)	Agreement (4–5)	Mean	Median
		1 s.d.	2 D	3 N	4 A	5 SA					
	adolescents with a history of TBI will positively impact upon their therapy outcomes										
	5.2 Completing cognitive-communication assessments will improve families' understanding of their child's impairments	1 (1.1)	0 (0)	1 (1.1)	40 (44.4)	48 (53.3)	2 (2.2)	88 (97.8)	4.49	5.00	
	Average domain score						(3.3)	(96.6)	4.44	–	
6. Beliefs about consequences	6.1 I do not believe that undertaking cognitive-communication assessments with children and adolescents with a history of TBI is important for intervention planning (R)	57 (63.3)	27 (30)	1 (1.1)	2 (2.2)	3 (3.3)	85 (94.4)	5 (5.5)	4.48 ^A	5.00 ^A	
	6.2 If I undertake cognitive-communication assessments, the educational and social outcomes for children and teens that have sustained a TBI will be better	0 (0)	0 (0)	13 (14.4)	47 (52.2)	30 (33.3)	13 (14.4)	77 (85.5)	4.19	4.00	
	Average domain score						(9.9)	(90.0)	4.34	–	
7. Reinforcement	7.1 When I complete cognitive-communication assessments with children and adolescents who have sustained a TBI, I get recognition from clients	0 (0)	19 (21.1)	57 (63.3)	9 (10)	5 (5.6)	76 (84.4)	14 (15.5)	3.00	3.00	
	7.2 When I engage in professional development related to cognitive-communication assessments, I get recognition from my workplace	1 (1.1)	13 (14.4)	44 (48.8)	28 (31.1)	4 (4.4)	58 (64.4)	32 (35.5)	3.23	3.00	
	Average domain score						(74.4)	(25.5)	3.12	–	
8. Intentions	8.1 I always intend to consider if a child or adolescents requires a cognitive-communication assessment if they have experienced a previous TBI	0 (0)	4 (4.4)	28 (31.1)	36 (40)	22 (24.4)	32 (35.6)	58 (64.4)	3.84	4.00	
	8.2 I always intend to identify case history factors that may indicate that a child or adolescent has previously experienced a mild TBI (e.g. concussion)	3 (3.3)	18 (20)	27 (30)	28 (31.1)	14 (15.6)	48 (53.3)	42 (46.6)	3.36	3.00	
	Average domain score						(44.5)	(55.5)	3.6	–	
9. Goals	9.1 I aim to undertake cognitive-communication assessments when a child or adolescent that has	0 (0)	8 (8.9)	19 (21.1)	36 (40)	27 (30)	27 (30)	63 (70)	3.91	4.00	

(Continued on next page)

Table 4. (Continued)

Domain	Survey statements	No. of participants (n = 90)						Mean	Median	
		1 s.d.	2 D	3 N	4 A	5 SA	Less than Agreement (1-3)			Agreement (4-5)
	sustained a TBI reports difficulties communicating in their school or social environment									
	9.2 I aim to improve my knowledge and skills for assessing cognitive-communication abilities in children and adolescents following TBI	0 (0)	1 (1.1)	19 (2.1)	45 (50)	25 (27.8)	20 (22.2)	70 (77.8)	4.04	4.00
	Average domain score						(26.1)	(73.9)	4.01	-
10. Memory, attention, decision processes	10.1 I have a clear system for confirming that I have undertaken cognitive-communication assessments for each paediatric/adolescent client who presents with a history of TBI	11 (12.2)	31 (34.4)	28 (31.1)	16 (17.7)	4 (4.4)	70 (77.7)	20 (22.2)	2.37	3.00
	10.2 I am able to determine if developmental communication assessments, aphasia assessments or cognitive-communication assessments need to be completed with children or adolescents who have a history of TBI	4 (4.4)	18 (20)	25 (27.7)	32 (35.5)	11 (12.2)	47 (52.2)	43 (47.7)	3.31	3.00
	Average domain score						(65.1)	(35.0)	2.84	-
11. Environmental context and resources	11.1 In the organisation that I work in, I have enough time and clinical support to plan cognitive-communication assessments for children and adolescents	7 (7.8)	33 (36.7)	18 (20)	27 (30)	5 (5.6)	58 (64.4)	32 (35.6)	2.83	3.00
	11.2 Management in my workplace provide opportunities for professional development to extend my clinical knowledge of paediatric/adolescent cognitive-communication assessment	4 (4.4)	11 (12.2)	32 (35.5)	33 (36.7)	10 (11.1)	47 (52.2)	43 (47.8)	2.27	3.00
	Average domain score						(58.3)	(41.7)	2.55	-
12. Social influences	12.1 I am more likely to undertake cognitive-communication assessments with children and adolescents with a history of TBI if my colleagues regularly complete such assessments	3 (3.3)	9 (10)	21 (23.3)	43 (47.7)	14 (15.6)	33 (36.7)	57 (63.3)	3.62	4.00
	12.2 My colleagues consistently undertake cognitive-communication assessments with children or adolescents following TBI	15 (16.7)	24 (26.7)	27 (30)	18 (20)	6 (6.7)	66 (73.3)	24 (26.7)	2.73	3.00
	Average domain score						(55)	(45)	3.21	-

(Continued on next page)

Table 4. (Continued)

Domain	Survey statements	No. of participants (n = 90)					Less than Agreement (1–3)	Agreement (4–5)	Mean	Median
		1 s.d.	2 D	3 N	4 A	5 SA				
13. Emotion	13.1 I find assessing children and adolescents for cognitive-communication disorders following TBI difficult	5 (5.6)	36 (40)	36 (40)	9 (10)	4 (4.4)	77 (85.6)	13 (14.4)	2.68 ^A	3.00
	13.2 When I work with children and adolescents who have a history of TBI I feel nervous	5 (5.6)	26 (28.9)	32 (35.6)	14 (15.6)	13 (14.4)	63 (70)	27 (30)	3.04 ^A	3.00
	Average domain score						(22.2)	(77.8)	2.86	–
14. Behavioural regulation	14.1 I have a clear plan that allows me to identify all children and adolescents that have, or potentially have, sustained either a mild, moderate or severe TBI on my caseload	11 (12.2)	40 (44.4)	23 (25.6)	11 (12.2)	5 (5.6)	74 (82.2)	16 (17.8)	2.54	2.00
	14.2 I have a clear plan that allows me to access and remain aware of current recommendations for assessing children and adolescents with a history of TBI	10 (11.1)	36 (40)	24 (26.7)	16 (17.7)	4 (4.4)	70 (77.8)	20 (22.2)	2.64	2.00
	Average domain score						(80)	(20)	2.59	–

Italicised data indicates reversed data.

Note. Scale: 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree. (–) indicate data not calculated; (R) = reversed data.

^ABased on reversed scores.

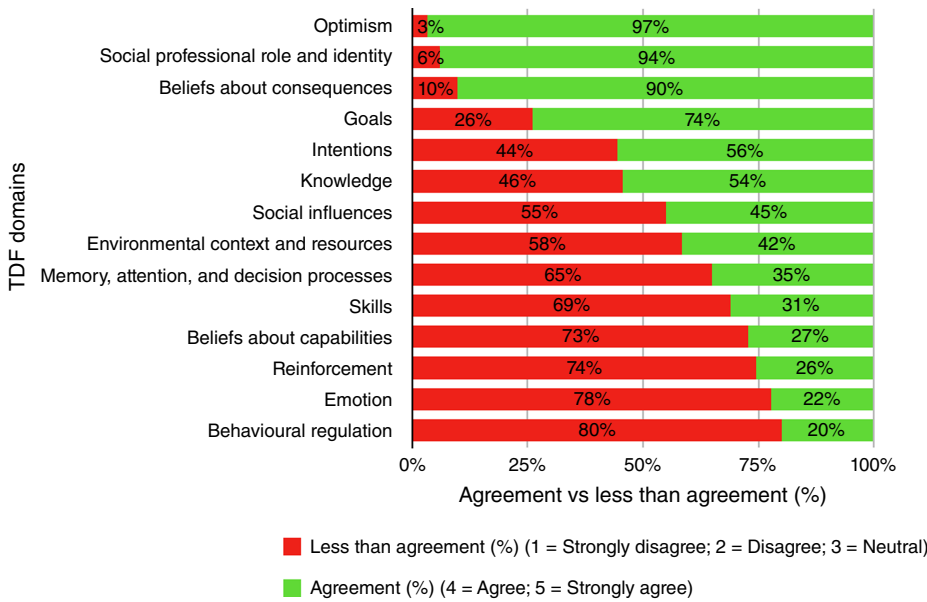


Fig. 3. Percentage of Australian SLPs providing agreement responses (agree and strongly agree) and less than agreement responses (strongly disagree, disagree, and neutral) to the TDF domains.

language (see Table 3). Twenty percent of Australian SLPs reported measuring quality of life (QoL) or psychosocial outcomes of children and adolescents with TBI ($n = 10/50$; 20%) (see Table 2).

Almost 70% ($n = 36$) of Australian SLPs who reported undertaking assessments with children and adolescents with TBI reported doing so more than 12 months following a child's or adolescent's injury. More than 90% ($n = 46$) of Australian SLPs reported recommending ongoing monitoring and reviews, primarily when parental or child-based concerns arose ($n = 29$; 58%), or when clients reached new developmental, transitional time points ($n = 28$; 56%) (see Table 2).

Australian SLPs reported mostly working with other health professional in a multi-disciplinary capacity to assess CCDs ($n = 18/37$; 48.6%). Most Australian SLPs reported working with clinical psychologists ('sometimes': $n = 21/32$; 65.6%), occupational therapists ('sometimes': $n = 22/37$; 59.5%) and neuropsychologists ('sometimes': $n = 20/37$; 54.1%) (see Table 2).

Australian SLPs reported using a total of 52 measurement instruments to assess the cognitive-communication abilities, QoL and psychosocial outcomes of children and adolescents with TBI. The most frequently reported measurement instrument was the Clinical Evaluation of Language Fundamentals – Fifth Edition (Semel et al. 2014) ($n = 32$; 86.5%). The Paediatric Quality of Life Inventory (Varni et al. 1999) was the most commonly reported measurement instrument for measuring QoL and/or psychosocial impacts ($n = 4/10$; 40%) (see Table 3).

What are the facilitators and barriers to Australian SLPs' assessment of CCDs in clinical practice?

A total of 90 Australian SLPs rated all TDF statements, and their responses were included in the final analysis (see

Table 4). The overall agreement and disagreement percentages for all Australian SLPs ($n = 90$) for each TDF domain are shown in Fig. 3. Having 'optimism' was identified as a primary/key facilitator for completing cognitive-communication assessments in clinical practice, with more than 90% of SLPs agreeing that undertaking cognitive-communication assessments with children and adolescents with a history of TBI positively impacts upon therapy outcomes (see TDF statement 5.1) and improves families' understanding of their child's impairments (see TDF statement 5.2). The domains of (1) 'social professional role and identity' (94%), (2) 'beliefs about consequences' (90.0%) and (3) 'goals' (74%) were also identified to be positive facilitators. That is, SLPs believed that assessment was (1) part of their role, (2) important for a child or adolescent's intervention and outcomes and (3) something that they aimed to undertake and to improve their knowledge and skills within.

Eight TDF domains had disagreement levels greater than 50% and so were considered to be barriers to Australian SLPs' abilities to undertake cognitive-communication assessments in clinical practice (i.e. 'behavioural regulation' (80%); 'emotion' (78%); 'reinforcement' (74%); 'beliefs about capabilities' (73%); 'skills' (69%); 'memory, attention and decision processes' (65%); 'environmental context and resources' (58%); and 'social influences' (55%)). 'Behavioural regulation' statements relating to SLPs having plans for identifying all children and adolescents with TBI (14.1) and for accessing research to remain aware of current recommendations (14.2) had the highest disagreement percentage (80%) and so were considered to the primary barriers to Australian SLPs' abilities to undertake cognitive-communication assessments in clinical practice (see Fig. 3 and Table 4).

Figures contained in Supplementary Files S3 and S4 show the agreement and disagreement percentages for SLPs working within specific sectors (workplace) and with varying

years of clinical experience respectively (see Supplementary Files S3 and S4). Closer examination of agreement and disagreement percentages within specific workplace sectors showed variance in terms of the TDF domains that were considered to be primary barriers (see Supplementary File S2). ‘Optimism’ and ‘social professional role and identity’ were primary facilitators across sectors (see Supplementary File S2), and ‘behavioural regulation’ remained the primary barrier to Australian SLPs in private practice (89.1%), the Department of Education (93.3%) and non-governmental organisations (95%). In comparison, Australian SLPs working in the Child Development Service ($n = 3$) reported ‘emotion’ to be the primary barrier (100%) to their clinical practice, reflecting perceived difficulty in undertaking assessments and feelings of nervousness. SLPs in (1) health ($n = 20$), (2) Juvenile Justice Service ($n = 2$), and (3) ‘other’ ($n = 7$) sectors reported ‘(i) reinforcement’ from clients (statement 7.1) or from their workplace (statement 7.2); (ii) having sufficient time, support (statement 11.1) and opportunities for professional development (statement 11.2); and (iii) having confidence (statement 4.1) and/or training in assessing CCDs to be the primary barriers to their assessments respectively (67.5%; 100%; 78.6%) (see Supplementary File S2).

‘Social professional role and identity’ continued to be a facilitator to SLPs’ abilities to assess the cognitive-communication abilities of children and adolescents with TBI, regardless of clinicians’ years of clinical experience (see Supplementary File S3). For clinicians with no experience/less than 1 year of clinical experience supporting children and adolescents with TBI ($n = 50$) and 4–6 years of professional experience ($n = 7$), ‘behavioural regulation’ continued to be the primary barrier in clinical practice (see Supplementary File S3). For clinicians with 1–3 years of experience supporting children and adolescents with TBI ($n = 14$), ‘emotion’ (82.1%) was reported to be the primary barrier in clinical practice, whereas for clinicians with 7–10 years of experience ($n = 8$) or more than 10 years’ experience ($n = 11$), the primary barriers were reported to be ‘beliefs about capabilities’ (56.3%) and ‘reinforcement’ (72.7%) respectively (see Supplementary File S3).

Discussion

The overall aim of this study was to explore the measurement practices of Australian SLPs when assessing CCDs in children and adolescents with TBI. Results from this study identified an inconsistent approach to clinical measurement and barriers to assessment, which reinforce calls for standardisation of TBI outcome measurement (Maas et al. 2017). Despite this, SLPs reported strong optimism, beliefs about consequences and professional identify with regards to assessing CCDs, regardless of workplace sector or years of experience (see Fig. 3, Table 4 and Supplementary Files S3,

S4). Key findings from this study are discussed with respect to relevant research, including recommendations for paediatric TBI management (Mei et al. 2018), published research showing clinical heterogeneity (Covington and Duff 2021) and the presence of hidden populations (e.g. Esterman et al. 2018; Linden et al. 2020; Cusimano et al. 2021), to highlight current challenges that may exist for Australian SLPs in clinical practice.

Clinical challenge I: identifying all children and adolescents with CCDs arising from TBI in case history interviews

This study aimed to understand the case history practices of SLPs when assessing children and adolescents both with documented TBI and without. More than half of the respondents reported ‘never’ enquiring about the incidence of car accidents, family violence, falls, sporting accidents and/or concussions when undertaking a case history with children and adolescents in general clinical practice (i.e. when a history of TBI had not been reported by families) (see Fig. 1). This finding is of concern, given (1) the significant number of children and adolescents living with undiagnosed brain injury (Cantor et al. 2004; Leo and McCrea 2016) and (2) families may fail to associate later-presenting CCDs with a previous TBI even if formal diagnosis has occurred (Turkstra et al. 2015), potentially resulting in important information not being shared with clinicians. Clinicians who do not routinely enquire about a range of TBI causes during case history interviews may fail to identify the underlying cause of a child’s or adolescent’s communication difficulties. Hence, it may be important for the profession moving forward to incorporate case history questions that explore a range of TBI causes into their general case history interviews. TBI populations show heterogeneity in their injury causes and general presentations (Covington and Duff 2021), and without first identifying the risk of TBIs, clinicians may struggle to work backwards and consider the likelihood of a secondarily occurring CCD.

The ‘one size fits all’ nature of TBI research (Maas et al. 2017) may cause additional challenges for clinicians attempting to develop their own case history practices in the absence of comprehensive guidance. Although results showed that clinicians intend to identify all children and adolescents with CCDs from TBIs (see Table 4, TDF statement 8.1), many SLPs reported experiencing barriers in having clinical plans that allowed them to actually do so (see Table 4, TDF statement 14.1). The generic nature of TBI research may mean that research fails to translate and be useful in clinical settings where clinical heterogeneity exists. Emerging research demonstrates that ‘silent’ populations have increased risk of TBI compared to the general population (e.g. Esterman et al. 2018; Linden et al. 2020; Cusimano et al. 2021); for example, Aboriginal peoples experience a two-fold increase in risk of brain injury compared to the

general Australian population (Fitts *et al.* 2019); an increased risk for juvenile offenders, children with pre-existing diagnoses and victims of abuse has also been established (e.g. McKinlay *et al.* 2012; Fitts *et al.* 2019; Cusimano *et al.* 2021; Martin *et al.* 2022). Without guidance, the onus falls on clinicians to be aware of the heightened risks of brain injury for such silent populations and to account for differences in family awareness, injury causes, personal factors, CCD outcomes and environmental factors in their case history practices. Therefore, it is understandable that Australian SLPs across sectors have reported that generating clinical plans is a primary barrier to their case history practices (see Supplementary File S2), a finding that only improved when SLPs had at least 7–10 years of experience (see Supplementary File S3). Ultimately, greater guidance on the far-ranging causes of TBIs and the clinical heterogeneity of paediatric CCD populations is needed so that all children and adolescents with brain injury can be readily identified through case history practices. Greater representation of injury causes, ethnicities, races, genders and psychosocial variables within future guidance would not only enable better clinical identification but would also ensure that research can actually generalise and be implemented in clinical practice where heterogeneity exists, thereby reducing research wastage.

This study also examined the case history practices of SLPs across a range of sectors (see Table 1). Given the barriers that can exist for silent populations accessing healthcare (Gilbert and Partridge 2012; Elkington *et al.* 2019; Department of Social Services 2021; Green *et al.* 2021; Nolan-Isles *et al.* 2021), it may stand to reason that many children and adolescents with TBI access or present to SLP services outside of dedicated brain injury sectors (e.g. youth justice sector, Department of Education). Thus, there is a need for all SLPs, across sectors, to be able to confidently undertake case histories and CCD assessments with children and adolescents with TBI. Yet results from TDF analysis revealed that feelings of difficulty and nervousness (see Table 4, statements 13.1–13.2) and beliefs about capabilities (see Table 4, statements 4.1–4.2) were consistent barriers to SLPs' assessment practices across sectors (See Supplementary File S2). Such results establish, for the first time, the need for all Australian workplaces to receive guidance on case history and assessment practices for paediatric populations with CCDs from TBI. There may also be need for a range of CCD case history practices to be developed, such that SLPs working in distinct sectors (e.g. Juvenile Justice) can aptly probe not only for possible causes of TBI but environmental and family factors that markedly influence their clients' recovery and ongoing development after injury (e.g. Yeates *et al.* 2012; Ryan *et al.* 2016, 2017). However, for some workplaces, this may be additionally challenging, given the reported barriers in time, resources and reinforcement that were also reported (see Supplementary File S2). The perceived barriers in undertaking and developing plans to

support case history interviews that were reported in this study may mean that some CCDs post-TBI are missed in Australian clinical practice. This is of concern, as clinicians must be able to identify the possibility of a child or adolescent presenting with a CCD if they are to make deliberate choices in their measurement practices to achieve accurate and precise assessments.

Clinical challenge 2: measurement inconsistency

Analysis of findings highlighted that SLPs are not using a common approach to CCD assessments, with 52 distinct measurement instruments (see Table 3), a range of constructs (see Table 3) and differences in interdisciplinary practices being reported (see Table 2). Application of the TDF within this study provides the first insight into possible reasons for the lack of consistency, with participants reporting not receiving tertiary training to support their selection of appropriate measurement instruments to use when assessing CCDs (see Table 4, TDF 2.1; mean = 2.60). Although not specifically queried within this study, barriers with tertiary education may also have included limited clinical education and exposure to paediatric TBI populations during undergraduate and/or post-graduate training. Participants also reported perceived barriers in the TDF domain of 'environmental context and resources' (i.e. time, support and opportunities for professional development) (see Table 4, TDF statements 11.1–11.2; mean = 2.83, 2.27 respectively) across sectors, paralleling findings by Kwok *et al.* (2022).

The reduced QoL of children and adolescents with TBI and the impacts of a range of psychosocial factors on recovery have been reported within the research literature (e.g. health-related QoL (Gabbe *et al.* 2010), friendship quality (Heverly-Fitt *et al.* 2014) and incarceration (Seagly *et al.* 2018)). Yet results indicated that the majority of SLPs reported not measuring QoL or psychosocial constructs ($n = 40$; 80%; see Table 3). SLPs' tendency to not measure QoL may simply reflect differences that were also reported in how SLPs complete CCD assessments (i.e. in different interdisciplinary arrangements) and in working with different health professionals (see Table 2). Yet if clinicians are prioritising other constructs ahead of QoL, results may reinforce recent movements within the speech pathology profession towards measuring 'meaningful' health outcomes (Morris *et al.* 2015; Wallace *et al.* 2017; Janik Blaskova and Gibson 2021), particularly due to the finding that clinicians and clients with TBI can have different perspectives on which constructs are most important to measure in clinical settings (Tate 2014).

Ultimately, inconsistencies in measurement practices have implications for individuals, health services and research advancement. Incorrect/missed diagnoses, treatment selection and prognostications from measurement inconsistencies may have real life consequences for individuals and cohorts of individuals (e.g. juvenile offenders). For clinicians, it also

may make referring and managing children and adolescents with TBI across sectors or service deliveries challenging, particularly if health services also have different terminologies for CCDs and CCD outcomes (Ciccina et al. 2021). Inconsistencies in the selection of measurement instruments and constructs also results in incomparable client data, which can impact upon continuity of care. Inconsistencies in measurement practices further limit the potential for meta-analysis of clinic-based data to further progress research in this area. Without consistent measurement, clinical data is not comparable, and robust data sets cannot be established to inform upon future clinically relevant research (Maas et al. 2017).

Clinical challenge 3: knowing what to measure

Results indicated that a range of constructs were measured through measurement instrument selection, including language, symbolic play and disability (see Table 3). Inconsistencies in the selection of constructs may reflect SLPs' difficulties in knowing which constructs are the most important to measure when assessing CCDs. Emerging recommendations and guidance on construct selection have been published (McCauley et al. 2012; Maas et al. 2017; MacDonald 2017; Mei et al. 2018), but by design, they relate to the selection of constructs for research purposes (McCauley et al. 2012) or to research that has not integrated the perspectives of children and adolescents with CCDs (MacDonald 2017; Mei et al. 2018) or is not specific to CCDs (Maas et al. 2017; Mei et al. 2018) (for comprehensive discussion see Crumlish et al. 2022). In the absence of a core outcome set or explicit recommendations, best-practice is unknown, and determining 'important' constructs to measure likely reflects clinicians' understandings of the range of CCD outcomes, childhood and adolescent development, and recovery trajectories, as well as an understanding of the health outcomes that are most meaningful for/to children and adolescent clients and their families.

Interestingly, the top five measurement instruments (each reported by >55% of respondents) all measured the construct of language (see Table 3). Although SLPs' knowledge of the difference between CCDs and developmental language disorders (DLDs) were reported to be a facilitator to their assessments (see Table 4, TDF statement 1.1), over-reliance on single sentence, oral language measurement instruments may reflect difficulties with delineating DLDs from CCDs in clinical practice and the need to continue bringing attention to the role of discourse and communication assessments for children and adolescents with TBI. Alternatively, it may reflect SLPs measuring language in lieu of communication due to the need to measure 'something' in light of a shortage of appropriate/purposefully developed paediatric CCD/TBI measurement instruments (Mei et al. 2018). Regardless of why, the measurement of single sentence language abilities may miss CCDs and lead

to missed diagnoses, poor treatment outcomes and incorrect prognostications, ultimately causing children and adolescents with subtle CCDs to be 'falling through the cracks' (Ciccina et al. 2021, p. 856). Although it may be important to measure language in the early stages of recovery to determine return to typical baseline (Mei et al. 2018), other outcomes, such as 'communication' (Chapman et al. 2016), 'quality of life' and 'discourse', may be of equal or more importance as children and adolescents enter into the chronic stages of recovery and ongoing development. As highlighted by Mei et al. (2018) and others (Hill et al. 2018), more research is particularly needed to support discourse language measurements for children and adolescents with brain injuries. Language sampling in the form of narrative retell (83.8%; $n = 31$) and play-based interactions (75.7%; $n = 28$) were also reported by SLPs (see Table 3), although conversational, expository and persuasive discourses were not. Such discourses, in both spoken and written formats, would have significance for children's and adolescents' social interactions, as well as their academic success, particularly as they progress through higher schooling years (Heilmann et al. 2020; Lundine 2020).

SLPs must also be cautious of relying upon adult cognitive-communication recommendations when considering which constructs to measure. Although adult cognitive-communication guidelines are comparatively well-established (e.g. Institut national d'excellence en santé et en services sociaux–Ontario Neurotrauma Foundation 2017; Ontario Neurotrauma Foundation 2018; e.g. Togher et al. 2014), marked differences between adult and paediatric brain injuries necessitate different approaches to assessment (Byom et al. 2014). Qualitative analysis of open-ended statements revealed, 'CCD assessments are more developed in the adult world. I am in an adult Special Interest Group as well and they talk about CCD in a different way from how we perceive it in paediatrics. It requires a lot of thought, experiment even and problem solving to translate this knowledge to children due to the age at which injury occurs and interrupts with where they are on their developmental trajectory.... We have a long way to go in the paediatric area with getting CCD recognised as an entity of TBI'.

Clinical challenge 4: Australian SLPs (regardless of sector and experience) seek training and professional development opportunities

The key perceived barriers to CCD assessments were behavioural regulation, emotion and reinforcement (see Fig. 3 and Table 4). This suggests that, as a profession, SLPs' feelings of nervousness and difficulty, the development of clinical plans and receiving recognition are the key barriers to their abilities to undertake CCD assessments. However, specific analysis according to SLPs' years of experience or sector did show variance. Interestingly, even clinicians with 7–10 years or more than 10 years of experience reported the

TDF domain of 'beliefs about capabilities' to be a key perceived barrier in their CCD assessments (see Supplementary File S3). As TDF statements concerning tertiary education and training were key barriers for the SLP profession (see Table 4, TDF statements 2.1 and 4.2), such results may indicate the need for additional training and clinical experience for students, as well as professional development opportunities for clinicians of all experience levels. The benefits of additional TBI training have also been supported by Duff and Stuck (2015), who predicted that increased training in TBI for American SLPs would improve service delivery to school-aged children with brain injuries.

Strengths, limitations and future directions

To the authors' knowledge, this is the first study to explore the measurement practices of SLPs undertaking CCD assessments with children and adolescents with TBI and the barriers and facilitators to assessments through the application of a behaviour change framework. This study also took a unique perspective, recruiting SLPs working within dedicated and non-dedicated brain injury services in an attempt to understand the measurement practices and clinical barriers that exist profession-wide. Positively, this study successfully recruited SLPs from every state and territory within Australia, across a range of sectors and with varying years of professional experience. This was considered to be an important recruitment strategy by the authorship team, given that most brain injuries are mild and unreported (Leo and McCrea 2016) and as both specialist and generalist SLPs are likely to be involved within the management of children and adolescents with brain injury (Turkstra *et al.* 2015; Ciccia *et al.* 2021), particularly those within silent populations.

A key limitation of this study was its specific focus on Australian clinical practice. However, results may still be of interest to an international readership, given Australia's multiculturalism, Indigenous populations, rates of sport among children and adolescents, and dedicated roles of SLPs within Juvenile Justice services, all factors that have been the focus of emerging paediatric TBI research internationally (e.g. Lequerica and Krch 2014; Lakhani *et al.* 2017; Snow 2019; Johnson *et al.* 2021). However, future studies may aim to understand if the patterns of CCD measurement practices identified within Australia exist more globally. Additionally, as some questions within the survey had lower response rates, data for such items would not have reflected the views and experiences of all participants. Finally, a greater number of participants may also have engaged within this study, had it not been undertaken during the COVID-19 pandemic.

Measurement inconsistency and barriers to clinical practice in this study support the need for more comprehensive guidance for clinicians. However, more primary research is needed to support the development of such guidance.

Although many gaps exist, a prudent next step may be to understand the most important outcomes to measure for children and adolescents with CCDs post-TBI. Such information could then be integrated with previous research to continue contributing towards the important strides that were achieved by Mei *et al.* (2018) and to give specific focus to CCDs. This understanding could also subsequently inform measurement instrument development/validation, timing of measurement and the development of much needed treatment research, allowing for the Lancet Commissions' recommendations of both measurement standardisation and treatment development (Maas *et al.* 2017) to be achieved. This would also allow for the advancement of paediatric CCD research to continue evolving in a systematic and efficient manner.

Conclusion

Despite the individual and social imperatives, clear guidance for the reliable, valid and evidence-based measurement of paediatric CCDs arising from TBIs, particularly for silent populations, does not yet exist. Results from this study identified inconsistencies in measurement practices and barriers to assessment for Australian SLPs working within health, disability, education, non-governmental organisations, private practice and juvenile justice sectors. The development of comprehensive and specific paediatric CCD guidelines would not only support measurement standardisation but would also ensure that measurement practices are evidence-based, consistent and contributing towards meaningful health outcomes for children and adolescents with CCDs. An important next step in developing comprehensive guidelines may be achieving consensus among a range of stakeholders on which constructs are most important to measure for children and adolescents with CCDs post-TBI.

Supplementary material

Supplementary material is available [online](#).

References

- Allied Health Professions (AHP) Outcome Measures UK Working Group (2019) Key questions to ask when selecting outcome measures: A checklist for allied health professionals. Available at <https://www.rcslt.org/wp-content/uploads/media/docs/selecting-outcome-measures.pdf>
- ASHA (2005) Roles of speech-language pathologists in the identification, diagnosis, and treatment of individuals with cognitive-communication disorders: Position statement. (American-Speech Language and Hearing Association: Rockville, MD, USA) Available at www.asha.org/policy
- Anderson VA, Catroppa C, Haritou F, Morse S, Rosenfeld JV (2005) Identifying factors contributing to child and family outcome 30 months after traumatic brain injury in children. *Journal of Neurology, Neurosurgery, and Psychiatry* 76(3), 401–408. doi:10.1136/jnnp.2003.019174

- Anderson V, Catroppa C, Godfrey C, Rosenfeld JV (2012) Intellectual Ability 10 Years after Traumatic Brain Injury in Infancy and Childhood: What Predicts Outcome? *Journal of Neurotrauma* 29(1), 143–153. doi:10.1089/neu.2011.2012
- Arnold H, Wallace SJ, Ryan B, Finch E, Shrubsole K (2020) Current practice and barriers and facilitators to outcome measurement in aphasia rehabilitation: A cross-sectional study using the theoretical domains framework. *Aphasiology* 34(1), 47–69. doi:10.1080/02687038.2019.1678090
- Atkins L, Francis J, Islam R, O'Connor D, Patey A, Ivers N, Foy R, Duncan EM, Colquhoun H, Grimshaw JM, Lawton R, Michie S (2017) A guide to using the Theoretical Domains Framework of behaviour change to investigate implementation problems. *Implementation Science* 12(1), 77. doi:10.1186/s13012-017-0605-9
- Babikian T, Satz P, Zauha K, Light R, Lewis RS, Asarnow RF (2011) The UCLA longitudinal study of neurocognitive outcomes following mild pediatric traumatic brain injury. *Journal of the International Neuropsychological Society* 17(5), 886–895. doi:10.1017/s1355617711000907
- Bernard CO, Ponsford JL, McKinlay A, McKenzie D, Krieser D (2017) Do Concussive Symptoms Really Resolve in Young Children? *Journal of Head Trauma Rehabilitation* 32(6), 413–424. doi:10.1097/htr.000000000000298
- Bierbaum M, Lystad RP, Curtis K, Mitchell R (2019) Incidence and severity of head injury hospitalisations in Australian children over a 10-year period. *Health Promotion Journal of Australia* 30(2), 189–198. doi:10.1002/hpja.186
- Bishop D (2003) 'Test for receptive grammar (TROG-2).' (Pearson Assessment: London, UK)
- Bishop D (2014) 'Expression, Reception, and Recall of Narrative Instrument.' (Harcourt Assessment)
- Blank M, Rose S, Berlin L (2003) 'Preschool Language Assessment Instrument (PLAI 2).' (Pro-Ed: Austin, TX, USA)
- Bowers L, Huisingh R, LoGiudice C (2005) 'Test of Problem Solving 3 - Elementary.' (Linguistics: East Moline, IL, USA)
- Bowers L, Huisingh R, LoGiudice C (2008) 'Social Language Development Test.' (Linguistics: East Moline, IL, USA)
- Bracken B (1998) 'Bracken Basic Concept Scale - Revised.' (The Psychological Corporation: San Antonio, TX, USA)
- Breaux KC (2009) 'Wechsler Individual Achievement Test–3rd Edition: Technical manual.' (Pearson: San Antonio, TX, USA)
- Brenner LA, Grassmeyer RP, Biffi S, Kinney AR, Dise-Lewis JE, Betthausen LM, Forster JE (2021) Met and unmet rehabilitative needs among pediatric patients with moderate to severe TBI. *Brain Injury* 35(10), 1162–1167. doi:10.1080/02699052.2021.1953146
- Bulut O, Cormier D, Acquilina A, Bulut H (2021) Age and Sex Invariance of the Woodcock-Johnson IV Tests of Cognitive Abilities: Evidence from Psychometric Network Modelling *Journal of Intelligence* 9(3), 35. doi:https://doi.org/10.3390/jintelligence9030035
- Byom L, Allison K, Turkstra L (2014) Issues in the assessment and treatment of cognitive communication disorders in children with TBI. In 'Social and communication disorders following traumatic brain injury', 2nd edn. (Eds S McDonald, L Togher, C Code) pp. 190–217. (Psychology Press)
- Bzoch KR, League R, Brown VL (2003) 'Receptive-Expressive Emergent Language Test.' (PRO-ED.)
- Cane J, O'Connor D, Michie S (2012) Validation of the theoretical domains framework for use in behaviour change and implementation research. *Implementation Science* 7(1), 37. doi:10.1186/1748-5908-7-37
- Cantor JB, Gordon WA, Schwartz ME, Charatz HJ, Ashman TA, Abramowitz S (2004) Child and parent responses to a brain injury screening questionnaire. *Archives of Physical Medicine and Rehabilitation* 85, 54–60. doi:10.1016/j.apmr.2003.08.113
- Chang HF, Power E, O'Halloran R, Foster A (2018) Stroke communication partner training: A national survey of 122 clinicians on current practice patterns and perceived implementation barriers and facilitators. *International Journal of Language and Communication Disorders* 53(6), 1094–1109. doi:10.1111/1460-6984.12421
- Chapman SB, Levin HS, Matejka J, Harward H, Kufera JA (1995) Discourse ability in children with brain injury: Correlations with psychosocial, linguistic, and cognitive factors. *Journal of Head Trauma Rehabilitation* 10(5), 36–37. doi:10.1097/00001199-199510000-00006
- Chapman S, Levin H, Lawyer S (2016) Communication problems resulting from brain injury in children: special issues of assessment and management. In 'Communication Disorders following Traumatic Brain Injury'. (Eds S McDonald, L Togher, C Code) pp. 235–270. (Psychology Press)
- Ciccia A, Lundine JP, O'Brien KH, Salley J, Krusen S, Wilson B, Kunz J, Haarbauer-Krupa J (2021) Understanding Cognitive Communication Needs in Pediatric Traumatic Brain Injury: Issues Identified at the 2020 International Cognitive-Communication Disorders Conference. *American Journal of Speech Language Pathology* 30(2s), 853–862. doi:10.1044/2020_ajslp-20-00077
- Covington NV, Duff MC (2021) Heterogeneity Is a Hallmark of Traumatic Brain Injury, Not a Limitation: A New Perspective on Study Design in Rehabilitation Research. *American Journal of Speech Language Pathology* 30(2s), 974–985. doi:10.1044/2020_ajslp-20-00081
- Crumlish L, Wallace SJ, Copley A, Rose TA (2022) Exploring the measurement of pediatric cognitive-communication disorders in traumatic brain injury research: A scoping review. *Brain Injury* 36(10–11), 1207–1227. doi:10.1080/02699052.2022.2111026
- Cusimano MD, Zhang S, Mei XY, Kennedy D, Saha A, Carpino M, Wolfe D (2021) Traumatic Brain Injury, Abuse, and Poor Sustained Attention in Youth and Young Adults Who Previously Experienced Foster Care. *Neurotrauma Reports* 2(1), 94–102. doi:10.1089/neur.2020.0030
- Department of Social Services (2021) Australia's disability strategy 2021–2031. Commonwealth of Australia Canberra, ACT, Australia.
- Dewan MC, Mummareddy N, Wellons JC, Bonfield CM (2016) Epidemiology of Global Pediatric Traumatic Brain Injury: Qualitative Review. *World Neurosurgery* 91, 497–509. doi:10.1016/j.wneu.2016.03.045
- Diener E, Emmons RA, Larsen RJ, Griffin S (1985) The Satisfaction With Life Scale. *Journal of Personality Assessment* 49(1), 71–75. doi:https://doi.org/10.1207/s15327752jpa4901_13
- Dollman AK, Figaji AA, Schrieff-Elson LE (2017) Academic and Behavioral Outcomes in School-Age South African Children Following Severe Traumatic Brain Injury. *Frontiers in Neuroanatomy* 11, 121. doi:10.3389/fnana.2017.00121
- Doswell G, Lewis V, Sylva K, Boucher J (1994) Validational data on the Warwick Symbolic Play Test. *International Journal of Language & Communication Disorders* 29(3), 289–298. doi:10.3109/13682829409111613
- Douglas JM, O'Flaherty CA, Snow PC (2000) Measuring perception of communicative ability: The development and evaluation of the La Trobe communication questionnaire. *Aphasiology* 14(3), 251–268. doi:10.1080/026870300401469
- Duff MC, Stuck S (2015) Paediatric concussion: Knowledge and practices of school speech-language pathologists. *Brain Injury* 29(1), 64–77. doi:10.3109/02699052.2014.965747
- Dunn DM (2019) 'Peabody Picture Vocabulary Test', 5th edn. (NCS Pearson)
- Elkington L, Hughes D, Manzanero S (2019) 'Concussion in Sport Australia Position Statement.' (Australian Institute of Sport, Australian Medical Association, Australasian College of Sport and Exercise Physicians and Sports Medicine Australia)
- Ellmo W, Graser J, Krchnavek B, Hauck K, Calabrese D (1995) 'Measure of Cognitive-Linguistic Abilities (MCLA).' (The Speech Bin)
- Eslinger PJ, Grattan LM, Damasio H, Damasio AR (1992) Developmental Consequences of Childhood Frontal Lobe Damage. *Archives of Neurology* 49(7), 764–769. doi:10.1001/archneur.1992.00530310112021
- Esterman A, Thompson F, Fitts M, Gilroy J, Fleming J, Maruff P, Clough A, Bohanna I (2018) Incidence of emergency department presentations for traumatic brain injury in Indigenous and non-Indigenous residents aged 15–64 over the 9-year period 2007–2015 in North Queensland, Australia. *Injury Epidemiology* 5(1), 40. doi:10.1186/s40621-018-0172-9
- Evans JR, Mathur A (2005) The value of online surveys. *Internet Research* 15(2), 195–219. doi:10.1108/10662240510590360
- Ewing-Cobbs L, Thompson NM, Miner ME, Fletcher JM (1994) Gunshot wounds to the brain in children and adolescents: Age and neurobehavioral development. *Neurosurgery* 35(2), 225–233. doi:10.1227/00006123-199408000-00007
- Eysenbach G (2004) Improving the quality of Web surveys: the Checklist for Reporting Results of Internet E-Surveys (CHERRIES).

- Journal of Medical Internet Research* 6(3), e34. doi:10.2196/jmir.6.3.e34
- Fann JR, Leonetti A, Jaffe K, Katon WJ, Cummings P, Thompson RS (2002) Psychiatric illness and subsequent traumatic brain injury: A case control study. *Journal of Neurology, Neurosurgery and Psychiatry* 72(5), 615–620. doi:10.1136/jnnp.72.5.615
- Fitts MS, Condon T, Gilroy J, Bird K, Bleakley E, Matheson L, Fleming J, Clough AR, Esterman A, Maruff P, Bohanna I (2019) Indigenous traumatic brain injury research: Responding to recruitment challenges in the hospital environment. *BMC Medical Research Methodology* 19(1), 172. doi:10.1186/s12874-019-0813-x
- Fisher JP, Glenister JM (1992) 'The hundred pictures naming test.' (Australian Council for Educational Research: Hawthorn, Melbourne, Australia)
- Fuentes MM, Wang J, Haarbauer-Krupa J, Yeates KO, Durbin D, Zonfrillo MR, Jaffe KM, Temkin N, Tulskey D, Bertisch H, Rivara FP (2018) Unmet Rehabilitation Needs After Hospitalization for Traumatic Brain Injury. *Pediatrics* 141(5), e20172859. doi:10.1542/peds.2017-2859
- Gabbe BJ, Simpson PM, Sutherland AM, Palmer CS, Butt W, Bevan C, Cameron PA (2010) Agreement between parent and child report of health-related quality of life: Impact of time postinjury. *The Journal of Trauma* 69(6), 1578–1582. doi:10.1097/TA.0b013e3181f8f5df
- Gilbert F, Partridge BJ (2012) The need to tackle concussion in Australian football codes. *The Medical Journal of Australia* 196(9), 561–563. doi:10.5694/mja11.11218
- Gill SL (2020) Qualitative Sampling Methods. *Journal of Human Lactation* 36(4), 579–581. doi:10.1177/0890334420949218
- Graneheim UH, Lundman B (2004) Qualitative content analysis in nursing research: Concepts, procedures and measures to achieve trustworthiness. *Nurse Education Today* 24(2), 105–112. doi:10.1016/j.nedt.2003.10.001
- Green A, Abbott P, Luckett T, Davidson PM, Delaney J, Delaney P, Gunasekera H, DiGiacomo M (2021) 'It's quite a complex trail for families now' – Provider understanding of access to services for Aboriginal children with a disability. *Journal of Child Health Care* 25(2), 194–211. doi:10.1177/1367493520919305
- Gregório GW, Gould KR, Spitz G, van Heugten CM, Ponsford JL (2014) Changes in self-reported pre- to postinjury coping styles in the first 3 years after traumatic brain injury and the effects on psychosocial and emotional functioning and quality of life. *Journal of Head Trauma Rehabilitation* 29(3), E43–E53. doi:10.1097/HTR.0b013e318292fb00
- Haider AH, Efron DT, Haut ER, DiRusso SM, Sullivan T, Cornwell III EE (2007) Black Children Experience Worse Clinical and Functional Outcomes After Traumatic Brain Injury: An Analysis of the National Pediatric Trauma Registry. *The Journal of Trauma: Injury, Infection, and Critical Care* 62(5), 1259–1263. doi:10.1097/TA.0b013e31803c760e
- Haley SM, Coster WJ, Faas RM (1991) A Content Validity Study of the Pediatric Evaluation of Disability Inventory. *Pediatric Physical Therapy* 3(4), 177–184. doi:10.1097/00001577-199100340-00002
- Hall K, Hamilton BB, Gordon W, Zasler N (2010) Functional Independence Measure and Functional Assessment Measure (FIM + FAM). In 'A compendium of tests, scales, and questionnaires: The practitioner's guide to measuring outcomes after acquired brain impairment'. (Ed. RL Tate) pp. 439–443. (Psychology Press)
- Hammill D, Newcomer P (2008) 'Test of Language Development - Intermediate.' (PRO-ED.)
- Hammill DD, Brown VL, Larsen SC, Wiederholt JL (2007) 'Test of Adolescent and Adult Language-Fourth Edition.' (Pro-Ed.)
- Hanten G, Li X, Newsome MR, Swank P, Chapman SB, Dennis M, Barnes M, Ewing-Cobbs L, Levin HS (2009) Oral Reading and Expressive Language After Childhood Traumatic Brain Injury: Trajectory and Correlates of Change Over Time. *Topics in Language Disorders* 29(3), 236–248. doi:10.1097/TLD.0b013e3181b531f0
- Harrison P, Oakland T (2003) 'Adaptive Behaviour Assessment System (ABAS-II).' (The Psychological Corporation)
- Heilmann J, Malone TO, Westerveld MF (2020) Properties of Spoken Persuasive Language Samples From Typically Developing Adolescents. *Language, Speech, and Hearing Services in Schools* 51(2), 441–456. doi:10.1044/2019_LSHSS-19-00078
- Heverly-Fitt S, Wimsatt MA, Menzer MM, Rubin KH, Dennis M, Taylor HG, Stancin T, Gerhardt CA, Vannatta K, Bigler ED, Yeates KO (2014) Friendship quality and psychosocial outcomes among children with traumatic brain injury. *Journal of the International Neuropsychological Society* 20(7), 684–693. doi:10.1017/s1355617714000393
- Hill E, Claessen M, Whitworth A, Boyes M, Ward R (2018) Discourse and cognition in speakers with acquired brain injury (ABI): A systematic review. *International Journal of Language & Communication Disorders* 53(4), 689–717. doi:10.1111/1460-6984.12394
- Hotz GA, Helm-Estabrooks N, Nelson NW, Plante E (2009) The Pediatric Test of Brain Injury: Development and Interpretation. *Topics in Language Disorders* 29(3), 207–223. doi:10.1097/TLD.0b013e3181b53198
- Huijg JM, Gebhardt WA, Dusseldorp E, Verheijden MW, van der Zouwe N, Middelkoop BJ, Crone MR (2014) Measuring determinants of implementation behavior: Psychometric properties of a questionnaire based on the theoretical domains framework. *Implementation Science* 9(1), 33. doi:10.1186/1748-5908-9-33
- Institut national d'excellence en santé et en services sociaux–Ontario Neurotrauma Foundation (2017) INESS-ONF clinical practice guidelines for the rehabilitation of adults with moderate to severe traumatic brain injury. Available at <https://braininjuryguidelines.org/>
- Intercollegiate Stroke Working Party (2012) 'National Clinical Guideline for Stroke.' (Royal College of Physicians: London)
- Janik Blaskova L, Gibson JL (2021) Reviewing the link between language abilities and peer relations in children with developmental language disorder: The importance of children's own perspectives. *Autism & Developmental Language Impairments* 6, 23969415211021515. doi:10.1177/23969415211021515
- Jimenez N, Ebel BE, Wang J, Koepsell TD, Jaffe KM, Dorsch A, Durbin D, Vavilala MS, Temkin N, Rivara FP (2013) Disparities in disability after traumatic brain injury among Hispanic children and adolescents. *Pediatrics* 131(6), e1850–e1856. doi:10.1542/peds.2012-3354
- Joanette Y, Ska B, Côté H (2004) 'Protocole Montréal d'évaluation de la communication (MEC)', Ortho Édition Le Centre de recherche de l'UUGM: Isbergues, France.
- Johnson AM, McCarty CA, Marcynyszyn LA, Zatzick DF, Chrisman SPD, Rivara FP (2021) Child- compared with parent-report ratings on psychosocial measures following a mild traumatic brain injury among youth with persistent post-concussion symptoms. *Brain Injury* 35(5), 574–586. doi:10.1080/02699052.2021.1889663
- Kang J-H, Lin H-C, Chung S-D (2013) Attention-deficit/hyperactivity disorder increased the risk of injury: A population-based follow-up study. *Acta Paediatrica* 102(6), 640–643. doi:10.1111/apa.12213
- Kaplan E, Goodglass H, Weintraub S (1983) 'The Boston Naming Test.' (Lea & Fibiger)
- Kertesz A (2022) The Western Aphasia Battery: A systematic review of research and clinical applications. *Aphasiology* 36(1), 21–50. doi:10.1080/02687038.2020.1852002
- Kimble DE, Murphy M, Dhandapani KM (2011) Concussion and the adolescent athlete. *The Journal of Neuroscience Nursing* 43(6), 286–290. doi:10.1097/JNN.0b013e31823858a6
- Koch T (2006) Establishing rigour in qualitative research: The decision trail. *Journal of Advanced Nursing* 53(1), 91–100. doi:10.1111/j.1365-2648.2006.03681.x
- Koseck K (1999) Review and Evaluation of Psychometric Properties of the Revised Bayley Scales of Infant Development. *Pediatric Physical Therapy* 11(4), 198–204. doi:10.1097/00001577-199901140-00005
- Kurowski BG, Haarbauer-Krupa J, Giza CC (2023) When Traumatic Brain Injuries in Children Become Chronic Health Conditions. *Journal of Head Trauma Rehabilitation* 38, 348–350. doi:10.1097/htr.0000000000000842
- Kwok EYL, Moodie STF, Cunningham BJ, Oram Cardy J (2022) Barriers and Facilitators to Implementation of a Preschool Outcome Measure: An Interview Study with Speech-Language Pathologists. *Journal of Communication Disorders* 95, 106166. doi:10.1016/j.jcomdis.2021.106166
- Lakhani A, Townsend C, Bishara J (2017) Traumatic brain injury amongst indigenous people: A systematic review. *Brain Injury* 31(13–14), 1718–1730. doi:10.1080/02699052.2017.1374468
- Laver-Fawcett A, Cox D (2021) 'Principles of Assessment and Outcome Measurement for Allied Health Professionals: Practice, Research and Development', 2nd edn. (Wiley-Blackwell)

- Lavrakas PJ (2008) Acquiescence Response Bias. In 'Encyclopedia of Survey Research Methods'. (Ed. PJ Lavrakas) pp. 1–3. (SAGE Publications, Inc.)
- Leo P, McCrea M (2016) Epidemiology. In 'Translational Research in Traumatic Brain Injury'. (Eds D Laskowitz, G Grant) (CRC Press/Taylor and Francis Group)
- Lequerica A, Krch D (2014) Issues of cultural diversity in acquired brain injury (ABI) rehabilitation. *NeuroRehabilitation* 34(4), 645–653. doi:10.3233/nre-141079
- Levin HS, Hanten G (2005) Executive functions after traumatic brain injury in children. *Pediatric Neurology* 33(2), 79–93. doi:10.1016/j.pediatrneurol.2005.02.002
- Linden MA, O'Rourke C, Lohan M (2020) Traumatic brain injury and social competence among young male offenders. *Disability and Rehabilitation* 42(17), 2422–2429. doi:10.1080/09638288.2019.1629699
- Lundine JP (2020) Assessing Expository Discourse Abilities Across Elementary, Middle, and High School. *Topics in Language Disorders* 40(2), 149–165. doi:10.1097/TLD.0000000000000211
- Lyons VH, Moore M, Guiney R, Ayyagari RC, Thompson L, Rivara FP, Fleming R, Crawley D, Harper D, Vavilala MS (2017) Strategies to Address Unmet Needs and Facilitate Return to Learn Guideline Adoption Following Concussion. *Journal of School Health* 87(6), 416–426. doi:10.1111/josh.12510
- Maas A, Menon DK, Adelson PD, Andelic N, Bell MJ, Belli A, Bragge P, Brazinova A, Büki A, Chesnut RM, Citerio G, Coburn M, Cooper DJ, Crowder AT, Czeiter E, Czornyka M, Diaz-Arrastia R, Dreier JP, Duhaime A-C, et al. (2017) Traumatic brain injury: Integrated approaches to improve prevention, clinical care, and research. *The Lancet Neurology* 16(12), 987–1048. doi:10.1016/S1474-4422(17)30371-X
- MacDonald S (2016) Assessment of higher level cognitive-communication functions in adolescents with ABI: Standardization of the student version of the functional assessment of verbal reasoning and executive strategies (S-FAVRES). *Brain Injury* 30(3), 295–310. doi:10.3109/02699052.2015.1091947
- MacDonald S (2017) Introducing the model of cognitive-communication competence: A model to guide evidence-based communication interventions after brain injury. *Brain Injury* 31(13–14), 1760–1780. doi:10.1080/02699052.2017.1379613
- Macdonald S, Johnson CJ (2005) Assessment of subtle cognitive-communication deficits following acquired brain injury: A normative study of the Functional Assessment of Verbal Reasoning and Executive Strategies (FAVRES). *Brain Injury* 19(11), 895–902. doi:10.1080/02699050400004294
- Martin AK, Petersen AJ, Sesma HW, Koolmo MB, Ingram KM, Slifko KB, Nguyen VN, Doss RC, Linabery AM (2022) Learning and Attention Deficit/Hyperactivity Disorders as Risk Factors for Prolonged Concussion Recovery in Children and Adolescents. *Journal of the International Neuropsychological Society* 28(2), 109–122. doi:10.1017/S1355617721000229
- Massagli TL, Jaffe KM, Fay GC, Polissar NL, Liao S, Rivara JB (1996) Neurobehavioral sequelae of severe pediatric traumatic brain injury: a cohort study. *Archives of Physical Medicine and Rehabilitation* 77(3), 223–231. doi:10.1016/s0003-9993(96)90102-1
- Mateer CA, Williams D (1991) Effects of frontal lobe injury in childhood. *Developmental Neuropsychology* 7(3), 359–376. doi:10.1080/87565649109540498
- McCauley SR, Wilde EA, Anderson VA, Bedell G, Beers SR, Campbell TF, Chapman SB, Ewing-Cobbs L, Gerring JP, Gioia GA, Levin HS, Michaud LJ, Prasad MR, Swaine BR, Turkstra LS, Wade SL, Yeates KO (2012) Recommendations for the use of common outcome measures in pediatric traumatic brain injury research. *Journal of Neurotrauma* 29(4), 678–705. doi:10.1089/neu.2011.1838
- McDonald S, Flanagan S, Rollins J, Kinch J (2003) TASIT: A new clinical tool for assessing social perception after traumatic brain injury. *The Journal of Head Trauma Rehabilitation* 18(3), 219–238. doi:10.1097/00001199-200305000-00001
- McKinlay A, Dalrymple-Alford JC, Horwood LJ, Fergusson DM (2002) Long term psychosocial outcomes after mild head injury in early childhood. *Journal of Neurology, Neurosurgery and Psychiatry* 73(3), 281–288. doi:10.1136/jnnp.73.3.281
- McKinlay A, McLellan T, Daffue C (2012) The invisible brain injury: The importance of identifying deficits following brain injury in children with intellectual disability. *NeuroRehabilitation* 30(3), 183–187. doi:10.3233/nre-2012-0743
- Mei C, Anderson V, Waugh MC, Cahill L, Morgan AT (2018) Evidence- and Consensus-Based Guidelines for the Management of Communication and Swallowing Disorders Following Pediatric Traumatic Brain Injury. *The Journal of Head Trauma Rehabilitation* 33(5), 326–341. doi:10.1097/htr.0000000000000366
- Merrell KW, Streeter AL, Boelter EW, Caldarella P, Gentry A (2001) Validity of the Home and Community Social Behavior Scales: Comparisons with five behavior-rating scales. *Psychology in the Schools* 38(4), 313–325. doi:10.1002/pits.1021
- Michie S, Johnston M, Abraham C, Lawton R, Parker D, Walker A (2005) Making psychological theory useful for implementing evidence based practice: A consensus approach. *BMJ Quality & Safety* 14(1), 26–33. doi:10.1136/qshc.2004.011155
- Morris C, Janssens A, Shilling V, Allard A, Fellowes A, Tomlinson R, Williams J, Thompson Coon J, Rogers M, Beresford B, Green C, Jenkinson C, Tennant A, Logan S (2015) Meaningful health outcomes for paediatric neurodisability: Stakeholder prioritisation and appropriateness of patient reported outcome measures. *Health and Quality of Life Outcomes* 13, 87. doi:10.1186/s12955-015-0284-7
- Neilson R (2003) 'Sutherland Phonological Awareness Test (Rev. ed.)'. (Language, Speech and Literacy Services)
- Nelson N, Plante E, Helm-Estabrooks N, Hotz G, Applegate E, Anderson M (2016). 'Test of Integrated Language and Literacy Skills (TILLS)'. (Paul H. Brookes Publishing Co., Inc.)
- Newcomer PL, Hammill DP (1997) 'Test of Language Development-Primary', 3rd edn. (PRO-ED: Austin, TX, USA)
- Nolan-Isles D, Macniven R, Hunter K, Gwynn J, Lincoln M, Moir R, Dimitropoulos Y, Taylor D, Agius T, Finlayson H, Martin R, Ward K, Tobin S, Gwynne K (2021) Enablers and Barriers to Accessing Healthcare Services for Aboriginal People in New South Wales, Australia. *International journal of environmental research and public health* 18(6), 3014. doi:10.3390/ijerph18063014
- Ontario Neurotrauma Foundation (2018) 'Guideline for Concussion/Mild Traumatic Brain Injury and Prolonged Symptoms: Healthcare professional version, adults (18+ years of age)', 3rd edn. Available at https://braininjuryguidelines.org/concussion/fileadmin/pdf/Concussion_guideline_3rd_edition_final.pdf
- Pankratz ME, Plante E, Vance R, Insalaco DM (2007) The Diagnostic and Predictive Validity of The Renfrew Bus Story. *Language, Speech, and Hearing Services in Schools* 38(4), 390–399. doi:10.1044/0161-1461(2007/040)
- Peterson AB, Sarmiento K, Xu L, Haileyesus T (2019) Traumatic brain injury-related hospitalizations and deaths among American Indians and Alaska natives - United States, 2008-2014. *Journal of Safety Research* 71, 315–318. doi:10.1016/j.jsr.2019.09.017
- Rappaport M, Hall KM, Hopkins K, Belleza T, Cope DN (1982) Disability rating scale for severe head trauma: Coma to community. *Archives of Physical Medicine and Rehabilitation* 63(3), 118–123.
- Rehfeld DM, Padgett RN (2019) Test Review: Comprehensive Assessment of Spoken Language—Second Edition. *Journal of Psychoeducational Assessment* 37(4), 524–529. doi:10.1177/0734282917753484
- Renfrew C (2010) 'The Renfrew Language Scales – Action Picture Test (Revised ed.)'. (Speechmark Publishing)
- Rosema S, Muscara F, Anderson V, Godfrey C, Hearsps S, Catroppa C (2015) The Trajectory of Long-Term Psychosocial Development 16 Years following Childhood Traumatic Brain Injury. *Journal of Neurotrauma* 32(13), 976–983. doi:10.1089/neu.2014.3567
- Ryan NP, van Bijnen L, Catroppa C, Beauchamp MH, Crossley L, Hearsps S, Anderson V (2016) Longitudinal outcome and recovery of social problems after pediatric traumatic brain injury (TBI): Contribution of brain insult and family environment. *International Journal of Developmental Neuroscience* 49, 23–30. doi:10.1016/j.ijdevneu.2015.12.004
- Ryan NP, Mihaljevic K, Beauchamp MH, Catroppa C, Crossley L, Hearsps S, Silk T, Godfrey C, Yeates KO, Anderson VA (2017) Examining the Prospective Relationship between Family Affective Responsiveness and Theory of Mind in Chronic Paediatric Traumatic Brain Injury. *Brain Impairment* 18(1), 88–101. doi:10.1017/BrImp.2016.20
- Safaz I, Alaca R, Yasar E, Tok F, Yilmaz B (2008) Medical complications, physical function and communication skills in patients with traumatic brain injury: A single centre 5-year experience. *Brain Injury* 22(10), 733–739. doi:10.1080/02699050802304714

- Seagly KS, O'Neil RL, Hanks RA (2018) Pre-injury psychosocial and demographic predictors of long-term functional outcomes post-TBI. *Brain Injury* 32(1), 78–83. doi:10.1080/02699052.2017.1374467
- Semel E, Wiig E, Secord W (2014) 'Clinical Evaluation of Language Fundamentals: Metalinguistics.' (Pearson)
- Semel E, Wiig E, Secord WA (2004) 'Clinical Evaluation of Language Fundamentals – Preschool – Second Edition.' (Pearson Assessment: London, UK).
- Shrubsole K, Worrall L, Power E, O'Connor DA (2019) Barriers and facilitators to meeting aphasia guideline recommendations: what factors influence speech pathologists' practice? *Disability and Rehabilitation* 41(13), 1596–1607. doi:10.1080/09638288.2018.1432706
- Silverberg ND, Otamendi T, Dulai A, Rai R, Chhina J, MacLellan A, Lizotte PP (2021) Barriers and facilitators to the management of mental health complications after mild traumatic brain injury. *Concussion* 6(3), Cnc92. doi:10.2217/cnc-2020-0022
- Snow PC (2019) Speech-Language Pathology and the Youth Offender: Epidemiological Overview and Roadmap for Future Speech-Language Pathology Research and Scope of Practice. *Language, Speech, and Hearing Services in Schools* 50(2), 324–339. doi:10.1044/2018_LSHSS-CCJS-18-0027
- Snowling M, Stothard S, Clarke P (2012) 'York Assessment of Reading for Comprehension (YARC) (Australian ed.)' (GL assessment)
- Sparrow S, Balla DA, Cicchetti DV (1984) 'Vineland Adaptive Behavior Scale.' (American Guidance Service)
- Stockbridge MD, Newman R (2019) Enduring Cognitive and Linguistic Deficits in Individuals With a History of Concussion. *American Journal of Speech Language Pathology* 28(4), 1554–1570. doi:10.1044/2019_ajslp-18-0196
- Tate RL (2014) Measuring outcomes using the international classification of functioning, disability and health (ICF) model, with special reference to participation and environmental factors. In 'Understanding traumatic brain injury: Current research and future directions'. (Eds H Levin, D Shum, R Chan) pp. 163–189. (Oxford University Press: Oxford, UK)
- Tate R, Hodgkinson A, Veerabangsa A, Maggioletto S 1996 Sydney Psychosocial Reintegration Scale (SPRS). APA PsycTests.
- Tavender EJ, Bosch M, Gruen RL, Green SE, Michie S, Brennan SE, Francis JJ, Ponsford JL, Knott JC, Meares S, Smyth T, O'Connor DA (2015) Developing a targeted, theory-informed implementation intervention using two theoretical frameworks to address health professional and organisational factors: A case study to improve the management of mild traumatic brain injury in the emergency department. *Implementation Science* 10(1), 74. doi:10.1186/s13012-015-0264-7
- Togher L, Wiseman-Hakes C, Douglas J, Stergiou-Kita M, Ponsford J, Teasell R, Bayley M, Turkstra LS (2014) INCOG recommendations for management of cognition following traumatic brain injury, part IV: Cognitive communication. *The Journal of Head Trauma Rehabilitation* 29(4), 353–368. doi:10.1097/htr.0000000000000071
- Tuerk C, Gagner C, Dégeilh F, Bellerose J, Lalonde G, Landry-Roy C, Séguin M, de Beaumont L, Gravel J, Bernier A, Beauchamp MH (2020) Quality of life 6 and 18 months after mild traumatic brain injury in early childhood: An exploratory study of the role of genetic, environmental, injury, and child factors. *Brain Research* 1748, 147061. doi:10.1016/j.brainres.2020.147061
- Turkstra LS, Politis AM, Forsyth R (2015) Cognitive-communication disorders in children with traumatic brain injury. *Developmental Medicine and Child Neurology* 57(3), 217–222. doi:10.1111/dmcn.12600
- Varni JW, Seid M, Rode CA (1999) The PedsQL: measurement model for the pediatric quality of life inventory. *Medical Care* 37(2), 126–139. doi:10.1097/00005650-199902000-00003
- Wallace SJ, Worrall L, Rose T, Le Dorze G, Cruice M, Isaksen J, Kong APH, Simmons-Mackie N, Scarinci N, Gauvreau CA (2017) Which outcomes are most important to people with aphasia and their families? An international nominal group technique study framed within the ICF. *Disability and Rehabilitation* 39(14), 1364–1379. doi:10.1080/09638288.2016.1194899
- Wallace SJ, Sullivan B, Rose TA, Worrall L, Le Dorze G, Shrubsole K (2021) Core Outcome Set Use in Poststroke Aphasia Treatment Research: Examining Barriers and Facilitators to Implementation Using the Theoretical Domains Framework. *Journal of Speech, Language and Hearing Research* 64(10), 3969–3982. doi:10.1044/2021_jslhr-20-00683
- Wang X, Cheng Z (2020) Cross-Sectional Studies: Strengths, Weaknesses, and Recommendations. *Chest* 158(1s), S65–S71. doi:10.1016/j.chest.2020.03.012
- Wiig E, Secord W (1989) 'Test of Language Competence. Expanded edition.' (Psychological Corporation)
- Williams KT (2019) 'Expressive Vocabulary Test', 3rd edn. (NCS Pearson)
- Williamson PR, Altman DG, Blazeby JM, Clarke M, Devane D, Gargon E, Tugwell P (2012) Developing core outcome sets for clinical trials: Issues to consider. *Trials* 13(1), 132. doi:10.1186/1745-6215-13-132
- Williamson PR, Altman DG, Bagley H, Barnes KL, Blazeby JM, Brookes ST, Clarke M, Gargon E, Gorst S, Harman N, Kirkham JJ, McNair A, Prinsen CAC, Schmitt J, Terwee CB, Young B (2017) The COMET Handbook: Version 1.0. *Trials* 18(Suppl 3), 280. doi:10.1186/s13063-017-1978-4
- Yeates KO, Taylor HG, Walz NC, Stancin T, Wade SL (2010) The family environment as a moderator of psychosocial outcomes following traumatic brain injury in young children. *Neuropsychology* 24(3), 345–356. doi:10.1037/a0018387
- Yeates KO, Taylor HG, Rusin J, Bangert B, Dietrich A, Nuss K, Wright M (2012) Premorbid child and family functioning as predictors of post-concussive symptoms in children with mild traumatic brain injuries. *International Journal of Developmental Neuroscience* 30(3), 231–237. doi:10.1016/j.ijdevneu.2011.05.008
- Ylvisaker M (1993) Communication outcome in children and adolescents with traumatic brain injury. *Neuropsychological Rehabilitation* 3(4), 367–387. doi:10.1080/09602019308401447
- Young L, Shrubsole K, Worrall L, Power E (2018) Factors that influence Australian speech-language pathologists' self-reported uptake of aphasia rehabilitation recommendations from clinical practice guidelines. *Aphasiology* 32(6), 646–665. doi:10.1080/02687038.2018.1443201
- Zimmerman IL, Steiner VG, Pond E (2011) 'Preschool Language Scales-Fifth Edition (PLS-5).' (Pearson)

Data availability. The data that support this study are available in the article and accompanying online supplementary material.

Conflicts of interest. The authors declare that they have no conflicts of interest.

Declaration of funding. Sarah Wallace is supported by a NHMRC Emerging Leadership Investigator Grant (1175821).

Ethics standard. The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008.

Author affiliations

^ASchool of Health and Rehabilitation Sciences, The University of Queensland, Brisbane, Australia.

^BQueensland Aphasia Research Centre, The University of Queensland, Brisbane, Australia.