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Review Article

Assessment and Treatment of Cognition and Communication Skills in Adults With Acquired Brain Injury via Telepractice: A Systematic Review

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Purpose: This is a systematic review of assessment and treatment of cognitive and communicative abilities of individuals with acquired brain injury via telepractice versus in person. The a priori clinical questions were informed by previous research that highlights the importance of considering any functional implications of outcomes, determining disorder- and setting-specific concerns, and measuring the potential impact of diagnostic accuracy and treatment efficacy data on interpretation of findings.
Method: A literature search of multiple databases (e.g., PubMed) was conducted using key words and study inclusion criteria associated with the clinical questions.
Results: Ten group studies were accepted that addressed assessment of motor speech, language, and cognitive impairments; assessment of motor speech and language activity limitations/participation restrictions; and treatment of cognitive impairments and activity limitations/participation restrictions. In most cases, equivalence of outcomes was noted across service delivery methods.
Conclusions: Limited findings, lack of diagnostic accuracy and treatment efficacy data, and heterogeneity of assessments and interventions precluded robust evaluation of clinical implications for telepractice equivalence and the broader area of telepractice efficacy. Future research is needed that will build upon current knowledge through replication. In addition, further evaluation at the impairment and activity limitation/participation restriction levels is needed.

Advances in medical technology that prolong and enhance life, coupled with rising health care costs, call for innovative, evidence-based, cost-effective management options for growing clinical populations, such as individuals with acquired brain injury (ABI). According to the Brain Injury Association of America (2012), more than 2 million new cases of ABI arise annually. ABI encompasses a number of medical conditions, including traumatic brain injury (TBI), stroke, brain tumor, and anoxia. The associated constellation of communication, cognitive, psychological, and behavioral deficits can be mild to severe and often necessitate multidisciplinary rehabilitation. Generally, speech-language pathologists (SLPs) are part of those service provider teams.

SLPs who treat individuals with cognitive and communication disorders are faced with service delivery challenges. In 2012, for example, 47% of school-based SLPs stated that job openings were more numerous than job seekers (American Speech-Language-Hearing Association [ASHA], 2012), and 24% of SLPs in home health agency settings or clients' homes reported funded, unfilled positions in 2013 (ASHA, 2013). Telepractice is a service delivery method that has been explored as an alternative approach to reducing the impact of the SLP shortage (Tucker, 2012) as well as addressing the service provision needs of patients who reside in remote areas or have limited access to services for other reasons (e.g., financial constraints, inadequate transportation; Hill & Theodoros, 2002; Mashima & Doarn, 2008; Theodoros, 2008; Tindall, 2012). *Telepractice* refers to "the application of telecommunications technology to the delivery of [SLP] and audiology professional services at a distance by linking clinician to client/patient, or clinician to clinician, for assessment, intervention, and/or consultation" (ASHA, n.d.). Much of

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today's telepractice technology (e.g., telephones, smartphones, videoconferencing equipment) can be categorized as synchronous, asynchronous, or a combination of both forms of online interaction. Synchronous telepractice is conducted in real time with an interactive audio and video connection that simulates an in-person experience, akin to a traditional face-to-face therapy interaction (ASHA, n.d.). Asynchronous telepractice uses "store-and-forward" software that captures and transmits images or other data for subsequent viewing or interpretation by professionals (ASHA, n.d).

A recent survey of audiologists and SLPs who reported telepractice as an area of expertise and resided in the United States, a United States territory, or Canada revealed that telepractice had been implemented in most states and U.S. territories as well as in 50 countries (e.g., France, Japan, Malaysia; ASHA, 2014). Furthermore, the types of settings (e.g., client's home, school, outpatient rehabilitation center), age groups, services provided (e.g., assessment, follow-up), and communication areas addressed (e.g., aural rehabilitation, literacy, cognitive communication disorders) were quite diverse (ASHA, 2014). Several of the barriers noted in the survey (e.g., lack of telepractice implementation standards, reimbursement issues) were consistent with the following barriers reported in a 2002 survey of telepractice use among SLPs: cost, lack of professional standards, insurance reimbursement policies, concern about malpractice liability, uncertainty about patient confidentiality, and licensure laws that affect interstate practice (ASHA, 2002).

Several reviews (e.g., Mashima & Doarn, 2008; Reynolds, Vick, & Haak, 2009; Rietdijk, Togher, & Power, 2012; Tindall, 2012) have been published on telepractice use to address a variety of communication disorders. Overall, equivalent assessment and intervention outcomes were revealed across telepractice and in-person service delivery methods. However, barriers to telepractice implementation continue to be reported, including the lack of data on telepractice efficacy and cost-effectiveness (Mashima & Doarn, 2008). Evaluation of telepractice efficacy is addressed in part by studies of assessment and intervention outcome equivalence across service delivery methods. Determination of the diagnostic accuracy of assessment tools and efficacy of interventions is also necessary and should occur prior to assessing cost-effectiveness (Fey & Finestack, 2009). *Diagnostic accuracy* is a measure of how well a diagnostic test detects the target condition or disorder (Whiting, Rutjes, Reitsma, Bossuyt, & Kleijnen, 2003) in comparison to a reference standard (i.e., a diagnostic tool previously determined acceptable for detecting and/or confirming a diagnosis). In treatment efficacy studies, outcomes from an intervention group are compared with those from a control group to determine the intervention's impact. Telepractice reviews completed thus far have primarily focused on equivalence of outcomes across service delivery methods. This may be due in part to the lack of telepractice studies that have used robust research designs such as randomized controlled trials (RCTs). This notion pertaining to research design was proposed in a recent review by Hall, Boisvert, and Steele (2013), who covered the impact of telepractice on assessment and intervention of aphasia. Though equivalence of assessment and intervention outcomes was noted across service delivery methods, diagnostic accuracy of assessments and treatment efficacy via telepractice for individuals with aphasia remained equivocal. Unquestionably, the accuracy of diagnostic tools and efficacy of interventions are critical to consider when interpreting findings in telepractice equivalence studies and reviews (Nelson & Palsbo, 2006) and ultimately for evaluating telepractice efficacy and cost-effectiveness.

Identification of disorder- and setting-specific considerations for telepractice implementation is also affected by treatment efficacy and diagnostic accuracy findings. The importance of identifying disorder- and setting-specific considerations has been noted in previous research. For example, school-based SLPs who provided services via telepractice reported an inability to foster carryover because they could not go into the child's classroom (Tucker, 2012). Another example is a review by Theodoros (2011) in which difficulty obtaining accurate recordings of sound pressure level pre– and post–voice therapy via telepractice was reported in multiple studies. These findings have implications for determining the ecological validity of assessment and intervention tools across service delivery methods (e.g., in person vs. telepractice) or from one clinical population to another. Although observations of patients' utilization of telepractice is one way to identify disorder- and setting-specific considerations, patient, caregiver, and/or service provider reports of satisfaction with service delivery and associated assessment and treatment outcomes provide additional information. Mair and Whitten (2000) reviewed the implications of reporting patient satisfaction findings. They encouraged future researchers to delineate reasons for satisfaction and dissatisfaction to facilitate further evaluation of telepractice acceptability and utility. In total, findings from previous telepractice reviews suggest that future syntheses should analyze findings in consideration of the disorder and service delivery setting (Reynolds et al., 2009). Furthermore, reporting satisfaction outcomes may inform that effort.

Telepractice is a promising service delivery method because its use has the potential to enhance the timing, frequency, and duration of neurorehabilitation services (Winters & Winters, 2004); support functional recovery and quality of care (McCue, Fairman, & Pramuka, 2010); and facilitate service provision in a less restrictive, natural environment (Torsney, 2003; Whitten, Doolittle, Mackert, & Rush, 2003). Together, these possibilities suggest that "telepractice has the capacity to optimize functional outcomes by facilitating generalization of treatment effects within the person's everyday environment" (Theodoros, 2008, p. 221). Those functional changes can be captured by the World Health Organization's (WHO, 2001) International Classification of Functioning, Disability, and Health (ICF) framework. The ICF can be applied to individuals with brain injury as a standardized mechanism for documenting the complexity of functioning (Scarponi, Sattin, Leonardi, Raggi, & Zampolini, 2009) as well as functional changes in everyday life at the individual and societal levels (Bilbao et al., 2003). Moreover, implementation of this standardized framework, which encourages the use of a shared language, has the potential to facilitate multidisciplinary rehabilitation efforts (Bilbao et al., 2003). The ICF has been used as a framework for describing functional use of target skills at the level of body structure and/or body function impairment (e.g., reduction in range of lip movement) and activity limitations/participation restrictions (e.g., difficulty learning a new task, difficulty making friends). In addition, it has been applied to characteristics in individuals with a variety of communication disorders that have been linked to ABI, such as acquired apraxia of speech (Wambaugh & Mauszycki, 2010), dysarthria (Dykstra, Hakel, & Adams, 2007), and aphasia (Simmons-Mackie & Kagan, 2007). Labeling assessment and treatment outcomes according to the ICF classification system may facilitate the creation of disorder- and setting-specific assessment and intervention frameworks.

Given that SLPs use telepractice to provide services to individuals with communication disorders associated with ABI and that previous research findings suggest the need for disorder- and setting-specific considerations for telepractice, an evidence-based systematic review (EBSR) of the impact of telepractice on cognitive and communication assessment and intervention outcomes of individuals with ABI is warranted. The need for more research on diagnostic accuracy and treatment efficacy in telepractice studies, recommendations for the continued collection of satisfaction outcomes, and the potential implications of applying the ICF classification system to assessment and intervention outcomes were considered in the formulation of the following clinical questions (CQs):

Assessment

CQ 1: For adults with ABI, what is the impact of telepractice versus in-person service delivery on SLP assessment of motor speech body function impairment?

CQ 2: For adults with ABI, what is the impact of telepractice versus in-person service delivery on SLP assessment of motor speech activity limitations/participation restrictions?

CQ 3: For adults with ABI, what is the impact of telepractice versus in-person service delivery on SLP assessment of language body function impairment?

CQ 4: For adults with ABI, what is the impact of telepractice versus in-person service delivery on SLP assessment of language activity limitations/participation restrictions?

CQ 5: For adults with ABI, what is the impact of telepractice versus in-person service delivery on SLP assessment of cognitive body function impairment?

CQ 6: For adults with ABI, what is the impact of telepractice versus in-person service delivery on SLP assessment of cognitive activity limitations/participation restrictions?

Intervention

CQ 7: For adults with ABI, what is the impact of telepractice versus in-person service delivery on SLP intervention for motor speech body function impairment?

CQ 8: For adults with ABI, what is the impact of telepractice versus in-person service delivery on SLP intervention for motor speech activity limitations/participation restrictions?

CQ 9: For adults with ABI, what is the impact of telepractice versus in-person service delivery on SLP intervention for language body function impairment?

CQ 10: For adults with ABI, what is the impact of telepractice versus in-person service delivery on SLP intervention for language activity limitations/participation restrictions?

CQ 11: For adults with ABI, what is the impact of telepractice versus in-person service delivery on SLP intervention for cognitive body function impairment?

CQ 12: For adults with ABI, what is the impact of telepractice versus in-person service delivery on SLP intervention for cognitive activity limitations/participation restrictions?

Method

Identification and Evaluation of Studies

To complete this EBSR, a multistep approach was taken: (a) identify peer-reviewed articles that address this EBSR's clinical questions, (b) evaluate the methodological rigor of accepted studies, (c) extract and label pertinent data from each accepted study, and (d) assess the findings in relation to the clinical questions. The systematic review development was closely aligned with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement framework, which provides guidance on how to improve the clarity and complete reporting of systematic reviews and meta-analyses (Liberati et al., 2009).

From April to August 2013, the third author conducted a search of 24 electronic databases (e.g., PubMed, PsycINFO, REHABDATA) using detailed search strings constructed from key words related to telepractice, acquired brain injury, assessment, and intervention (see the Supplemental Appendix for a complete list of databases, key words, and search strategy). The first and second authors independently scanned and evaluated the titles, abstracts, and full texts of all potential articles using the study inclusion and exclusion criteria outlined below. Additional studies, which were identified through reference checking of full-text articles and prolific author searches, were also independently evaluated. All references were documented and stored using a bibliographic citation manager. Disagreements about study inclusion and exclusion were discussed and resolved through consensus, with final vetting completed by at least two authors.

The first and second authors also independently assessed each accepted study for methodological rigor. All studies were included in the EBSR regardless of quality. Study quality of accepted group studies was determined using ASHA's critical appraisal scheme (Cherney, Patterson, Raymer, Frymark, & Schooling, 2008; Mullen, 2007), which is described in Supplemental Materials Table S1. The Single-Case Experimental Design (SCED) scale (Tate et al., 2008) was selected to evaluate accepted single-case design studies; a description of each rating scale item is available in Tate et al. (2008). Disagreements in methodological quality ratings were reviewed and discussed by the first and second authors, with the final appraisal rating reached by consensus on the basis of the presence or absence of any supporting evidence in the associated journal article.

Study Inclusion Criteria

Included studies examined the impact of telepractice on assessment and intervention of cognitive and communication outcomes of individuals 16 years or older with a history of ABI. A clinician, such as an SLP, had to provide the assessment or intervention in the in-person condition and via telepractice. Participants were considered to have sustained an ABI if they were labeled as such in the article or diagnosed with a condition resulting from trauma to the brain, such as TBI or nontraumatic brain injury (e.g., stroke). Studies that included participants with neurodegenerative disorders (e.g., dementia) or head and neck cancer were not accepted unless more than half of participants had an ABI. Furthermore, studies had to contain original research (e.g., systematic reviews were excluded), be peer reviewed, be quasi-experimental or experimental, and have been published in English sometime from 1980 to the present. In consideration of the clinical questions, only group and single-case design studies that included a comparison of assessment and/or treatment outcomes across both telepractice and in-person service delivery methods were included.

Data Extraction and Outcomes Classification

The primary outcomes of interest were assessment and treatment equivalence outcomes in the form of statistics used to reflect differences in test scores or interrater reliability ratings. Equivalence of outcomes was indicated when there was no statistically significant difference (i.e., p value > .05 or the effect size interval contained the null effect, $d = 0$) between assessment or treatment outcomes obtained in person versus via telepractice. For interrater reliability ratings, outcomes were labeled as equivalent if percent exact agreement was at or above 70% or if kappa was at the level of moderate agreement or higher (see Landis and Koch's [1977] scale for interpreting kappa herein). In addition, any information pertaining to reliability, validity, or diagnostic accuracy of assessments and treatment efficacy of interventions was extracted from studies to facilitate interpretation of equivalence outcomes. Diagnostic accuracy was noted if the following statistics were reported or calculable: sensitivity and specificity, positive and negative predictive values, positive and negative likelihood ratios, and area under receiver operating characteristic curves. Treatment efficacy was recorded if it was reported or if data were provided from which it could be calculated. For single-case design studies, treatment efficacy could be evaluated if a control mechanism was integrated that allowed comparison of outcomes from an in-person and a telepractice condition (e.g., alternating treatment design with a nontreatment baseline). Determination of treatment efficacy for group designs required that target outcomes from a no-treatment (or wait-listed) control group be compared with those same outcomes from the treatment group via the same service delivery method. Therefore, the determination of treatment efficacy in the in-person condition was separate from the determination of treatment efficacy in the telepractice condition. Furthermore, a significant difference between the control group and treatment group outcomes in favor of the treatment group indicated treatment efficacy.

Assessment and intervention outcomes were from standardized and nonstandardized measures of motor speech (i.e., dysarthria, apraxia), language (i.e., listening, speaking, reading, writing), or cognitive ability (e.g., memory, attention, processing speed, problem solving). Data from screening tools were excluded. Reports of patient satisfaction with the service delivery methods and associated assessment and intervention outcomes were also recorded. In addition, key telepractice (e.g., hardware, software, bandwidth, type of telepractice [e.g., synchronous]), participant (e.g., age, gender, diagnostic characteristics), study design (e.g., randomized controlled trial), and service delivery (e.g., type, frequency, duration, setting) data were extracted from each study, and the main findings were summarized.

Using the ICF's classification categories, outcomes were labeled as impairments if they related to a body structure or body function (e.g., misarticulation of phonemes [motor speech], inability to organize grammatical structures in a sentence [language] or difficulty thinking abstractly [cognition]) or as activity limitations/participation restrictions for observations of participants' completion of daily living tasks, for participant or caregiver reports of ability to complete daily living tasks, or if the outcomes pertained to involvement in life situations. The first and second authors independently labeled outcomes according to the ICF classification labels. Subsequently, they jointly reviewed their ratings and used consensus to resolve any discrepancies.

Statistical Analysis

For group studies, statistical significance and effect sizes were reported if included in a study or calculated if applicable raw data were provided. When effect sizes were not reported in within-group or repeated measures design studies, they were computed only when applicable raw data were available and when the correlation (i.e., r) between groups was provided or calculable. The calculated effect size metric was Cohen's *d*. For the purpose of assigning descriptive labels to Cohen's *d* effect sizes reported in this EBSR, the following modified version of Cohen's classification of effect size magnitude was used: small = 0.34 or less, medium = 0.35–0.64, large = 0.65 or greater.

Interrater Reliability

Cohen's kappa and/or percent agreement were used to calculate the interrater reliability of the first and second authors, who completed the sifting of abstracts and full-text articles as well as the critical appraisal process. Percent agreement was reported when sufficient data were not available to accurately calculate kappa or when the kappa value was zero but the percent agreement was high. Landis and Koch's (1977) scale for interpreting kappa was used to categorize the strength of the agreement: poor agreement (<.00), slight agreement (.00–.20), fair agreement (.21–.40), moderate agreement (.41–.60), substantial agreement (.61–.80), and almost perfect agreement (.81–1.00).

Abstracts and full-text articles were independently coded for their pertinence to one or more of the clinical questions in this EBSR. The authors' ratings were entered into Analyse-it (Analyse-it Software, 2009), a statistical software program that created a 2 × 2 contingency table from which kappa was generated. Interrater reliability for article selection was substantial (κ = .72). The same process was undertaken for determining interrater reliability for each critical appraisal item across each of the accepted studies. Weighted kappa was used for items that had more than two hierarchically ranked items. A notable imbalance in the marginal totals in the kappa tables for critical appraisal points precluded calculation of kappa; therefore, percent agreement—that is, (total agreements / [total agreements + total disagreements]) × 100, was reported instead. This issue was described by Feinstein and Cicchetti (1990) as a paradox in which a high observed agreement is converted into a relatively low kappa value. Interrater reliability for study appraisals ranged from 64%–100%. Most ratings were 82% or higher; only the critical appraisal point pertaining to treatment effect precision (i.e., effect size and its confidence interval) fell below 70%.

Results

The systematic search yielded 218 citations; of those, 208 were rejected after a review of the abstract or full text. Therefore, 10 studies (*k* = 8 assessment studies; *k* = 2 intervention studies) were accepted for this EBSR. Specifically, assessment of impairment studies were identified for motor speech (*k* = 4), language (*k* = 3), and cognition (*k* = 2), whereas assessment of activity limitations/participation restrictions studies were located for motor speech (*k* = 1) and language (*k* = 2). Intervention studies addressed cognition impairment (*k* = 2) and cognition activity limitations/participation restrictions (*k* = 1). None of the single case studies reviewed were accepted because they did not include a comparison of target outcomes from an in-person and a telepractice condition. Other reasons for study exclusion include the following: no outcomes of interest were reported (*k* = 71; e.g., comparison of hospital-stay length), not an applicable telepractice study (*k* = 45; e.g., comparison of two telepractice conditions, such as videoconferencing and telephone; a clinical service provider did not administer the assessment or intervention), not a study design of interest (*k* = 30; e.g., case study), not the population of interest (*k* = 20; e.g., adults diagnosed with mental illness), and results were reported in a previously accepted study (*k* = 1). A full list of excluded studies and reasons for exclusion are available upon request.

RCTs were used in all studies except Theodoros, Russell, Hill, Cahill, and Clark (2003), who used a nonrandomized, quasi-experimental crossover design. Crossover design was also integrated into RCTs conducted by Georgeadis, Brennan, Barker, and Baron (2004) and Turkstra, Quinn-Padron, Johnson, Workinger, and Antoniotti (2012); all other RCTs were parallel-group designs. Moreover, most group studies included an adequate description of the study protocol and reported the *p* value. Substantial variability was noted for blinding of assessors and sampling allocation. Most studies did not report equivalence of groups at pretest or the use of intention-to-treat analysis. See Table 1 for more information about group study critical appraisal findings.

Participant Characteristics

A total of 272 participants (*n* = 201 assessment study participants; *n* = 71 intervention study participants), 16–90 years old, were included in the accepted studies. Participants had ABIs (most often TBI or stroke) of varying severity levels. Time postonset of ABI ranged from 1 month to 29 years. Only one study included a mixture of participants with ABI and other medical diagnoses (Hill, Theodoros, Russell, & Ward, 2009a), with the majority of participants in that study having been diagnosed with ABI. Few studies reported ethnic background (*k* = 2; e.g., Asian, White, Native American), primary language spoken (*k* = 3; i.e., Chinese and English), or handedness (*k* = 1; i.e., right-handed). See Tables 2–5 for more details about participant characteristics.

Telepractice Technology

For the bulk of assessment and intervention studies, either synchronous videoconferencing or combined synchronous and asynchronous videoconferencing was the telepractice method implemented. In Smith, Illig, Fielder, Hamilton, and Ottenbacher (1996), a telephone was used. Furthermore, in five assessment studies (Georgeadis et al., 2004; Hill et al., 2009a; Hill, Theodoros, Russell, & Ward, 2009b; Palsbo, 2007; Theodoros, Hill, Russell, Ward, & Wootton, 2008), the assessments were scored simultaneously by two clinicians, one via videoconferencing and the other in person. Assessments were presented serially (i.e., one service delivery method per assessment session) in the remaining telepractice studies by using videoconferencing. In most

Table 1. Critical appraisal of group design study quality.

Citation	Study design	Adequate description of study protocol	Assessors blinded	Sampling allocation	Randomization/ counterbalancing	Equivalence of participants/groups at pretest	Treatment fidelity	*p* reported or calculable	ES and/or CI reported or calculable	Analyzed by ITT
Georgeadis et al. (2004)	RCT crossover	Yes	No	NS	Yes	No	N/A	Yes	Yes	No
Hill et al. (2009a)	RCT	Yes	Yes	NS	Yes	No	N/A	Yes	No	NS
Hill et al. (2009b)	RCT	Yes	Yes	NS	Yes	No	N/A	Yes	No	NS
Man et al. (2006)	RCT	Yes	Yes	Random	Yes	Yes	No	Yes	Yes	No
Palsbo (2007)	RCT	Yes	NS	Conv	Yes	No	N/A	No	No	NS
Riegler et al. (2013)	RCT	Yes	NS	Conv	NS	No	No	Yes	Yes	NS
Smith et al. (1996)	RCT	Yes	NS	Random	Yes	No	N/A	Yes	Yes	NS
Theodoros et al. (2008)	RCT	Yes	Yes	Conv	Yes	No	N/A	Yes	No	NS
Theodoros et al. (2003)	CT crossover	Yes	NS	NS	NS	No	N/A	Yes	No	N/A
Turkstra et al. (2012)	RCT crossover	Yes	NS	Conv	Yes	No	N/A	Yes	No	NS

Note. ES = effect size; CI = confidence interval; ITT = intention-to-treat; RCT = randomized controlled trial; CT = controlled trial; NS = not stated; N/A = not applicable; Conv = convenience sampling.

Table 2. Motor speech assessment studies.

Citation	Participant characteristics	Telepractice technology and procedures	Assessment presentation	Equivalence of assessment outcomes: ICF category	Outcome	Interrater scoring reliability	Test score differences
Hill et al. (2009a)	15 males and 9 females, 16–78 years old (M = 50.2 years), with CVA, TBI, progressive neurological impairment, or brain tumor and stable dysarthria and mild apraxia of speech[a] ABI TPO: 6 months–11 years	Videoconference (AS) Assessments were administered in real time. Data-sharing capabilities were made possible by custom-built, store-and-forward software integrated into the computers, which had web cameras (Logitech, Pro4000) that captured high-resolution video (680 × 480 pixels) and high-quality audio.	Simultaneous	I	Perceptual Rating Scale: Intelligibility while reading	κ = .59, SE = .18	
				I	Perceptual Rating Scale: Articulatory imprecision	κ = .68, SE = .10	
				I	ASSIDS: Sentence intelligibility	PA = 95.83% ± 8.6%	p = .17
				I	ASSIDS: Communication efficiency ratio:	PA = 95.83% ± 0.27%	p = .05
				I	Oromotor Rating Scales: Diadochokinetic rates	κ = .95, SE = .03	
Hill et al. (2009b)	8 males and 3 females, 16–78 years old (M = 50.2 years), with CVA or TBI and mild to moderate aphasia, mild to moderate dysarthria, and/or apraxia ABI TPO: 42.6 months, on average	Videoconference (AS) Assessments were conducted in real time with the support of custom-built, store-and-forward software that met Microsoft NetMeeting security guidelines and was integrated into computers with high-resolution video (320 × 240 pixels; 680 × 480 pixels). Images and high-quality audio were captured with web cameras (Logitech, Pro4000) that had accompanying remote controls. Other features included touch screen facilities and data-sharing capabilities that were provided over a 128-kbit/s Internet connection.	Simultaneous	I	ABA-2: Diadochokinetic Rate	Raw score: κ = .97, SE = .30 Severity level: κ = .83, SE = .27	p = .25
				I	ABA-2: Increasing Word Length	Raw score: κ = .73, SE = .27 Severity level: κ = .68, SE = .24	p = .06
				I	ABA-2: Oral Apraxia	Raw score: κ = .84, SE = .29 Severity level: κ = .77, SE = .28	p = .52
				I	ABA-2: Utterance Time for Polysyllabic Words	Raw score: κ = .59, SE = .26 Severity level: κ = 1.00, SE = .30	p = .12
				I	ABA-2: Inventory of Articulation Characteristics of Apraxia	Raw score: κ = .66, SE = .29 Severity level: κ = N/A, SE = N/A	

(*table continues*)

Table 2 *(Continued).*

Citation	Participant characteristics	Telepractice technology and procedures	Assessment presentation	Equivalence of assessment outcomes: ICF category	Outcome	Interrater scoring reliability	Test score differences
Palsbo (2007)	18 men and 6 women, 25–81 years old (*Mdn* = 64 years old), of American Indian, Black, White, or unknown descent who sustained a stroke ABI TPO: 2 months–15 years	Videoconference (S) The videoconferencing equipment (Soundstation, Polycom) had a transmission speed of 384 kbit/s.	Simultaneous	A/P A/P	FCM: Motor Speech (T) FCM: Motor Speech (in person)	PEA = 67% PEA = 25%	
Theodoros et al. (2008)	22 men and 10 women, 21–80 years old (*M* = 58.13 years old), with CVA or TBI and mild to severe aphasia ABI TPO: 1 month–10 years	Videoconference (AS) Assessments were conducted in real time via computer over a 128-kbit/s Internet connection using an application that met Microsoft NetMeeting security guidelines. One of two cameras was used to provide the 320 × 240 pixel videoconference link. Custom-built store-and-forward software, which was integrated into the computers, was used to house and transfer high-resolution video clips (680 × 480 pixels) captured with a remote-controlled web camera (Logitech, Pro4000) and high-quality audio recorded with participants' headset microphones. Participants wore earphones to hear instructions and used a touch screen to record manual responses to assessment items.	Simultaneous	I	Rating scale: Articulatory agility	κ = .81, *SE* = .05	

(*table continues*)

Table 2 *(Continued).*

Citation	Participant characteristics	Telepractice technology and procedures	Assessment presentation	Equivalence of assessment outcomes: ICF category	Outcome	Interrater scoring reliability	Test score differences
Theodoros et al. (2003)	10 participants, 20–70 years old, with ABI and dysarthria ABI TPO: NR	Videoconference (AS) Assessments were administered via the Internet at 128 kbit/s in real time using a customized graphical user interface that used Microsoft NetMeeting software. An offline video-recording module compressed video data (WMV, Version 9, Microsoft) at 250 kbit/s and audio data (WMA, Microsoft) at 70 kbit/s. Those data were then stored and forwarded to the clinician's computer. Participants wore headset microphones to record their speech and were able to view printed materials in the chat feature of Microsoft NetMeeting.	Serial	I	Dysarthria 7-point rating scale	PA = 90%	
				I	ASSIDS: Word intelligibility		*p* = .03
				I	ASSIDS: Sentence intelligibility		*p* = .39
				I	ASSIDS: Words per minute		*p* = .80
				I	ASSIDS: Communication efficiency ratio		*P* = .65

Note. ICF = *International Classification of Functioning, Disability, and Health* (World Health Organization, 2001); CVA = cerebrovascular accident; TBI = traumatic brain injury; AS = combined asynchronous and synchronous telepractice technology; I = body function impairment; ABI = acquired brain injury; TPO = time postonset; *SE* = standard error; ASSIDS = Assessment of Intelligibility of Dysarthric Speech (Yorkston & Beukelman, 1981); PA = percent agreement; ABA-2 = Apraxia Battery for Adults–Second Edition (Dabul, 2000); N/A = not applicable; S = synchronous telepractice technology; A/P = activity limitation/participation restriction; FCM = Functional Communication Measure; T = telepractice condition; PEA = percent exact agreement; NR = not reported; WMA = Windows Media Audio; WMV = Windows Media Video.

[a]Only one participant had concomitant mild apraxia of speech.

Table 3. Language assessment studies.

				Equivalence of assessment outcomes			
Citation	**Participant characteristics**	**Telepractice technology and procedures**	**Assessment presentation**	**ICF category**	**Outcome**	**Interrater scoring reliability**	**Test score differences**
Georgeadis et al. (2004)	23 men and 17 women, 18–70 years old (*M* = 43.4 years old), with TBI, LCVA, or RCVA and a range of cognitive–communicative, language, and/or speech impairments of varying severity levels ABI TPO: < 1 year	Videoconference (S) Using Microsoft NetMeeting, clinicians and participants videoconferenced with full-duplex (i.e., at least two people can speak and listen to each other simultaneously) audio and video using a 1,000-kbit/s bandwidth LAN connection. Assessment materials were .wav files in PCM format (22.050 kHz, 16 bit, mono) transmitted at 43 kbit/s. As the stories played, scanned versions of associated drawings were displayed alongside them in a video window. Training data were saved as .wav files in PCM format (11.025 kHz, 8 bit, mono) at 10 kbit/s.	Simultaneous	I	Story retell procedure: All participants		*d* = 0.16 [–4.36, 4.25], *p* = .49
				I	Story retell procedure: TBI		*d* = –0.56 [–6.79, 5.00], *p* = 0.21
				I	Story retell procedure: LCVA		*d* = 0 [–7.04, 6.94], *p* = .99
				I	Story retell procedure: RCVA		*d* = 0.77 [–6.95, 8.10], *p* = .06
Palsbo (2007)	18 men and 6 women, 25–81 years old (*Mdn* = 64 years), of American Indian, Black, White, or unknown descent who suffered a stroke ABI TPO: 2 months–15 years	Videoconference (S) The videoconferencing equipment (Soundstation, Polycom) had a transmission speed of 384 kbit/s.	Simultaneous	A/P	FCM: Spoken Language Comprehension[a] (T)	PEA = 50%	
				A/P	FCM: Spoken Language Comprehension[a] (in person)	PEA = 8%	
				A/P	FCM: Spoken Language Expression[a] (T)	PEA = 50%	
				A/P	FCM: Spoken Language Expression[a] (in person)	PEA = 25%	
Smith et al. (1996)	22 men and 18 women, 37–90 years old (*M* = 67.4 years), with CVA and hemiparesis ABI TPO: NR	Telephone[b]	Serial	A/P	FIM: Communication subscale–Comprehension	κ = .48	
				A/P	FIM: Communication subscale–Expression	κ = .81	
				A/P	FIM: Social Cognition subscale–Social Interaction	κ = .13	

(*table continues*)

Table 3 *(Continued).*

Citation	Participant characteristics	Telepractice technology and procedures	Assessment presentation	Equivalence of assessment outcomes: ICF category	Outcome	Interrater scoring reliability	Test score differences
Theodoros et al. (2008)	22 men and 10 women, 21–80 years old (*M* = 58.13 years), with CVA or TBI and mild to severe aphasia ABI TPO: 1 month–10 years	Videoconference (AS) Assessments were conducted in real time via computer over a 128-kbit/s Internet connection using an application that met Microsoft NetMeeting security guidelines. One of two cameras was used to provide the 320 × 240 pixel videoconference link. Custom-built store-and-forward software, which was integrated into the computers, was used to house and transfer high-resolution video clips (680 × 480 pixels) captured with a remote-controlled web camera (Logitech, Pro4000) and high-quality audio recorded with participants' headset microphones. Participants wore earphones to hear instructions and used a touch screen to record manual responses to assessment items.	Simultaneous	I	BDAE-3: Subtest scores	κ = .59–1.00, *SE* = 0–.25	*p*s = .04–1.00
				I	BNT	κ = .99, *SE* = .004	*p* = .20
				I	Rating scale: Phrase length	κ = .95, *SE* = .01	
				I	Rating scale: Grammatical form	κ = .78, *SE* = .08	
				I	Rating scale: Paraphasia in speech	κ = .75, *SE* = .08	
				I	Rating scale: Word finding & fluency	κ = .81, *SE* = .07	
				I	Rating scale: Auditory comprehension	κ = .95, *SE* = .01	
				I	Rating scale: Severity	κ = .80, *SE* = .05	

(*table continues*)

Table 3 *(Continued).*

				Equivalence of assessment outcomes			
Citation	Participant characteristics	Telepractice technology and procedures	Assessment presentation	ICF category	Outcome	Interrater scoring reliability	Test score differences
Turkstra et al. (2012)	13 men and 7 women, all English speakers, 21–69 years old, White, with moderate–severe TBI ABI TPO: 1.4–29.0 years	Videoconference (S) Using a software-only codec on a standard medical-issue computer, clinicians videoconferenced with participants over broadband (512 kbit/s). Participants assessed at the rehabilitation clinic used a Polycom 7000s that was run on 10/100 IT infrastructure in an H.323 environment on a VCON Vigo™ clinical workstation. Participants tested in the laboratory used two Macintosh PowerBooks that ran iChat and iSight on a 10,000-kbit/s network infrastructure with H.264 encoding; the video ran up to 900 kbit/s and had a frame size up to 640 × 480 pixels. For both participants and clinicians, the network ran QoS at full duplex (i.e., at least two people can speak and listen to each other simultaneously) using the following preferences: Voice No. 1, Video No. 2, and Data No. 3.	Serial	I	MDEP/AB: Conversation		
				I	C-units		$p = .08$
				I	Type–token ratio		$p = .17$
				I	Mazes		$p = .17$
				I	Clinician words		$p = .17$
				I	MDEP/AB: Story generation		
				I	C-units		$p = 1.00$
				I	Type–token ratio		$p = 1.00$
				I	Mazes		$p = 1.00$
				I	Clinician words		$p = .83$
				I	MDEP/AB: Picture description		
				I	C-units		$p = .79$
				I	Type–token ratio		$p = .79$
				I	Mazes		$p = .79$
				I	Clinician words		$p = .79$
				I	MDEP/AB: Procedural description		
				I	C-units		$p = 1.00$
				I	Type–token ratio		$p = 1.00$
				I	Mazes		$p = 1.00$
				I	Clinician words		$p = 1.00$

Note. ICF = *International Classification of Functioning, Disability, and Health* (World Health Organization, 2001); TBI = traumatic brain injury; LCVA = left-hemisphere cerebrovascular accident; RCVA = right-hemisphere cerebrovascular accident; ABI = acquired brain injury; TPO = time postonset; S = synchronous telepractice technology; I = body function impairment; A/P = activity limitation/participation restriction; FCM = Functional Communication Measure; T = telepractice condition; PEA = percent exact agreement; CVA = cerebrovascular accident; NR = not reported; FIM = Functional Independence Measure (Keith, Granger, Hamilton, & Sherwin, 1987); AS = combined asynchronous and synchronous telepractice technology; BDAE-3 = Boston Diagnostic Aphasia Examination–Third Edition (Goodglass, Kaplan, & Barresi, 2001); *SE* = standard error; BNT = Boston Naming Test (Kaplan, Goodglass, & Weintraub, 2001); MDEP/AB = Mediated Discourse Elicitation Protocol (Hengst & Duff, 2007)/AphasiaBank (MacWhinney, Fromm, Forbes, & Holland, 2011); PCM = pulse-code modulation; LAN = local area network; QoS = quality of service.

[a]The authors referred to *spoken language comprehension* as *speech comprehension* and *spoken language expression* as *speech expression;* the titles were changed to reflect the titles used in the outcome measure (i.e., American Speech-Language-Hearing Association's FCMs). [b]Use of a telephone only as a telepractice modality is not considered to be synchronous or asynchronous telepractice.

Table 4. Cognitive assessment studies.

Citation	Participant characteristics	Telepractice technology and procedures	Assessment presentation	Equivalence of assessment outcomes: ICF category	Outcome	Interrater scoring reliability	Test score differences
Smith et al. (1996)	22 men and 18 women, 37–90 years old (*M* = 67.4 years), with CVA and hemiparesis ABI TPO: NR	Telephone[a]	Serial	I	FIM: Social Cognition subscale–Problem Solving	κ = not calculable	
				I	FIM: Social Cognition subscale–Memory	κ = not calculable	
Turkstra et al. (2012)	13 men and 7 women, all English speakers, 21–69 years old, White, with moderate–severe TBI ABI TPO: 1.4–29.0 years	Videoconference (S) Using a software-only codec on a standard medical issue computer, clinicians videoconferenced with participants over broadband (512 kbit/s). Participants assessed at the rehabilitation clinic used a Polycom 7000s that was run on 10/100 IT infrastructure in an H.323 environment on a VCON Vigo™ clinical workstation. Participants tested in the laboratory used two Macintosh PowerBooks that ran iChat and iSight on a 10,000-kbit/s network infrastructure with H.264 encoding; the video ran up to 900 kbit/s and had a frame size up to 640 × 480 pixels. For both participants and clinicians, the network ran QoS at full duplex (i.e., at least two people can speak and listen to each other simultaneously) using the following preferences: Voice No. 1, Video No. 2, and Data No. 3.	Serial	I	RBANS		*p* = .77[b]

Note. *ICF* = *International Classification of Functioning, Disability, and Health* (World Health Organization, 2001); CVA = cerebrovascular accident; ABI = acquired brain injury; TPO = time postonset; NR = not reported; I = body function impairment; FIM = Functional Independence Measure; TBI = traumatic brain injury; S = synchronous telepractice technology; RBANS = Repeatable Battery for the Assessment of Neuropsychological Status (Randolph, 2001).

[a]Use of a telephone only as a telepractice modality is not considered to be synchronous or asynchronous telepractice. [b]The nonstatistical difference between participant groups is based on a comparison of combined pretest and posttest scores.

Table 5. Cognitive intervention studies.

Citation	Participant characteristics	Telepractice technology and procedures	Intervention(s) by setting	Intervention dosage and duration	Equivalence of intervention outcomes: ICF category	Outcome	Test score differences
Man et al. (2006)	59 participants ($M_{\text{Age-OCRG}}$ = 44.87 years; $M_{\text{Age-TCRG}}$ = 44.24 years) of Chinese descent with mildly impaired higher cognitive functions ABI TPO: M_{OCRG} = 5.15 years; M_{TCRG} = 3.48 years	Videoconference (S) In an online, interactive computer-based program (i.e., OCRG), data sharing features of Microsoft NetMeeting software were used to exchange video images (Polycom VidaVideo web camera) and audio via broadband.	Analogical problem solving skills training approach: OCRG (T) vs. TCRG (in person)	45 min/session 20 sessions 2 months	I I I A/P A/P A/P A/P I	PSSC: Convergence PSSC: Divergence PSSC: Comparison PSSC: Basic Skills PSSC: Functional Skills PSSC: Overall LIADL CTA	*d* = –0.15 [–0.68, 0.38] *d* = –0.21 [–0.74, 0.33] *d* = –0.22 [–0.74, 0.32] *d* = –0.21 [–0.74, 0.33] *d* = –0.24 [–0.77, 0.29] *d* = –0.25 [–0.78, 0.29] *d* = –0.43 [–0.96, 0.11] *d* = 0 [–0.53, 0.53]
Riegler et al. (2013)	12 English-speaking[a] participants ($M_{\text{Age–MOPS-VI}}$ = 30.17 years; $M_{\text{Age-CG}}$ = 30.67 years) with mild TBI and attention and memory impairments ABI TPO: NR	Videoconference (S) A laptop computer, wireless Internet, and TeleVyou 500SP videophone, which used plain old telephone service, were used weekly to simulate face-to-face therapy. Plain old telephone service was used because it met Veterans Administration encryption requirements.	MOPS-VI (T) vs. CG[b] (in person)	60 min/module 1 module/week for 6 weeks 3–5 months	I I	TOMAL-2: Posttreatment TOMAL-2: Setting × Pre- Versus Post-Assessment Interaction	*d* = 0.36, *p* = .55 *d* = 1.07, *p* = .09

Note. *ICF = International Classification of Functioning, Disability, and Health* (World Health Organization, 2001); OCRG = online interactive computer-assisted skill-training program; TCRG = therapist-administered training program; ABI = acquired brain injury; TPO = time postonset; S = synchronous telepractice technology; T = telepractice condition; I = body function impairment; PSSC = problem-solving skills categories; A/P = activity limitation/participation restriction; LIADL = Lawton Instrumental Activities of Daily Living Scale (Lawton & Brody, 1969); CTA = Category Test for Adults; TBI = traumatic brain injury; MOPS-VI = Military Online Problem Solving Videophone Intervention; CG = control group; NR = not reported; TOMAL-2 = Test of Memory and Learning–2nd Edition (Reynolds & Voress, 2007).

[a]The primary language spoken was reported only for participants in the treatment group. [b]The participants in the control group received the same treatment as those in the treatment group.

cases in which videoconferencing was implemented, the following components were included: Microsoft NetMeeting; video camera; high-resolution video (e.g., 680 × 480 pixels); high-quality audio; computers for the participant and clinician; and software for capturing, compressing, storing, and, in some cases, forwarding data. Great variability was noted in the bandwidth (128 kbit/s vs. 1,000 kbits/s) and video and audio capture rates (70 kbit/s vs. 250 kbit/s). See Tables 2–5 for more details about the features of the telepractice technologies used.

Motor Speech Outcomes

Three studies (Hill et al., 2009a, 2009b; Theodoros et al., 2003) addressed CQ1 (i.e., impact of assessment via telepractice vs. in person on motor speech impairment) and one study (Palsbo, 2007) provided findings for CQ2 (i.e., impact of assessment via telepractice vs. in person on motor speech activity limitations/participation restrictions). In assessment studies of motor speech impairment (Hill et al., 2009b) and motor speech activity limitations/participation restrictions (Palsbo, 2007), assessment measures had their psychometric properties evaluated in person; no specific information was provided about the diagnostic accuracy of any assessment tools when used in the telepractice context. Equivalence of assessment outcomes was indicated by interrater reliability scores for motor speech impairment findings in the form of kappa values, which ranged from moderate (κ = .59) to perfect agreement (κ = 1.00; Hill et al., 2009a, 2009b) and percent agreement (Hill et al., 2009a: 95.83%; Theodoros et al., 2003: 90%). These findings were supported by the lack of statistically significant differences between comparisons of test scores across service delivery methods (Hill et al., 2009a, 2009b; Theodoros et al., 2003), with the exception of the communication efficiency ratio finding in Hill et al. (2009a), which displayed a trend toward significance (i.e., p = .05) and the statistically significant difference for the percentage word intelligibility finding in Theodoros et al. (2003). In regard to motor speech activity limitations/participation restrictions, interrater scoring reliability was higher for telepractice (67%) than in person (25%; Palsbo, 2007), which does not support equivalence of assessment outcomes. No intervention studies were located that reported motor speech impairment (i.e., CQ7) or motor speech activity limitations/participation restrictions (CQ8) findings. See Table 2 for more information about motor speech findings.

Language Outcomes

Assessment studies of language impairment (CQ3: Georgeadis et al., 2004; Theodoros et al., 2008; Turkstra et al., 2012) and language activity limitations/participation restrictions (CQ4: Palsbo, 2007; Smith et al., 1996) were identified. No studies reported information about the diagnostic accuracy of the assessments administered. The metric (i.e., Percent Information Unit; McNeil, Doyle, Fossett, Park, & Goda, 2001) used in Georgeadis et al. (2004) was previously found to be a reliable and valid method for measuring comprehension and production of spoken narrative discourse. With regard to assessment outcomes equivalence, interrater reliability ratings related to language impairment findings ranged from fair agreement (e.g., κ = .40) to perfect agreement (κ = 1.00; Theodoros et al., 2008). Furthermore, no significant differences were noted between assessment scores for language impairment (Georgeadis et al., 2004; Theodoros et al., 2008; Turkstra et al., 2012), with the exception of one finding in Theodoros et al. (2008) in which the narrative writing subtest outcomes were higher for participants in the telepractice group than for those who received services in person (i.e., p = .04). However, the authors adopted a stringent alpha level of .01 due to the multiplicity of testing and, as such, did not consider this finding at the p = .04 level to be statistically significant. Furthermore, effect sizes, which were calculable in Georgeadis et al. were small in magnitude and accompanied by confidence intervals containing the null effect. Assessment equivalence findings pertaining to language activity limitations/participation restrictions outcomes were mixed. Almost perfect agreement was found for comprehension (κ = .81), moderate agreement for expression (κ = .48), and slight agreement for social interaction (κ = .13; Smith et al., 1996). Additionally, Palsbo (2007) reported that the percent exact agreement was higher for telepractice than in person across both measures of language activity limitations/participation restrictions outcomes. See Table 3 for more information about language assessment study findings. No intervention studies of language impairment or language activity limitations/participation restrictions were located (i.e., CQ10).

Cognitive Outcomes

Smith et al. (1996) and Turkstra et al. (2012) compared cognitive impairment outcomes gathered via telepractice versus in person (i.e., CQ5). No assessment studies of cognitive activity limitations/participation restrictions were identified (i.e., CQ6). No detailed information about diagnostic accuracy was provided in any study; however, Smith et al. reported that a previous Rasch analysis of their study outcome measure showed that it assessed two distinct constructs (i.e., motor and cognitive abilities). In Turkstra et al., cognitive impairment assessment outcomes were equivalent as indicated by the absence of a statistically significant difference between outcomes gathered from both service delivery methods. Kappa statistics for cognitive impairment outcomes were not calculable in Smith et al., yet the coefficient of variation for method error (CV_{ME}) was computed for the following cognitive outcomes: problem solving (CV_{ME} = 3.2%) and memory (CV_{ME} = 1.6%). The authors reported that those CV_{ME} percentages reflect good stability of the items across service delivery methods as well as a reduction in variability in kappa but not low agreement (Smith et al., 1996). See Table 4 for more information about cognitive assessment study findings.

Intervention studies of cognitive impairment (i.e., CQ11) were completed by Man, Tam, and Hui-Chan

(2006) and Riegler, Neils-Strunjas, Boyce, Wade, and Scheifele (2013); cognitive activity limitations/participation restrictions outcomes (i.e., CQ12) were also included in Man et al. No treatment efficacy findings were located or calculable for the telepractice condition. Treatment equivalency was evaluated in two studies (Man et al., 2006; Riegler et al., 2013) for cognitive impairment findings and in Man et al. for cognitive activity limitations/participation restrictions outcomes. No statistically significant differences in cognitive impairment or activity limitations/participation restrictions intervention outcomes were reported between service delivery methods, which indicates treatment outcomes equivalence. Effect sizes reported for impairment and activity limitations/participation restrictions outcomes were primarily small in magnitude (Man et al., 2006; Riegler et al., 2013) and accompanied by confidence intervals containing the null effect (Man et al., 2006). The latter finding also indicates treatment outcomes equivalence. See Table 5 for more information about cognitive intervention study findings.

Patient Satisfaction

Patient satisfaction findings were captured in a variety of ways across studies (Georgeadis et al., 2004; Hill et al., 2009a, 2009b; Theodoros et al., 2008; Turkstra et al., 2012) that reported those findings. A survey of patient satisfaction with telepractice versus in-person outcomes was administered in Georgeadis et al. (2004), with some associated participant comments recorded as well; participants completed a questionnaire that addressed a number of factors (e.g., satisfaction with audiovisual quality, level of comfort) in three studies (Hill et al., 2009a, 2009b; Theodoros et al., 2008), and unsolicited consumer comments about the service delivery methods were recorded in Turkstra et al. (2012). Across studies, participants indicated that they were comfortable and satisfied with the use of telepractice, with some stating that they would opt to use telepractice in the future. In addition, one participant, who was assessed for language and cognitive impairment, noted other potential benefits of telepractice, such as cost savings, efficiency, and the ability to take advantage of resources remotely (Turkstra et al., 2012). However, a few participants with motor speech impairment said that telepractice would not work for them because they did not have Internet access in their homes (Hill et al., 2009a). Some participants were indifferent to the service delivery method (Turkstra et al., 2012). Conversely, participants with a language impairment provided mixed feedback, with some having a preference for in-person therapy (Georgeadis et al., 2004) and others considering telepractice as potentially more convenient than in-person service (Theodoros et al., 2008).

Discussion

Overall, equivalence of outcomes was noted in both assessment and intervention studies of telepractice versus in-person sessions for persons with ABI, which suggests that the two service delivery methods are comparable. This finding was consistent across study designs (i.e., RCTs and a nonrandomized controlled trial), telepractice types (e.g., synchronous), service delivery variables (e.g., serial vs. simultaneous assessment presentation), medical diagnoses (e.g., TBI), outcomes (e.g., cognition), and ICF categories. Furthermore, positive findings were associated with the use of telepractice in intervention studies. However, the clinical implications are equivocal given that study findings applied to only seven of the 12 clinical questions, with most questions being addressed by two or fewer studies that varied in methodological quality. Moreover, the small body of evidence does not adequately address telepractice efficacy, which is informed by a number of factors, including telepractice equivalence study findings and ecological validity of outcomes. With regard to this EBSR, treatment efficacy was evaluated in only one study in the in-person condition (Man et al., 2006); results suggested that the treatment was not efficacious. No diagnostic accuracy data (e.g., sensitivity, specificity) were reported. Clearly, the data culled for this EBSR are too limited to comprehensively inform the creation of disorder- and setting-specific assessment and intervention frameworks.

The limited evidence pertaining to the impact of telepractice for individuals with ABI does not indicate limited benefit. Instead, continued research is needed on the effect of telepractice on broadening access to clinical services and ultimately improving treatment outcomes. This research should be conducted in consideration of the following ecological validity indicators: patient characteristics appropriately aligned to telepractice technology; patient satisfaction with telepractice; ability to generalize study findings to real-life situations, which can be moderated by the diagnostic accuracy of assessment tools and treatment efficacy data; and cost-effectiveness of telepractice relative to in-person services. The use of telepractice to achieve optimal outcomes, such as attaining independence or returning to work, is promising for certain individuals with ABI given the improvements in access to and familiarity with personal computer technology and the Internet (Andelic et al., 2014). The findings of this EBSR then provide a state of the evidence on telepractice equivalence to standard forms of service provision as well as on the broader issue of telepractice efficacy relative to the clinical questions posed. As such, the findings will be discussed within the context of the aforementioned future research needs.

Telepractice Equivalence

In two studies in this EBSR (Palsbo, 2007; Theodoros et al., 2003), lack of equivalent findings between the two service delivery methods was attributed to factors other than the need for disorder- or setting-specific considerations. Differences in raters' perceptual judgments of participants' motor speech skills and participant test–retest performance variability were the reasons posited by Theodoros et al. (2003), whereas Palsbo (2007) surmised that the lack of randomization of clinicians to a service delivery method and the conservative scoring of one clinician caused the discrepancy. The authors' conclusions are not cause to disregard previous research that suggests that disorder- and setting-specific considerations may be needed (Theodoros, 2011; Tucker, 2012); instead, those conclusions expand the type of factors that should be considered when examining why clinical and statistical differences exist between interrater agreement scores and test scores in future telepractice equivalence studies.

The most robust telepractice equivalence studies are well-controlled, experimental-group (e.g., RCTs with concurrent control groups), and single-subject (e.g., multiple-baseline design across participants) designs with adequate statistical power that address threats to internal and external validity noted in this EBSR (e.g., lack of assessor blinding, no mention of treatment fidelity, convenience sampling). Though the study design inclusion criterion for this EBSR extended beyond RCTs and experimental single-subject design studies (i.e., experimental or quasi-experimental studies that compared assessment and/or treatment outcomes gathered via telepractice and in person), only a small number of pertinent studies (k = 10) was located, which indicates that this is an emerging research area. Furthermore, the heterogeneity across study variables (e.g., ABI subpopulations, outcome metrics) impeded determination of the strength of the body of evidence for each communication outcome category and in consideration of the ICF classifications. With regard to the ICF findings, the majority were in the impairment category, which is consistent with what others (Simmons-Mackie & Kagan, 2007; Wambaugh & Mauszycki, 2010) have reported. Additional research is needed on telepractice assessment and intervention of cognitive and communication impairment and activity limitations/participation restrictions outcomes in the ABI population.

Researchers are encouraged to refine the clinical questions in various ways such that telepractice equivalence is evaluated across different patient characteristics (e.g., level of severity, age, experience with technology, and cultural background), telepractice technologies, and various settings (e.g., home, schools, clinical centers). In addition, methodological issues reported in this EBSR and by others who have analyzed the methodological quality of ABI research (e.g., Perdices et al., 2006; Togher et al., 2009) should also be addressed. Findings from those types of studies will provide specific information about telepractice equivalence; however, questions such as "Which patients are most likely to benefit from telepractice?" and "Which features of telepractice technology have the greatest impact on services?" will still need to be answered. These questions fall in the realm of telepractice efficacy; require different research methodological considerations; and have implications for evidence-based practice, the manifestation of knowledge translation.

Telepractice Efficacy

Evaluation of diagnostic accuracy and treatment efficacy for individuals with ABI is important. Since they require specialized interventions tailored to their needs and injuries (Rispoli, Machalicek, & Lang, 2010), an accurate diagnosis is paramount, in addition to understanding which interventions improve which outcomes. Telepractice may be a more ecologically attractive method for evaluating and treating individuals with ABI because service delivery can take place in the home and other functional settings. Evaluation of impairment and activities limitations/participation restrictions outcomes in these settings are best captured by mixed-method research approaches (i.e., qualitative and quantitative) aligned with the tenets of ecological validity. Quantitative methods were primarily used in this EBSR to evaluate telepractice equivalence and gather patient satisfaction outcomes, although unsolicited qualitative data in the form of participant comments about telepractice satisfaction and service delivery method preference were reported in two studies (Georgeadis et al., 2004; Turkstra et al., 2012). In pursuit of better clinical support systems and generalization of positive study findings, future studies should incorporate formal qualitative research techniques, such as phenomenological methods, to evaluate participants' "lived experiences" associated with the use of telepractice. To examine the impact of generalization more thoroughly, treatment effectiveness studies, which examine treatment effect in real-world contexts, are to follow treatment efficacy studies, which evaluate treatment effect under ideal laboratory conditions (Fey & Finestack, 2009). To fully gauge the impact of an intervention, subsequent cost-effectiveness studies have to be undertaken; lack of data on cost-effectiveness has been cited as a barrier to telepractice implementation (Mashima & Doarn, 2008).

Cost-effectiveness analyses of early-initiated rehabilitation of individuals with severe TBI across the continuum of care have shown that uninterrupted treatment was associated with lower costs and improved outcomes (Andelic et al., 2014). Telepractice is an ideal service delivery method for maintaining treatment along the continuum because it can occur in any setting that has adequate technological resources and technical support. Preliminary cost analyses (Tindall & Huebner, 2009; Tindall, Huebner, Stemple, & Kleinert, 2008) and cost-effectiveness studies (Hicks, Fleming, & Desaulnier, 2009) across service delivery methods suggest that telepractice may be a more financially viable option, yet additional research is needed to fully evaluate the economic impact of telepractice (Theodoros, 2011). Cost savings was among the potential benefits of telepractice reported by one study participant (Turkstra et al., 2012) in this EBSR. Cost is one of many aspects that affects patients' use of telepractice; other factors include patients' abilities (e.g., visual perception), telepractice accessibility, and satisfaction with telepractice.

Patient selection for telepractice services should be based on a number of factors, such as patients' physical and sensory abilities (e.g., visual and hearing ability); cognitive, behavioral, and/or motivational characteristics (e.g., level of cognitive functioning); communication skills (e.g., auditory comprehension); and availability of support resources (e.g., access to technology, caregiver support; ASHA, n.d.). Once services are initiated, patient satisfaction with telepractice should be evaluated. The patient satisfaction findings from this EBSR revealed that study participants were generally pleased with telepractice, yet some participants also indicated that because they did not have Internet access in their homes, telepractice was not a viable service delivery method (Hill et al., 2009a). The latter finding may no longer be an issue for many individuals given that almost 70% of homes had broadband Internet service in 2011 (National Telecommunications and Information Administration & Economics and Statistics Administration, 2014). Improved Internet access can facilitate widespread research of the impact of telepractice on cognitive and communication assessment and treatment outcomes in subpopulations with ABI (i.e., mild vs. severe TBI), the relationship between telepractice and the wait period for clinical services, and the cost-effectiveness of telepractice. With regard to enhancing widespread telepractice access, patient factors should be considered along with the fidelity of telepractice technology.

Evaluations of digital communication technologies to be used for telepractice should include assessment of the space required to transmit data bundles across the network path (i.e., bandwidth), loss of video and audio data bundles (i.e., packets), the interval between sending a packet and its reception at the target destination (i.e., end-to-end delay), variation in packet delay (i.e., jitter), and security and privacy of data transmission (Gemmill, 2005). Because only the amount of bandwidth was reported in studies accepted for this EBSR, holistic conclusions cannot be drawn about the adequacy of the technical components of the telepractice technologies. With regard to bandwidth, use of high bandwidth is recommended to reduce degradation or packet loss (Gemmill, 2005; Xue & Lower, 2010), which is associated with slow transfer or unintelligible audio and video content (Gemmill, 2005). In this EBSR, technical issues associated with low bandwidth (e.g., Hill et al., 2009a, 2009b; Theodoros et al., 2008) did not prevent the successful administration of assessments (e.g., Hill et al., 2009a). This portends positive implications for service provision in areas with low bandwidth Internet access. Furthermore, results of this EBSR suggest that telepractice is, at a minimum, comparable to standard forms of service delivery. Future research is warranted to determine which features of telepractice technologies have the greatest impact on services (e.g., Does signal quality affect clinical outcomes or patient satisfaction?).

Although several barriers to telepractice implementation exist, two that have the most impact are (a) the variability in state telepractice licensure laws and regulations and (b) insurance reimbursement policies. As of December 2014, there were 14 states (e.g., Alabama and Georgia) that regulate telepractice, and California and the District of Columbia provide policy guidance (C. Frailey, personal communication, December 1, 2014). Practitioners are left with uncertainty as to whether providing services via telepractice is allowable in states that have not issued licensure and/or regulations as well as in states that simply provide a definition of *telepractice* (ASHA, 2014). Furthermore, variability in reimbursements for Medicaid (e.g., only children in schools are covered in Ohio and Virginia) and the lack of Medicare reimbursement for speech and language services via telepractice compound issues surrounding telepractice access and implementation (C. Frailey, personal communication, December 1, 2014). With regard to private insurers, state parity laws exist which indicate that reimbursements for telepractice services should be comparable to reimbursements for in-person therapy (C. Frailey, personal communication, December 1, 2014). However, if private insurers' coverage for in-person services excludes reimbursement for services that are specific to telepractice, then it is possible that providers of the two service delivery methods will receive differential reimbursement rates. These barriers associated with evolving state policies and associated insurance reimbursement considerations will need to be addressed to facilitate refinement of telepractice standards that promote effective widespread telepractice implementation (Keck & Doarn, 2014).

Evidence-Based Practice Considerations

Given the numerous questions that remain about telepractice equivalence and efficacy, clinicians are left without conclusive answers regarding implementation. However, evidence-based practice emphasizes consideration of the current best research as part of clinical decision making in addition to clinical expertise and patients' perspectives and values. Clinicians are encouraged to consider the research noted in this EBSR as well as the unique set of needs of their patients with ABI along the progression through different stages of recovery (Turner-Stokes, Disler, Nair, & Wade, 2005). The constellation of deficits (e.g., cognitive impairment) in addition to the medical diagnosis (i.e., TBI) is important to consider when planning therapy (Turner-Stokes, 2003). Another concern for this population is that rehabilitation goals may be moderated by the age group. For example, the focus for younger adults with ABI may be on returning to work (Turner-Stokes et al., 2005). Age data in studies accepted for this EBSR were mixed, which precludes identification of any issues specific to younger versus older adults. Severity of ABI symptoms is another matter that affects assessment and treatment outcomes. Research has shown that patients with less severe symptoms, such as mild TBI, often make a good recovery, whereas patients with moderate to severe symptoms benefit from higher levels of intervention (Turner-Stokes et al., 2005). Because minimal information was provided about the severity of participants' ABI symptoms as well as service delivery dosage in the studies accepted in this EBSR, no conclusions can be drawn about those facets for in-person services versus via telepractice. The inception of intervention relative to time postonset of injury may also affect outcomes, with earlier rehabilitation associated with better outcomes, particularly for patients with more severe symptoms (Cullen, Chundamala, Bayley, & Jutai, 2007). Patients' time postonset of injury reported in studies included in this EBSR varied considerably (i.e., 1 month–29 years). Study authors did not group study participants by time postonset of injury, so any differences in assessment or treatment equivalence associated with time postonset of injury were masked. The aforementioned individual characteristics of persons with ABI are as varied as the associated assessment and intervention considerations (Turner-Stokes et al., 2005). Future research should evaluate factors within each of those categories to inform patient-specific considerations for telepractice.

Limitations of This EBSR

Only peer-reviewed research was accepted in this EBSR to ensure that study quality had been vetted by experts in the field. As such, the risk of publication bias is high because the likelihood of publishing studies with significant findings is higher than the likelihood of publishing studies with non–statistically significant results. Also, only studies written in English were accepted; this limited the scope of the search for relevant articles for this EBSR. Studies written in other languages that address the clinical questions in this EBSR could provide another dimension to the understanding of this topic and/or may contain results that are principally contrary to the findings in this EBSR.

Conclusion

In sum, the implications of these findings for individuals with ABI are that similar assessment and treatment outcomes can be obtained via both service delivery methods; however, questions remain about the generalizability across subpopulations of individuals with ABI and telepractice technologies. Future telepractice equivalence research should incorporate diagnostic accuracy and treatment efficacy data and patient satisfaction findings derived from strong qualitative studies to better evaluate outcomes within the ICF categories, which ultimately should inform development of disorder- and setting-specific considerations.

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