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Speech and language screening for children with medical complexity: A comparison of telepractice and in-person methods

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Abstract

Effective communication is vital for healthy development and successful educational and vocational outcomes. For children with medical complexity (CMC), the interaction between medical complexity and a speech and language impairment may put them at particular risk for adverse effects. It is important that these children are promptly assessed and diagnosed so that intervention can be started early. Medical complexity is rare in childhood, thus CMC usually access speech pathology services through tertiary facilities where staff have specialist experience and resources, and work as part of a coordinated tertiary team. Unfortunately these facilities are typically located in metropolitan centres, which may compromise service accessibility for CMC living in rural and remote locations.

A potential solution to improve service accessibility is remote speech and language screening using telepractice. Telepractice screening allows the speech-language pathologist (SLP) to distinguish those children who need further assessment at the tertiary hospital from those with normal speech and language. This model is increasingly used for the delivery of tertiary medical services, however, there is little research to support the use of telepractice for paediatric speech and language screening, and very few studies have included CMC. Thus, the overall purpose of this research project was to investigate the role of telepractice for remote speech and language screening of CMC. To achieve this aim, two studies were carried out.

The first study was an international survey of tertiary SLPs that aimed to describe access difficulties experienced by CMC, and to investigate the rate of telepractice adoption among SLPs who work with CMC. The survey was administered in 2011 ($n = 46$) and repeated in 2015 ($n = 47$). This survey identified widespread access difficulties experienced by CMC, highlighting a need for alternative service delivery models such as telepractice. Telepractice adoption among tertiary SLPs more than doubled between 2011 and 2015 ($p < 0.05$), and in 2015 the rates of telepractice adoption were higher (40%) than previously reported for the general speech pathology profession. Tertiary SLPs were willing to use telepractice with their CMC patients, and considered a wide range of patient groups and service types to be appropriate for telepractice delivery. However, some SLPs were reluctant to use telepractice for direct services such as screening, and a number of barriers to telepractice adoption were identified, including inability poor audio and image quality, lack of experience with telepractice, concerns about behaviour management and use of hands-on techniques, and concerns about the caregiver's inability to assist during telepractice sessions.

The second study was an exploratory method comparison study that aimed to investigate the feasibility, validity, and acceptability of speech and language screening via telepractice for CMC. This study compared in-person speech and language screening with two telepractice screening methods: a hardware-based telepractice (HBT) approach using point-to-point videoconferencing equipment, and a software-based telepractice (SBT) approach using consumer-grade equipment and free videoconferencing software. Unfortunately, due to recruitment difficulties, only eight CMC participated in this study. A further twenty-six children aged 3-12 years were recruited from the general paediatric population. The children's speech and language was screened across all three methods, in random order.

All of the in-person and HBT screening assessments were completed. However, due to technical difficulties during SBT screening, 6% of sessions were not completed and 32% of sessions were interrupted. Children were more likely to request repetitions ($p < 0.05$) and to demonstrate poor compliance during telepractice screening ($p < 0.05$) than they were during in-person screening. There was no clinically important difference in screening duration between in-person and telepractice methods.

Correlation between in-person and telepractice screening was high for oromotor screening ($r = 0.5$-0.93), and for inconsistency screening using the HBT method (agreement = 90.6%), although inconsistency screening was only valid for school-aged children using the SBT method (agreement = 92.9%). A number of individual speech sounds could not be reliably judged via telepractice during speech screening. Correlation was high between in-person and HBT screening for language screening using the *CELF-4 Screener* ($r = 0.68$), and for SBT screening using the *PLS-4 Screening Test* ($r = 0.65$), however, the opposite was not true. Caregivers were satisfied with telepractice approaches and were willing to use telepractice again, however, they preferred in-person services if available.

The work presented in this thesis has highlighted the need for initiatives that will improve speech pathology service accessibility for CMC, and demonstrated that tertiary SLPs are interested and willing to provide telepractice services to their CMC patients. It has also provided preliminary evidence to support the feasibility and acceptability of HBT and SBT screening for the general paediatric population, and has confirmed that oromotor function, inconsistency, and language can be validly screened via telepractice for some age groups. Further work is required to confirm the efficacy of telepractice screening for the CMC population. Clinicians who use telepractice for speech and language screening should be aware that reduced child compliance and technical difficulties may reduce screening accuracy.

Declaration by author

This thesis is composed of my original work, and contains no material previously published or written by another person except where due reference has been made in the text. I have clearly stated the contribution by others to jointly-authored works that I have included in my thesis.

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Publications during candidature

Peer-reviewed papers

Taylor OD, Armfield NR, Dodrill P, Smith AC. A review of the efficacy and effectiveness of using telehealth for paediatric speech and language assessment. Journal of Telemedicine & Telecare. 2014; 20(7):405-12.

Conference abstracts

Taylor OD, Armfield NR, Dodrill P, Smith AC. Using telehealth to screen speech and language. Paper presented at: Children's Health Queensland Research Day; 2015 December 11; Brisbane, Australia.

Taylor OD, Armfield NR, Dodrill P, Smith AC. Paediatric speech and language screening using telehealth. Paper presented at: Successes and Failures in Telehealth; 2015 November 12-13; Brisbane, Australia.

Taylor OD, Armfield NR, Dodrill P, Smith, AC. A review of the efficacy and effectiveness of using telehealth for paediatric speech and language assessment. Paper presented at: Successes and Failures in Telehealth; 2014 November 17-18; Adelaide, Australia.

Publications included in this thesis

No publications included.

Contributions by others to the thesis

Dr Pamela Dodrill made a significant input in the original concept and design of this work. She also provided guidance in the development of the research plan, particularly with respect to speech and language screening tools.

A/Professor Anthony Smith, Dr Nigel Armfield, and Mr Adam Mothershaw provided guidance in the development of the research plan, particularly with respect to telepractice equipment and processes.

Mr Adam Mothershaw and Ms Lisa Garner provided technical support during telepractice data collection.

Dr Nigel Armfield made a significant contribution towards statistical analysis of research data.

A/Professor Anthony Smith, Dr Nigel Armfield, and Dr Pamela Dodrill provided guidance for this thesis through editing of chapter drafts.

Statement of parts of the thesis submitted to qualify for the award of another degree

None.

Research Involving Human or Animal Subjects

Ethical approval for my first study, "Telepractice use among speech-language pathologists who provide services to children with medical complexity: an international survey", was received from The University of Queensland (#2011000492; #2015000925) and from Children's Health Queensland (Queensland Health) (HREC/11/QRCH/26).

Ethical approval for my second study, "Speech and language screening via telepractice for children with medical complexity: a method comparison study", was received from The University of Queensland (#2011000492) and from Children's Health Queensland (Queensland Health) (HREC/11/QRCH/26).

Ethics approval documents can be found in Appendix A.

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Keywords

speech-language pathology, speech, language, screening, telepractice, children with medical complexity

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LIST OF ABBREVIATIONS

ASD	Autistic spectrum disorder
ASHA	The American Speech-Language-Hearing Association
CA	Close agreement
CASL	*Comprehensive Assessment of Spoken Language*
CELF-4	*Clinical Evaluation of Language Fundamentals, 4th Edition*
CELF-4 Screener	*Clinical Evaluation of Language Fundamentals Screener, 4th Edition*
CELF-P2	*Clinical Evaluation of Language Fundamentals - Preschool, 2nd Edition*
CI	Cochlear implant
CMC	Children with medical complexity
CP	Cerebral palsy
DDK	Diadochokinetic
DEAP	*Diagnostic Evaluation of Articulation and Phonology*
EA	Exact agreement
EOWPVT	*Expressive One-Word Picture Vocabulary Test*
GFTA-2	*Goldman-Fristoe Test of Articulation, 2nd Edition*
HBT	Hardware-based telepractice
HD	High definition
ICC	Intra-class correlation coefficient
II	Intellectual impairment
INV-II	*MacArthur Inventarios del Desarrollo de Habilidades Communicativas. Inventario II: Palabras y Enunciados*
LAN	Local area network
LCCH	Lady Cilento Children's Hospital, Brisbane
NDIS	National Disability Insurance Scheme

NWR	Non-word repetition
OMA	Oromotor assessment
PLS-4	*Preschool Language Scales, 4th Edition*
PLS-4 Screening Test	*Preschool Language Scales Screening Test, 4th Edition*
PPVT-III	*Peabody Picture Vocabulary Test, 3rd Edition*
RCH	Royal Children's Hospital, Brisbane
REEL-3	*Receptive-Expressive Emergent Language Test, 3rd Edition*
SBT	Software-based telepractice
SD	Standard definition
SDLQ	*Spanish Developmental Language Questionnaire*
SIR	Speech intelligibility rating
SKOLD	*Screening Kit of Language Development*
SLP	Speech-language pathologist
SPA	Speech Pathology Australia
SPLS-4	*Preschool Language Scale, Spanish Edition, 4th Edition*
SPS	*Westby's Symbolic Play Scale*
SWAT	Single word articulation test
UK	The United Kingdom
UQ	The University of Queensland
USA	The United States of America
VFSS	Videofluoroscopic swallow study

CHAPTER 1 Introduction

Children with medical complexity (CMC) are a group of children with one or more chronic and serious medical conditions, functional limitations, and extensive service needs (1). These children may experience speech and language impairments as a result of their primary diagnosis, treatment effects, long-term hospitalisation and missed school, or as a co-morbidity. There is a well-established link between childhood speech and language impairments and adverse effects across social-emotional (2-8), behavioural (6, 9-16), academic (3, 7, 13, 17-25), and vocational domains (26-28). The interplay between medical complexity and speech and language impairment may place CMC at particular risk of developing these adverse outcomes. Early assessment with a speech-language pathologist (SLP) is vital for CMC with suspected speech and language impairments, so that treatment can be started early when prognosis is best (29).

Medical complexity is rare in childhood, thus CMC are often seen by SLPs who work in tertiary facilities. Tertiary SLPs have specialist skills and experience in managing CMC, can access specialist resources, and work as part of a coordinated tertiary team. Unfortunately, most tertiary facilities are located in major metropolitan areas, which reduces accessibility for CMC who live in rural and remote areas. Comprehensive speech and language assessment is also time-consuming, and may take multiple appointments to complete. This is inconvenient for families who need to travel long distances, and can increase waiting list times. To differentiate the children who require comprehensive assessment from those who do not, screening can be conducted prior to full assessment. An assessment pathway that includes screening may reduce inconvenience to families, improve service efficiency, reduce costs, and decrease waiting periods (30). In some cases, children may be screened by their local speech pathology service, and then referred to tertiary services for full assessment, if necessary.

Another service delivery option that may improve children's access to early speech pathology assessment is speech and language screening via telepractice. Telepractice allows CMC to access speech pathology screening remotely, which may save money (31, 32), travel, and time (31), and can also reduce waiting lists. There is a growing body of research that supports telepractice for speech pathology service delivery (32), however, only one study to date has investigated the use of telepractice for screening or assessment with CMC (33). There is also limited evidence to support telepractice speech and language screening among the broader paediatric population (34-41). Thus, the overall aim of my thesis is to investigate the role of telepractice for remote speech and language screening of CMC.

In the next three chapters of my thesis I will present background information to this body of work. In Chapter 2 I will examine speech and language impairment among CMC, and demonstrate the importance of timely speech pathology involvement. In Chapter 3 I will explore the availability and accessibility of speech pathology services for CMC, and introduce telepractice as a possible service delivery model to improve the accessibility of screening. In this chapter I will broadly discuss evidence for speech pathology service delivery via telepractice, and examine telepractice adoption among SLPs. In Chapter 4 I will present the results of a systematic review which summarises the use of telepractice for speech and language screening and assessment with children.

To achieve the overall aim of my thesis, it was first necessary to explore service accessibility for CMC; to describe current telepractice use with this population; and to investigate the feasibility, accuracy, and acceptability of speech and language screening via telepractice. To accomplish this, I undertook two research studies (see Figure 1).

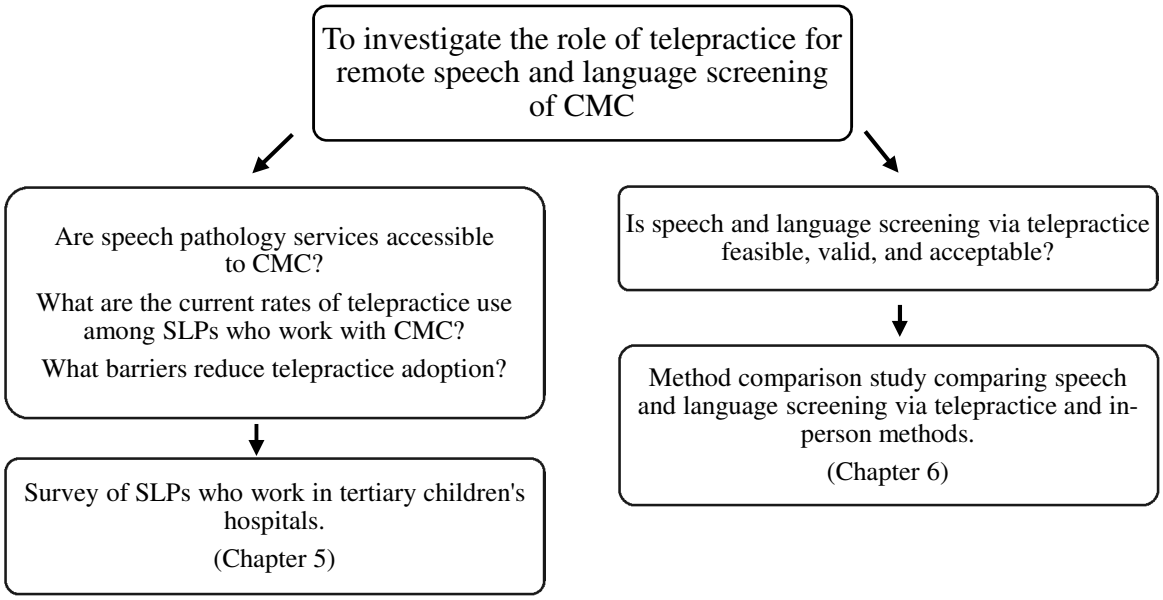


Figure 1 Research questions and methodology

The first study, which is described in Chapter 5, is a survey of SLPs who work in tertiary children's hospitals. The first aim of this survey was to investigate access issues experienced by CMC patients, as reported by SLPs, in order to ascertain whether alternative service delivery models are needed for this population. The second aim of this study was to investigate the rate of telepractice adoption among tertiary SLPs, and to explore any changes in telepractice adoption over time. This study also explored SLP's attitudes towards telepractice, and barriers and facilitators to telepractice adoption.

The second study, which is described in Chapter 6, is an exploratory method comparison study that compared in-person and telepractice speech and language screening for CMC. This study aimed to explore the feasibility, validity, and acceptability of two readily-accessible telepractice screening methods.

In Chapter 7 I will integrate and discuss the results from my studies in order to draw conclusions regarding the overall aim of my thesis. Findings will improve our understanding of access issues experienced by CMC, telepractice adoption among tertiary SLPs, and the feasibility, validity, and acceptability of easily-accessible telepractice speech and language screening with CMC. Findings will expand the evidence base for speech and language assessment/screening via telepractice, and provide new information on the use of telepractice for speech pathology service delivery for CMC. Specific outcomes will also guide the development of telepractice services for SLPs and other allied health professionals, such as occupational therapists and psychologists.

CHAPTER 2 Speech and language impairment and children with medical complexity

As outlined in the introduction, the overall aim of my thesis is to investigate the role of telepractice for remote speech and language screening of CMC. The purpose of my first background chapter is to provide the reader with an understanding of speech and language impairment among children with complex medical conditions, and to highlight the importance of timely speech pathology involvement.

In this chapter I will define speech and language, and discuss the prevalence and outcomes of impaired speech and language development. I will discuss the SLPs' role in screening, assessment, and treatment of childhood speech and language impairment. In the second part of this chapter I will focus on my population of interest: CMC. I will define this group, and describe the nature of speech and language impairments among these children.

2.1 Speech and language impairment

Communication is defined as "imparting or exchanging of information by speaking, writing, or using some other medium" (42). Communication disorders include disorders of hearing, voice, fluency (stuttering), and non-verbal communication; as well as speech and language impairments, which are the most common communication disorders experienced by children (43). Speech and language impairments may be temporary or permanent, and vary in severity. They may occur as a child's primary condition (i.e. unrelated to another diagnosis), or may be associated with another diagnosis such as Down syndrome, cleft palate, or hearing impairment.

Speech is "the spoken medium of language" (44). A child with a speech impairment may be difficult to understand due to a limited repertoire of sounds, specific sound errors, difficulty saying complex word structures (e.g. multi-syllable words), or unusual stress patterns (prosody) (45). Some children have variable production of words (i.e. the same word is produced a number of different ways), and this is known as inconsistency. A child who says words differently more than 40% of the time is considered to have an inconsistent speech disorder (45). Some children with speech difficulties may also have impaired oromotor function, characterised by incoordination or weakness of the oral muscles.

Language is a system of rules that allows us to communicate with each other using words, writing, and gesture (44). There are two main types of language impairment, which often occur in combination:

- receptive language impairment, which is difficulty understanding language
- expressive language impairment, which is difficulty using language.

Children with impaired language may have difficulty using or understanding different language components, including word and sentence form (morphology and syntax), language content (semantics), or the functional and social use of language (pragmatics) (46).

Some speech and language errors are a part of normal child development. Children who continue to use these "normal" errors past the appropriate age are considered to have a speech or language delay. Children who use unusual errors that are not observed during typical development are considered to have a speech or language disorder.

An international systematic review in 2000 concluded that 6% of children worldwide have a speech and language impairment (47). There is a lack of data on the prevalence of speech and language impairment among Australian children, and research to date has focused on the prevalence of communication impairment among specific patient sub-groups. However, a 2014 Senate report concluded that speech and language disorders are high prevalence conditions among Australian children, citing submissions and evidence from the Australian Bureau of Statistics, and expert opinion from researchers (26).

Short- and long-term effects

Children with speech and language impairments often have difficulty engaging and participating in activities at home, school, and in the community. Speech and language difficulties are associated with adverse short- and long-term effects across a range of domains, leading to significant and pervasive impacts for the child, their family and peers, and society.

Social-emotional development

Social-emotional development refers to a child's ability to build relationships with others, and to understand and express their emotions. Children with social-emotional difficulties are at an increased risk for mental health issues (2). Studies have found that children with speech and language impairments are more likely to have social problems (3, 6), emotional difficulties (6), and low self-esteem (7, 8). They may have difficulty interacting with others (3-7), and are more likely to experience bullying (3, 6, 10, 48) and social isolation (6, 10).

Behaviour

Behaviour and communication are closely related, and the presence of a communication impairment increases the risk of behavioural disorder among children (9, 12), particularly when speech and language difficulties continue into adolescence (13). A range of behavioural problems have been documented among children with speech and language impairment, including bullying and fighting, hyperactivity (6), aggression (10), difficulty coping with stress and controlling their own behaviour (11), anti-social behaviour, and criminal activity (13-16).

Education

Children need effective communication skills to participate fully in the classroom, and the presence of a speech and language impairment predicts poor academic results (3, 17). Studies that have investigated classroom performance among children with speech and language impairments report that children have difficulty meeting classroom demands and completing tasks, are disorganised, and have a reduced ability to participate in school life (3). Children with speech and language impairment are more likely to have attention difficulties (18), and may have reduced memory, thinking, and reasoning skills (19). The link between communication impairment and literacy difficulties is well-established (20, 21), and children who start school with speech and language difficulties are likely to experience problems with literacy that persist throughout primary school (22) and into high school (23). Children with communication impairment are also at increased risk of impaired numeracy skills (3, 13, 24). Given these difficulties, it is not surprising that children with communication impairments often report negative educational experiences (7), and that adolescents with a history of speech and language impairment are less likely to complete secondary school or to pursue tertiary education (25).

Employment

Employment in developed countries such as Australia is mostly communication based (17, 27), which places people with speech and language impairments at a disadvantage when it comes to finding work. In 2000, research in the United States of America (USA) found that people with communication disorders had less money and higher rates of unemployment than the general population, and were also less likely to be employed than people with other disabilities (e.g. physical impairment) (27). In 1997 the United States Department of Labor reported that 67% of people with reduced speech intelligibility were unemployed, and this figure rose to 75% among those who were unable to speak intelligibly (28). Increased unemployment among people with communication disability is likely to be associated with higher welfare costs (26).

2.2 Screening, assessment, and treatment

Screening and assessment

Speech-language pathologists are specialists in communication disability (17). It is important that children with a suspected speech or language impairment receive timely assessment with an SLP, as this allows the SLP to make a prompt diagnosis and start early treatment, when the child's potential for improvement is optimal (29).

According to the American Speech-Language-Hearing Association (ASHA), a thorough speech and language assessment requires integration of the following information (49):

- developmental, medical, and educational history
- family background, including socioeconomic status, and cultural and linguistic background
- information from other involved service providers (e.g. teachers, medical team)
- an understanding of hearing and visual function, motor function, and cognition
- results of standardised or informal assessment measures that examine the child's speech and/or language function
- prognosis
- results of ongoing monitoring, to document changes and evaluate the effectiveness of chosen therapy approaches.

A comprehensive speech and language assessment involving all of these components is time-consuming. In many cases, assessment must be completed over a number of appointments, particularly for younger children who have short attention spans. This increases the service provider's costs and waiting periods. Attendance at multiple appointments can be inconvenient for families, particularly if the child is eventually found to have normally developing communication skills (see Figure 2).

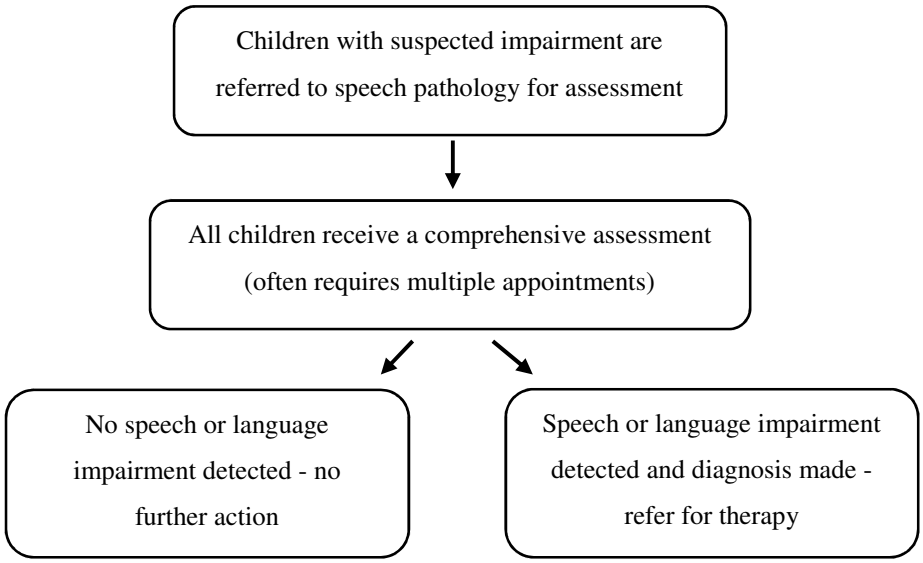


Figure 2 Assessment pathway if all children receive a full speech and language assessment

Speech and language screening may be completed prior to full assessment to save costs and improve efficiency. A screening test is a brief assessment that allows an SLP or other qualified professional (e.g., teacher, doctor) to identify children who are at risk for a speech or language disorder, and to refer children to other professionals for assessment and management if required (e.g. for a hearing test). Only those at risk for communication impairment are referred on for a comprehensive assessment (see Figure 3). Screening has been identified by ASHA as a core service delivery domain for SLPs, that can "facilitate referral for appropriate follow-up in a timely and cost-effective manner" (30).

Screening may be completed as part of a universal screening program, for example, during routine developmental checks with a child health nurse or general practitioner. Alternatively, the SLP may screen children with identified risk factors (e.g. history of ear infections, English as a second language); or those who have a suspected impairment, as reported by parents, teachers, or other health professionals. A speech pathology screening test should be quick and easy to administer, cost-effective, valid, and reliable, convenient, and accurate (50).

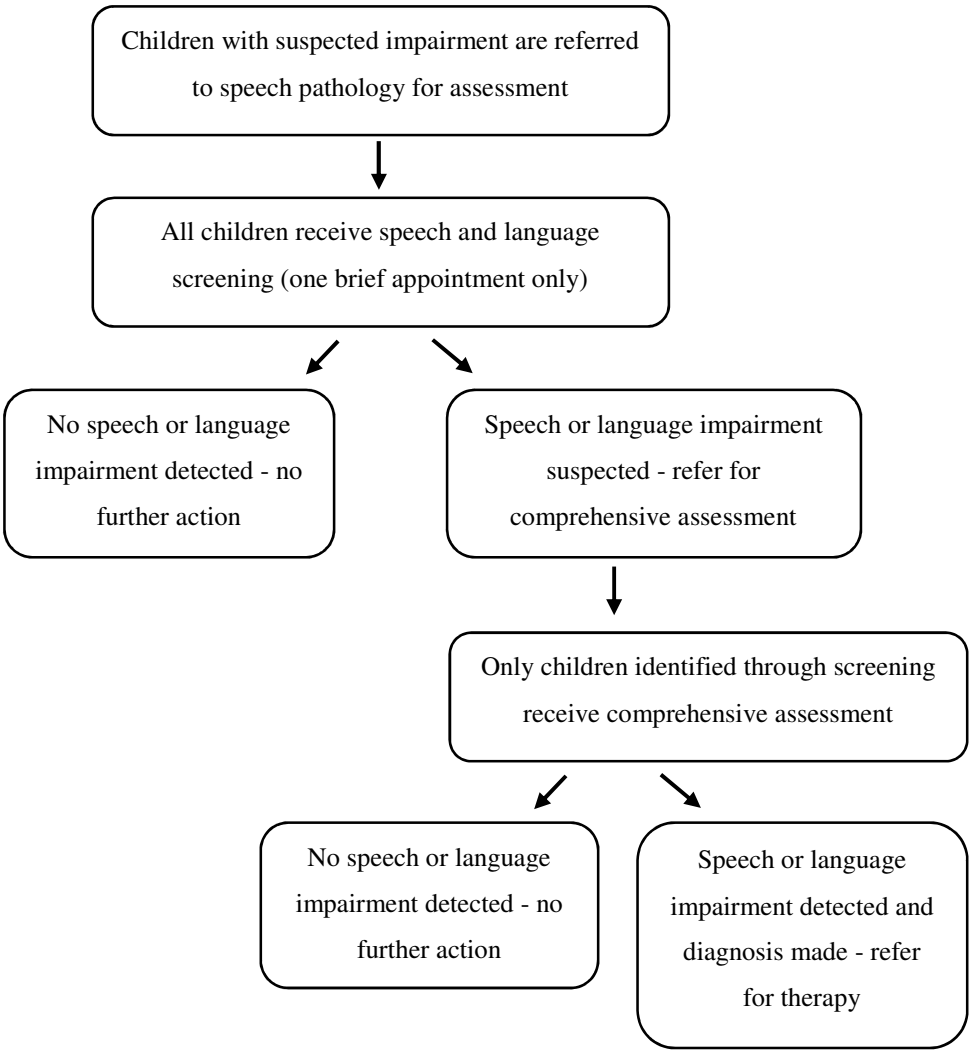


Figure 3 Assessment pathway if screening tests are used

Treatment

Once a child has been assessed, the SLP can make a diagnosis and start therapy. Early treatment with an SLP can prevent or minimise long-term communication disability, and a number of systematic reviews and meta-analyses have demonstrated the effectiveness of speech pathology for treatment of children with speech and language impairment (29, 51-59). Research has also found that therapy with an SLP leads to improvements in social-emotional status, attention, behaviour, play, and quality of life among children with speech and language impairments (60).

2.3 Children with medical complexity (CMC)

The Maternal and Child Health Bureau defined children with special health care needs as those "who have or are at increased risk for a chronic physical, developmental, behavioural, or emotional condition and who also require health and related services of a type or amount beyond that required by children generally" (61). Among children with special health care needs is a smaller subgroup of children with more serious and complex medical needs, known as CMC (1).

Cohen et al. (1) described CMC as those who:

- have extensive medical, therapy, and/or educational service needs
- have one or more chronic and serious medical conditions
- have functional limitations
- require significant health care resources (e.g. technology and pharmaceutical needs; frequent or prolonged hospitalisation; service needs across hospital, community, home-care, and care-coordination services).

The prevalence of CMC is increasing, most likely due to improved survival rates among premature infants and children who have serious health conditions. As survival rates increase, so too does the incidence of childhood disability, as these children have an increased risk for chronic health conditions and developmental delay (62). Given the complex nature of this group of children, services are usually provided or coordinated from a tertiary children's hospital (62).

Children with medical complexity may have speech and language impairments associated with their medical condition (45, 63-79), the effects of treatments (73, 74, 80-88), long-term hospitalisation (89), or missed school (90). Given the high prevalence of speech and language impairment among the general population (26, 47), it is also likely that some CMC have co-morbid speech and language deficits unrelated to their primary condition (45, 91-96).

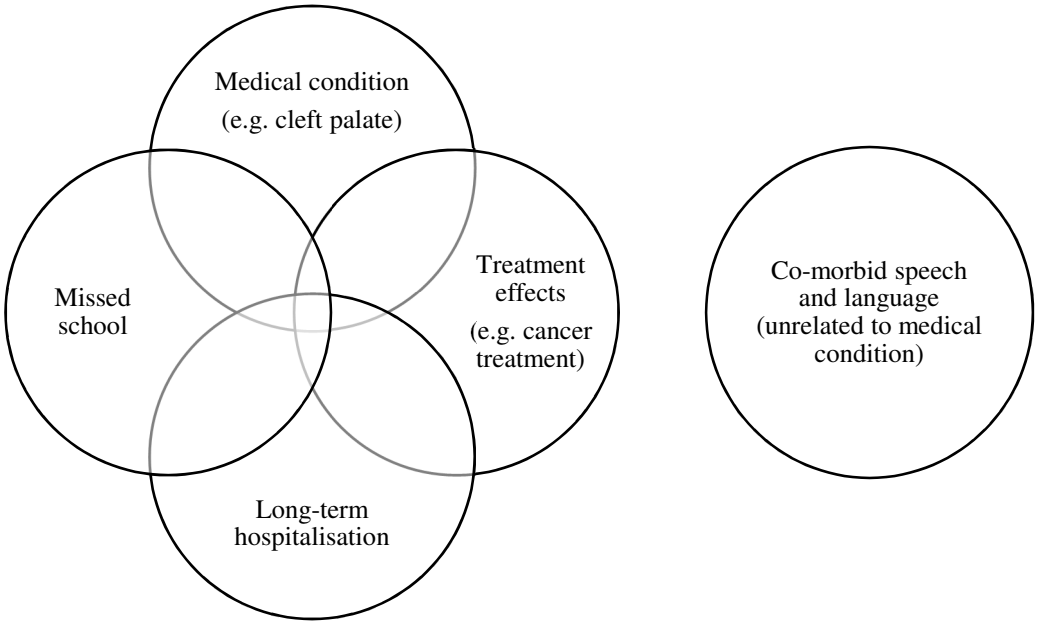


Figure 4 Aetiology of speech and language impairment among CMC

It is beyond the scope of my thesis to comprehensively describe all paediatric medical diagnoses with associated communication impairments, however, some major diagnostic groups are discussed below.

Cancer

Children with cancer may experience speech and language impairment as a result of tumour location. For example, children with brain tumours or tumours of the head and neck may have acquired speech and language disorders due to cranial nerve compression (63-65), raised intracranial pressure (66), or obstructive hydrocephalus (67). Some cancer treatments also contribute to communication difficulties. For example, surgery to resect posterior fossa tumours is associated with postoperative mutism, dysarthria, and language difficulties (80-82); and chemotherapy and radiation therapy have been linked with language impairment (83-87) and permanent hearing loss (88). A number of genetic syndromes are associated with cancer, and many of these have co-morbid communication dysfunction, including Down syndrome (91, 92), 13q deletion syndrome (93, 94), and ataxia-telangiectasia (95, 96).

Cerebral palsy

Cerebral palsy (CP) is an acquired movement disorder which occurs following brain damage in-utero or soon after birth (97). Children with CP often have speech, language, and non-verbal difficulties (e.g. difficulty with gesture and facial expression) (68). Parkes et al. (69) examined the prevalence of communication impairments among 1,268 children with early-onset CP and found that 36% had a speech impairment, and that 42% had other communication deficits.

Cleft palate

A cleft palate occurs when the palate (roof of mouth) fails to join during early pregnancy. Most children with cleft palate receive some level of speech therapy input, and a number will require intensive, long-term support. Specific characteristics of cleft palate speech include velopharyngeal insufficiency (the palate is short, or moves abnormally), impaired nasal resonance (too much or too little air goes through the nose during speech), and unusual articulation errors (e.g. use of a nasal snort in place of /s/) (45). A study in 2005 (70) examined the speech of 212 young children with repaired cleft palate, and found that 68% required therapy with an SLP. Many genetic syndromes are associated with cleft palate (45), so some children will also have impaired language and cognition.

Cochlear implant

Adequate hearing is important for speech and language development, and children with severe-to-profound hearing impairments often experience communication delay. Some of these children are suitable candidates for a cochlear implant (CI), a hearing device that directly stimulates the auditory nerve (98). Following cochlear implantation, children may receive speech therapy targeting language development, social interaction skills, and speech sound production (98). When compared with normal-hearing children, children with CI have significantly reduced speech intelligibility when controlling for age and length of cochlear implant use (71). Children with cochlear implants have also been found to have lower vocabulary scores than their normal-hearing peers, although over time children who are implanted before the age of 2 years can achieve normal receptive vocabulary skills(72).

Epilepsy

Epilepsy is a common (99) neurological disorder involving recurrent seizure activity (100). Seizures, anti-epileptic medications, and surgeries affect cognitive-communication; including effects on attention, memory, verbal fluency (73), receptive and expressive language, and literacy (74). The speech and language abilities of children with epilepsy may fluctuate, and often decline with time,

leading to significant impacts on academic performance, social-emotional development, and vocational outcomes (99).

Premature and low-birth weight infants

Medical advances have increased survival rates for premature and low birth weight babies. Unfortunately, these children often go on to have long-term developmental disabilities, and are at increased risk for intellectual impairment (II), CP, epilepsy, and sensory impairments (75). When compared with children born at term, ex-premature children are at increased risk for receptive and expressive language deficits (75, 76), and speech impairment (76, 77). Additional medical issues such as bronchopulmonary dysplasia (78, 79) or patent ductus arteriosus (79) further increase the risk for speech and language impairment.

Other risk factors

Another risk factors for CMC include frequent or prolonged hospital admissions, and missed school days. Children require a language-rich environment to develop language, and the hospital environment is unlikely to provide this. Epstein and Wayman (89) investigated the effect of hospitalisation on language development, and found that staff rarely spoke to infants during medical procedures, and often ignored children's communication attempts. The authors concluded that repeated or long-term hospitalisation is a risk factor for language impairment. Children with medical complexity who miss school because of hospitalisation, appointments, procedures, and illness are likely to fall behind academically, as well as losing opportunities to develop language and social skills. Children with cancer are at particular risk, as they miss school up to 50% more often than other CMC (90).

Other factors that may affect children's development include:

- sensory (101, 102), motor, and cognitive impairments (49)
- nutritional factors (103-105)
- family functioning, attachment, and other psychosocial factors (106, 107)
- the effects of abuse or poverty, and out-of-home care (104, 106, 107)
- the child's self-regulation (108-110)
- cultural and linguistic diversity (106, 111).

2.4 Chapter conclusion

In this chapter I aimed to describe speech and language impairment among CMC, and to emphasise the importance of timely speech pathology involvement. Children with speech and language impairment have an increased risk for adverse social-emotional, behavioural, academic, and vocational outcomes. The interplay between medical complexity and communication impairment may put CMC at particular risk for developing these adverse outcomes. Prompt screening or assessment allows the SLP to diagnose and treat the child early, when prognosis is best. This helps to prevent or minimise communication disability and the occurrence of adverse long-term outcomes.

Unfortunately, CMC may experience reduced access to speech pathology services. In the next chapter I will examine issues related to speech pathology service access across Australia, with a particular focus on tertiary-level services. I will also explore various service delivery options and their potential to improve access to speech pathology for CMC.

CHAPTER 3 Access and availability of speech pathology services for CMC

Childhood speech and language impairments have the potential to negatively affect social-emotional development, behaviour, academic performance, and employment outcomes. In the previous chapter I defined and discussed a subgroup of children with complex medical conditions with reference to their special needs. For CMC, the interplay between medical complexity and communication impairment may place them at particular risk for developing adverse outcomes. Timely speech pathology assessment can facilitate early diagnosis and treatment, however, comprehensive speech assessment is time-consuming and may take multiple appointments. Screening may be a useful first step in identifying children who need speech pathology input.

It is anticipated that CMC may find it difficult to access tertiary speech pathology support. Thus, in this chapter I will investigate the availability and accessibility of speech pathology services for children in Australia, and the specific access issues experienced by CMC. I will describe four service delivery models, including telepractice, and reflect upon the advantages and disadvantages of each with respect to accessibility. In the second part of this chapter I will provide an overview of the evidence regarding telepractice for speech pathology service delivery, and discuss current telepractice use among SLPs.

3.1 Speech pathology availability and accessibility in Australia

Speech-language pathologists in Australia work across metropolitan, rural, and remote areas, and may be employed by government services, non-government organisations, universities, or private practices. Traditionally, SLPs provide in-person assessment and therapy services. Some agencies use a consultative model in which speech pathology advice or programming is provided to non-speech pathology personnel (e.g. teacher aides), however, these models usually involve some degree of in-person contact, usually for assessment and reviews. Unfortunately, a traditional model of service delivery is out of reach for many children, and studies have found poor availability and accessibility of paediatric services in Australia, despite the range of settings and locations in which SLPs practice (17, 112-117).

Service availability

Service availability is defined as "the actual existence of a health service in a particular location" (114), or "whether services exist and are fairly distributed and resourced according to population need" (118). Mapping of Australian SLPs in 2015 found that paediatric services were unavailable in

63% of local government areas, with rural and remote areas particularly affected (115). Poor availability in rural areas is not surprising. Although almost a third of Australians live in rural and remote areas, Speech Pathology Australia (SPA) estimates that fewer than 5% of SLPs work in these areas (26).

Poor service availability in Australia is due in part to government policy. Unlike some other countries, Australia does not mandate therapy services for children with communication difficulties (119). Most speech pathology services in Australia are state-funded, resulting in variability between states (26, 115). Funding may be inadequate (115, 119) which results in poor service availability for certain geographical areas (118, 120), particularly rural and remote areas (113, 114, 117).

The National Disability Insurance Scheme (NDIS) is currently being rolled out across Australia, providing support to eligible Australians with disabilities, including speech pathology support (121). The implications of the NDIS on speech pathology services is not yet fully known, however, SPA is concerned that caps on providers' travel claims will reduce service availability for some patients (122). Many service providers are concerned that the NDIS will increase demand for speech pathology services, thus decreasing service availability for many patients (26).

Service access

If services are available in a community, service accessibility refers to the consumers' ability "to utilise … services and the barriers that impact upon this" (114). Surveys of parents have shown that many Australian families have difficulty accessing speech pathology services. Ruggero et al. (116) surveyed parents of Australian children, and found that 89% of parents considered their local speech pathology service to be inaccessible. Another paper by O'Callaghan et al. (112) reported that 63% of rural and remote parents had difficulty accessing speech pathology support. A review of the literature uncovered many barriers that affect children's access to speech pathology services in Australia. These are discussed below using the Health Care Access Barriers Model, a model developed by Carrillo et al. (123) (see Figure 5).

Financial barriers

Financial barriers are associated with the costs of care. The main financial barriers reported by Carrillo et al. (123) are related to uninsured or under-insured patients. Australia has a publicly-funded, universal health care system (Medicare) (124), so health insurance has a smaller impact. However, financial barriers are still significant, and many studies have shown that children from low-income families are less likely to receive speech pathology support (118, 125).

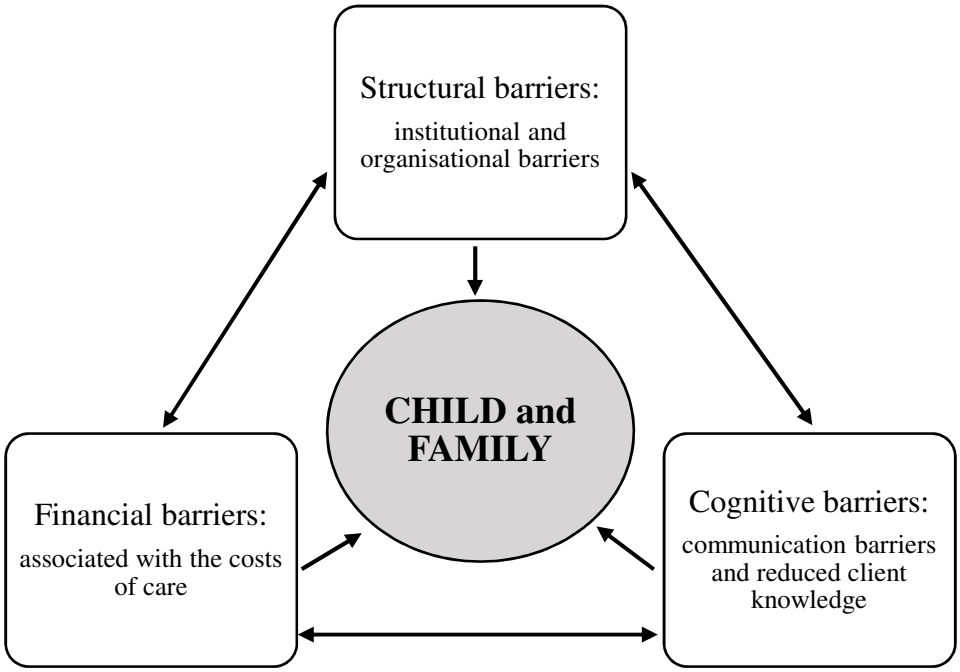


Figure 5 Health Care Access Barriers model

The main financial barrier that affects Australian families, particularly those in rural and remote areas, is travel costs (113, 115). O'Callaghan et al. (112) found that 53% of parents considered travel costs to be a major barrier to speech pathology access. Although state governments may provide travel subsidies, O'Callaghan found that only 13% of surveyed families were eligible for these subsidies (112). Families who need to travel may also experience lost income when parents request time away from work (113).

The cost of private services is also an access barrier (116, 126). Some private health funds allow families to claim a rebate for speech pathology services, however, gap payments and service caps are common. Children with chronic conditions can receive five subsidised private sessions per year through Medicare, however, gap payments still apply, and five sessions is insufficient for most children (127, 128). Due to gap payments, this funding scheme has a limited effect on accessibility for financially disadvantaged families (128).

Structural barriers

Structural barriers include institutional and organisational barriers (123). Even when a service is available in the community, the physical location of that service can be a barrier, particularly for families without a car (113) or where public transport is inadequate or unavailable (112, 113, 115). In rural areas, families who live outside of towns need to travel to access services (112, 115, 126),

and Wilson et al. (113) found that rural parents travelled an average of 143 kilometres to attend speech pathology appointments.

Many rural speech pathology departments are based in larger rural centres, with occasional outreach visits provided to smaller towns. Infrequent service delivery can be a significant barrier to service access (117), and may affect quality of care (116). Speech-language pathologists have limited time during outreach visits (114, 117), and caseload size may restrict the SLP's ability to see all clients during each visit (113). Many rural speech pathology departments are staffed by sole practitioners (114), resulting in service gaps during leave periods.

Speech-language pathologists may have limited ability to offer parents their preferred appointment day or time, which may be difficult for parents who work (125) or have additional family demands (120). Another organisational barrier cited in the literature are appointment changes and cancellations by the family and SLP (112), which can lead to infrequent service access, and may cause families to disengage from services.

Most speech pathology services are in high demand, forcing service providers to implement waiting lists which is a common access barrier (113, 116, 126). A study of Australian waiting lists found that 23% of children waited between two and six months for an initial assessment, and 42% of children waited a further month for therapy. It is concerning that 15% of children waited over a year for assessment, and that 10% of children waited a further year for therapy (116). Unsurprisingly, long waiting lists are a major cause of dissatisfaction among parents (112). In response to waiting lists, service providers may limit the number and duration of appointments (26), which may reduce quality of care.

Other structural barriers that reduce access include restrictive eligibility requirements (including cut-off ages), and discharge processes (116). For example, some services do not see children aged over 4 years, causing children to wait until they start school to access education speech pathology services. Other services prioritise moderate and severe impairments, and may not accept children with mild impairments. This means that families of children with mild impairments must pay for private services or go without. As a result of negative experiences while attempting to access services, families may choose not to continue with speech pathology services (112, 120).

Cognitive barriers

Cognitive barriers include the client's understanding of their health condition and available services, and communication barriers between clients and service providers (123). Many parents have a limited understanding of speech and language impairment (112, 126), which may result in low referral rates. Service access may be affected by poor understanding of the health care system (120) and referral processes (125), and cultural differences may mean that some families do not consider communication impairment to be a problem (120).

The ability of the service and SLP to communicate and engage with the community plays an important role in service accessibility. Minority groups, low-income families, and transient, migrant, and indigenous populations experience particular service access barriers (118). Speech-language pathologists may incorrectly believe that these groups do not want a service (120). Access barriers for these groups include culturally inappropriate services (117, 120) and poorly accessible information about services (120). In rural and remote areas, barriers include confidentiality concerns, poorly promoted and coordinated outreach services, and difficulty building rapport and trust (117).

3.2 Speech pathology availability and accessibility for CMC

Children with medical complexity are likely to experience additional access issues related to their medical condition and extraordinary service needs. No studies to date have specifically investigated speech pathology availability and accessibility for CMC, however, it is likely that many of these children have difficulty accessing speech pathology support. A study in the USA found that 14% of children with special health care needs (of which CMC is a subgroup) do not receive all of the allied health services they require (129), and another study reported high levels of unmet therapy need among CMC (130).

Because complex medical conditions are high acuity and are rare in childhood, most CMC are seen by an SLP who works in a tertiary children's hospital. Tertiary facilities offer a range of paediatric subspecialties and support services, and SLPs who work in these hospitals work as part of a coordinated team, and have specialist skills and knowledge, and access to specialist resources. Tertiary children's hospitals are usually located in major metropolitan areas, which means that many CMC live at a distance from tertiary care. As a result, many families are forced to travel long distances. Smith et al. (31) found that families travelled for a long time (median = 80 minutes) to attend specialist appointments at a children's hospital in Brisbane. Families may have to make this trip regularly, which places a significant time burden on the family. Travel for speech pathology

appointments in addition to other medical and allied health appointments is costly and difficult, particularly for children with physical, psychological, or behavioural impairments, those with equipment needs, or for children who are medically fragile (131, 132).

Frequent travel for appointments also contributes to family stress. Mothers of children with cancer were interviewed regarding their treatment experiences, and reported that family upheaval was common. Families are unable to maintain a "normal" family life, which affects relationships, family functioning, and the mental health of family members (133). By improving the accessibility of speech pathology services, family pressure may be reduced.

3.3 Service delivery options

As discussed in the previous section, CMC are likely to experience difficulty accessing tertiary speech pathology support. Reduced service access may delay assessment, diagnosis, and treatment, leading to poorer service outcomes for these children. To improve service speed and efficiency, screening may be conducted prior to full assessment. Currently, within the Queensland government health system, CMC are likely to receive speech and language screening following attendance at the tertiary hospital, via outreach services, or as part of a shared care arrangement between the tertiary hospital and local services. These three options and their advantages and disadvantages are discussed below, along with a fourth proposed approach: telepractice screening.

Option 1: Screening at the tertiary hospital

Currently, most CMC travel to the tertiary hospital for speech pathology services. Although this is efficient and cost-effective for the service provider, there are disadvantages for families, including travel distance and family upheaval (due to time spent away from home). Appointments with the SLP are usually coordinated with medical appointments or admissions, which can lead to scheduling difficulties. The child can become fatigued if they see multiple professionals in one visit, which can affect assessment findings. Scheduling difficulties and travel may increase waiting times, thereby delaying diagnosis and treatment. Communication between the tertiary SLP and local healthcare team may be limited, which can reduce service coordination and quality.

Option 2: Outreach screening services

Many tertiary children's hospitals provide occasional outreach services. Speech pathology service accessibility would be improved if the frequency and reach of these outreach services was increased. This would allow children to access screening with a tertiary SLP in their local community, reducing

travel time and costs for the family. The SLP can easily communicate with the local healthcare team during outreach visits, which can increase care coordination. However, an outreach service cannot provide services as frequently as a permanent service, thus increasing waiting times. Regular outreach services may be cost-prohibitive for service providers, and outreach services are inefficient, as the SLP spends a lot of time travelling in order to see a small number of clients.

Option 3: Shared care

Some CMC may have access to local speech pathology, or to other professionals trained to undertake screening (e.g. child health nurses, general practitioners). This means that local professionals and tertiary SLPs may cooperate to form a shared care arrangement, where clinicians share information and resources. In this model, screening can be conducted either locally or by the tertiary SLP. As discussed previously, screening appointments at the tertiary hospital are usually coordinated with other appointments, which may lead to scheduling difficulties and fatigue. If this is an issue, the child can instead see the local SLP for screening. This reduces the family's travel, time-burden, and expenses. Unfortunately, many CMC will not be eligible for local speech pathology services (e.g. due to age, severity level), or may be considered low priority as they already receive a service via the tertiary hospital. Some local therapists may lack expertise in the area of medical complexity, meaning that subtle or emergent deficits may be missed, and local nursing and medical professionals may not have experience in using speech and language screening tools.

Option 4: Telepractice screening services

Telehealth is defined as the use of "computer-assisted telecommunications to support management, surveillance, literature, and access to medical knowledge" (134), and "the application of telecommunications technology to the delivery of … professional services at a distance, by linking clinician to client/patient, or clinician to clinician for assessment, intervention, and/or consultation" (135). Telepractice may be conducted using synchronous methods (technologies that allow real-time audio and video interaction), such as videoconferencing or teleconferencing between the patient and clinician, or can be conducted using asynchronous methods (store-and-forward), for example, transmission of images or data via email for viewing by a professional (135). Telehealth is also known by other terms, including telemedicine, telerehabilitation, and telepractice. The term telepractice is used by ASHA and SPA to reflect that speech pathology services are delivered across a range of settings, and not just in a medical environment (135, 136).

Telepractice allows CMC to access speech pathology screening services from home or a local hospital or clinic, which may reduce travel time, costs, and family disruption (31). A telepractice service allows the SLP to screen the child promptly, and thus prioritise children who require assessment during their next hospital visit. Alternatively, if no upcoming visits are planned, the tertiary SLP may organise a local assessment through a shared care arrangement. Either way the child will be diagnosed and treated sooner than would be possible within a traditional service delivery model at a tertiary hospital (see Figure 6).

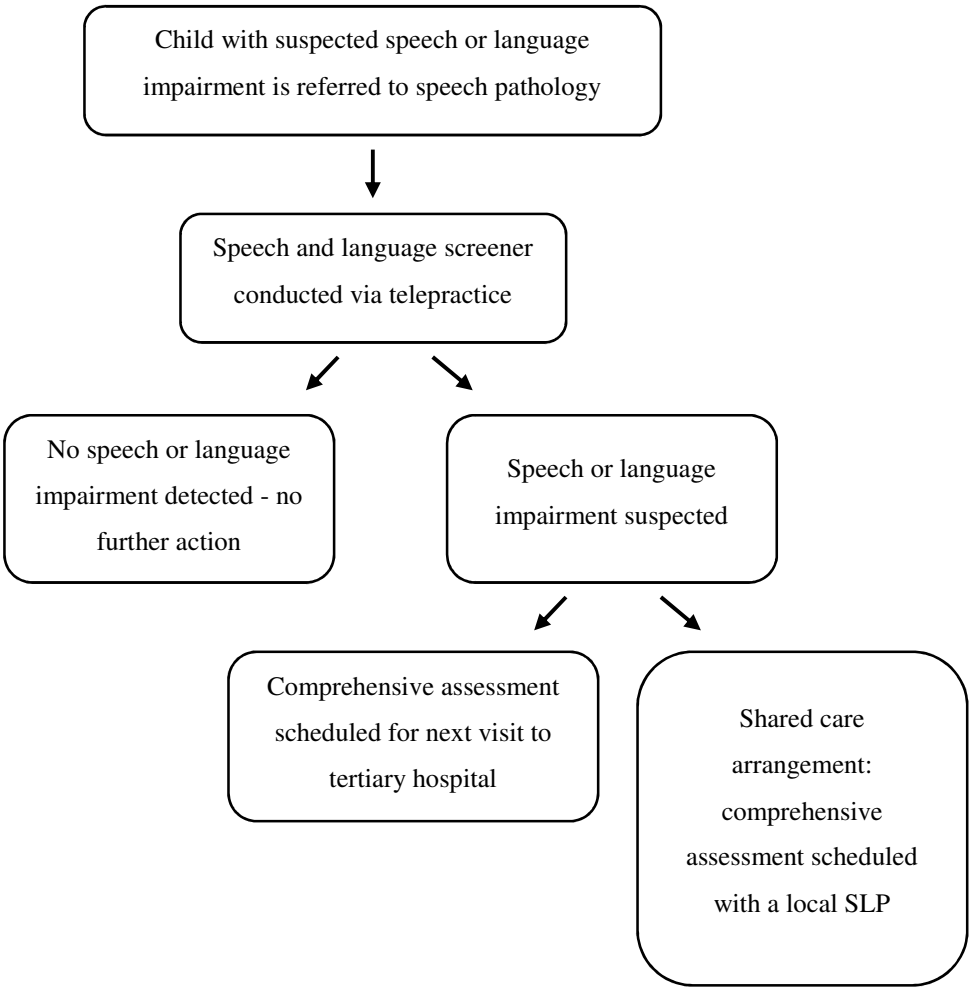


Figure 6 Possible telepractice screening pathway

Telepractice screening allows the SLP to remotely screen children who live across a wide geographical area prior to completing in-person assessment. Some children will present with normal skills, and will not require a comprehensive assessment. This may improve efficiency and save costs for the service provider (32). Although there are set-up costs associated with a new telepractice

service, many organisations have already invested in the necessary equipment. In some cases the service provider may need to buy or loan equipment for the family to use, however, a 2013 study in Queensland, Australia found that 93% of CMC already owned the equipment necessary for a telepractice consult (137).

Telepractice also offers the opportunity for local SLPs to access educational and mentoring opportunities (131, 138-140). Telemedicine studies have reported improved communication between local doctors and paediatric subspecialists (138, 139, 141), with subsequent improvements in the quality and continuity of care (138, 139, 141-145). It is likely that similar effects would occur for speech pathology patients.

3.4 Efficacy and adoption of speech pathology telepractice

Over the last 40 years, many studies have investigated the use of telepractice for speech pathology service delivery (136). Speech pathology interactions may be particularly suitable for telepractice adoption, as many interactions between an SLP and their client are visual and auditory with little need for physical contact (146). Since 2010, the body of evidence in this area has grown rapidly (32) as developing technologies have become cheaper, more accessible, and more effective. A number of literature reviews and recent research papers have found telepractice to be an efficacious and acceptable method for speech pathology management of:

- acquired speech and language disorders (147-152)
- cognitive communication disorders (151)
- adult voice disorders (149-151, 153-155)
- dysphagia (swallowing impairment) (149, 151, 156)
- literacy impairment (157)
- stuttering (149, 151, 158).

A number of narrative reviews have concluded that therapy for childhood speech and language impairment via telepractice is feasible and valid (149, 151, 152, 159-161). However, there are no published systematic reviews describing the use of telepractice for paediatric speech and language screening.

Telepractice has been well-established as an effective way to deliver tertiary-level medical and nursing services to CMC (131, 141, 144, 162-170). However, there is limited evidence to support

telepractice for speech pathology management of complex paediatric patients. A literature search (see Chapter 4) found only seven studies that investigated the effectiveness of telepractice for speech pathology service delivery to CMC (33, 139, 140, 171-173). None of these studies investigated language screening or assessment, and only three studies examined the use of telepractice for assessment of speech production. These three studies all described the use of telepractice for assessment or treatment of speech impairment among international patients with cleft lip and palate (33, 140, 171). Whitehead et al. (33) and Furr et al. (171) both reported high patient satisfaction with telepractice services, and Whitehead et al. (33) established that telepractice assessment of cleft palate speech is equivalent to in-person assessment. These studies concluded that telepractice can be used to increase service access for patients with cleft lip and palate in developing countries.

Despite this growing evidence-base for speech pathology telepractice, it is unclear how many SLPs currently use telepractice. Surveys conducted in the USA between 2002-2012 reported low rates of telepractice adoption among SLPs, with only 2-9% of respondents using telepractice (174-176). A more recent survey in 2014 found an increased number of telepractice users, with 55% of SLPs using telepractice (177). However, this survey targeted respondents with an interest in telepractice (members of a telepractice special interest group), so rates of telepractice use across the profession are likely to be lower than this. To date, no studies have investigated telepractice use among Australian SLPs, although a survey in 2011 found that only 3% of Australian allied health practitioners (including SLPs) used telepractice for direct clinical work (e.g. remote consultations with patients) (178), thus adoption is likely to be low. However, this study did not include remote patient monitoring via telephone or email within their definition of "telepractice", which may account in part for these low rates of adoption.

Although SLPs indicate an awareness of telepractice benefits (179-182), therapists identify a number of barriers that prevent them from using telepractice with their clients. These include:

- negative perceptions (175, 176, 180)
- reduced understanding (176, 180)
- a lack of training (179, 180, 183)
- a need for assessment and therapy tools that have been adapted for the telepractice environment (175, 182, 183)
- a desire for more professional standards, research evidence, and guidelines (175, 176, 178, 180, 182)
- concerns about equipment and technology (175, 178-183)

- a lack of information and communications technology (ICT) support (182)
- concerns about time required for consults, and to establish a telepractice service (176, 179)
- a lack of funding and difficulty with reimbursement (175, 176, 178-180, 182)
- concerns about patient confidentiality (176)
- confusion surrounding licensing and medicolegal requirements (176).

Paediatric SLPs identified an additional barrier: concerns regarding their ability to build relationships with children, caregivers, and teachers during telepractice consults (175, 183).

It is encouraging to see in the literature that many SLPs hope to use telepractice in the future despite these barriers (176, 178, 180, 181), and that the majority of current users view telepractice positively (175, 183) and would like to use it more often with their patients (176, 182). No studies have reported data regarding rates of telepractice adoption among SLPs who work in tertiary children's hospitals, so it is not clear how many CMC currently receive telepractice services, or what the specific challenges and opportunities are for telepractice use among this group of children.

3.5 Chapter conclusion

The aim of this chapter was to examine availability and accessibility of speech pathology support for CMC, and to introduce telepractice as a possible solution to improve service access for these children. Tertiary SLPs have specialist skills and experience in managing complex patients, however, many CMC have difficulty accessing screening with a tertiary SLP due to distance, time, and cost. In this chapter I have described four possible service delivery models, and considered their usefulness for conducting speech and language screening. Telepractice offers many advantages over the other service delivery models, however, rates of telepractice adoption among SLPs remain low.

Evidence to support speech pathology telepractice is growing, although there is limited evidence that specifically considers CMC, and no published reviews that have examined the effectiveness of paediatric speech and language screening via telepractice. In the following chapter I will examine what is currently known in this area, by systematically reviewing the published literature relating to speech and language assessment via telepractice for children, including those with medical complexity.

CHAPTER 4 A review of the efficacy and effectiveness of using telepractice for paediatric speech and language assessment

The previous chapter outlined the current literature relating to the use of telepractice for speech pathology service delivery. Research has found telepractice to be efficacious and acceptable for delivery of services to a range of adult and paediatric client groups. Although some literature reviews have included paediatric studies, no reviews have focused specifically on the use of telepractice for screening/assessment of speech and language among the general paediatric population, or with CMC.

This chapter will identify and evaluate studies describing the use of telepractice for paediatric speech and language screening/assessment, including studies with the CMC population, in order to answer this research question: in children, is telepractice efficacious and effective for conducting remote speech and language screening and assessment when compared with in-person methods?

The first part of this chapter contains relevant definitions and a description of the systematic search method. This is followed by summary and critical appraisal of the relevant evidence, and identification of current knowledge gaps.

4.1 Methods

Definitions

For this systematic review, efficacy has been defined as "the extent to which a specific intervention … produces a beneficial result under ideal conditions" (184). Effectiveness has been defined as "the extent to which a specific intervention … when deployed in the usual circumstances … does what it is intended to do for a specified population" (184).

Inclusion criteria

Studies were included if they reported research into speech and language screening or assessment via telepractice for children 0-16 years, and had been published in an English-language, peer-reviewed journal between January 2006 and October 2017. Telepractice was defined as "the application of telecommunications technology to the delivery of … professional services at a distance" (135). Conference proceedings, reviews, editorials, commentaries, and grey literature were excluded, as the focus of this systematic review was on formal studies from which data could be extracted (i.e. peer-reviewed literature).

Although my body of work is concerned with the use of screening via telepractice, studies into telepractice assessment were also included in this review. Speech and language screening tools are often adapted from comprehensive assessment tools, thus, information pertaining to comprehensive assessment via telepractice will also be applicable to screening.

Search process

A literature search was undertaken using the PubMed database, with the following search string:

(telepractice OR telehealth OR telemedicine OR telerehabilitation OR telecare)
AND (speech OR language OR communication)
AND (assess* OR evaluat* OR screen*)
AND (pediatric* OR paediatric* OR child*)

Equivalent searches were completed using the CINAHL, PsycINFO and ERIC databases.

I reviewed the titles and abstracts of all identified papers to determine their relevance, and to remove duplicate records. If required, I read the full-text article, and I consulted my advisors if it was unclear whether or not to include an article. I searched reference lists to identify relevant papers, which were then acquired. Articles were categorised and tabulated according to study design, equipment, validity, reliability, satisfaction, and child behaviour. A formal quality appraisal of the included studies was not performed.

4.2 Results

The database search and associated reference lists identified 312 papers after duplicates were removed. After reading the title and abstracts, 301 articles were excluded as they did not describe paediatric speech and language assessment via telepractice. After reading the full study, a further three papers were excluded as they did not address the research question. Only nine papers met the inclusion criteria (see Figure 7). All of the identified papers aimed to demonstrate efficacy, and no studies of effectiveness were found (see Table 1).

All of the studies were method comparison studies (33-41). Two related studies by Guiberson et al. (40) and Guiberson (39) investigated the validity of telepractice language screening by comparing telepractice screening results (i.e. pass/fail) with the results of comprehensive in-person assessment. For these studies, all screening test administration and scoring was conducted via telepractice. The remaining studies investigated telepractice validity by comparing assessment results gathered by a remote, telepractice SLP with those gathered simultaneously by an in-person SLP. Two of these studies randomly allocated participants to an in-person- or telepractice-led condition, and these studies also randomly allocated SLP roles (34, 35). The other studies did not use randomisation to allocate participants or assign SLP roles (33, 36-38, 41).

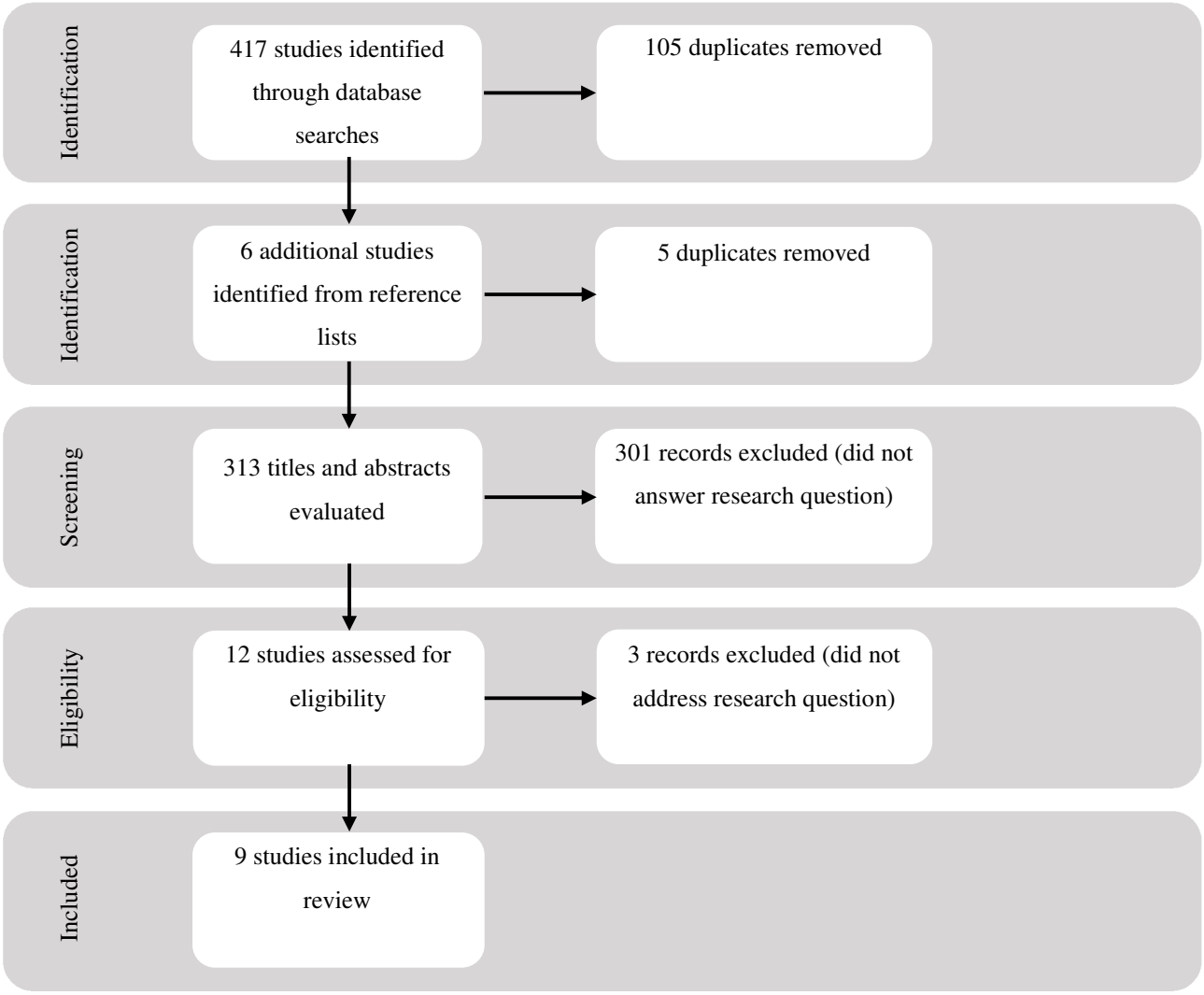


Figure 7 PRISMA flowchart of study selection process

Study design

Four studies investigated the reliability of telepractice assessment by measuring intra- and/or inter-rater reliability (34-36, 40). Three papers included a parent satisfaction survey (33, 38, 41). Sutherland et al. (41) gathered information regarding telepractice quality, and also included a comparison of child behaviour across in-person and telepractice modalities. Studies also varied according to participants, speech/language assessment tools, statistical analysis, and equipment.

Participants

Most of the studies focused on older children (33-37, 41), although two studies included preschool-aged children (38, 40). Papers by Guiberson et al. (39) and Whitehead et al. (33) investigated telepractice screening/assessment with toddlers and secondary school-aged children respectively. Three studies investigated the use of telepractice for screening or assessment with Spanish-speaking children (33, 39, 40), although the other studies included English-speaking children only. Many of the studies had fewer than 25 participants, and studies by Waite et al. (36), Eriks-Brophy et al. (37), and Whitehead et al. (33) had particularly small sample sizes (n = 6-9). Ciccia et al. (38) had a large sample size of 263 participants who were assessed via telepractice, although only 10 of these children received a simultaneous in-person assessment as a comparator. The studies by Guiberson et al. (40) and Guiberson (39) had reasonable samples of 82 and 62 participants respectively.

Whitehead et al. (33) focused on speech evaluation for children after surgical cleft palate repair, and this was the only paper that included CMC. Other papers that included CMC were excluded from this review as they did not answer the research question, or meet eligibility requirements.

Speech and language assessment tools

Two papers completed formal screening tools via telepractice (38, 40) and two papers used other screening methods (e.g. parent checklists, play/gesture ratings) (39), and language sampling (39, 40). The remaining papers completed comprehensive assessment via telepractice using both formal and informal tools (33-37, 41). All of the formal speech and language screeners and assessments used in the studies are validated tools (185-194). Four papers examined language screening/assessment (35, 39-41), three papers examined speech screening/assessment (33, 34, 36), and two papers considered both speech and language screening/assessment (37, 38).

Statistical analysis

The identified studies investigated validity and/or reliability of telepractice assessment by calculating concordance between telepractice and in-person modalities for assessment scores or diagnostic

accuracy, or by measuring agreement between repeated telepractice conditions. The most common statistical method used to calculate concordance was percentage agreement, with criteria for acceptable agreement ranging between 70-95% (34, 36-38). Kappa statistic was used by three studies (both weighted and unweighted) (33-35), with criterion for acceptable agreement based on Altman (195). Whitehead et al. (33) used both percentage agreement and kappa statistic, but did not specify what the criteria was for acceptable agreement. Other analyses used included paired t-tests (35, 41), Pearson product-moment correlation coefficients (40, 41), partial correlation (39), diagnostic accuracy (sensitivity and specificity, likelihood ratios) (39, 40), and Bland-Altman analyses (41). Guiberson (39) used logistic regression to calculate the diagnostic accuracy of combined telepractice screening measures.

Equipment

A custom-built, hardware-based system was used in three studies (34-36). This equipment was specially designed for low-speed network connections, and used a 128 kbit/s Internet link to reflect the minimum available speed available to health and education facilities in the state of Queensland. The study by Whitehead et al. (33) also used a hardware-based telemedicine system along with a dedicated Internet link of unspecified bandwidth. In contrast, four other studies used a software-based system with consumer-grade equipment. Software and equipment used included Skype on standard computers with webcams (38), a web-based telepractice interface on standard computers with webcam and touch screen (41), and Apple iPads (39, 40). None of these studies specified the available Internet bandwidth. Eriks-Brophy et al. (37) did not describe the equipment used in their study.

All of the studies except one used real-time videoconferencing (i.e. synchronous interaction) (33-38, 40, 41) to conduct screening or assessment. Four of these studies video-recorded the assessment session for later scoring (i.e. asynchronous interaction) (34-36, 40). The remaining study by Guiberson (39) used an asynchronous-only model. Studies that used the custom-built hardware-based system had access to store-and-forward technology that could transfer digital recordings via the Internet (34-36). Guiberson et al. (40) and Guiberson (39) video-recorded the assessment, then provided a physical copy of the tape to the SLP for later viewing and scoring.

The three studies by Waite et al. (34-36) remotely displayed images and pre-recorded test stimuli on the participant's computer. Sutherland et al. (41) also displayed images remotely, using a feature of the web-based telepractice interface. Two papers (39, 40) played e-books with pre-recorded test stimuli on the participant's iPad, although was controlled by the parent or an assistant (not remotely controlled). The other studies (33, 37, 38) did not describe how assessment stimuli were displayed.

Validity of speech assessment

Five studies (33, 34, 36-38) examined the validity of telepractice assessment for at least one aspect of speech production. The different speech assessment tasks investigated included

- oromotor assessment (OMA), evaluation of the function of the oral muscles (34, 36)
- articulation assessment, an assessment of speech production (36-38)
- speech intelligibility rating (SIR), a rating of how easily the child's speech can be understood by a listener (34, 36)
- evaluation of cleft palate speech (33).

Oromotor assessment (OMA)

Two studies compared OMA via telepractice with in-person assessment (34, 36). Both demonstrated high levels of concordance between the modalities, with 91% agreement reported in the first study (36), and 73% exact and 96% close agreement (within 1 point on the rating scale) found in the second study (34). There was reduced agreement for some individual oromotor tasks, including sequenced movements (63% agreement) (36), tongue protrusion ($\kappa = 0.12$), tongue lateralisation ($\kappa = 0.36$), and diadochokinetic (DDK) tasks (how quickly a person can repeat a series of sounds, such as pa-ta-ka) ($\kappa = 0.14–0.30$) (34).

Articulation assessment

Three studies investigated articulation assessment (36-38). Ciccia et al. (38) screened speech production using the *Preschool Language Scale, 4th Edition (PLS-4)* articulation screener (187), and measured percentage agreement between telepractice and in-person conditions. Exact agreement (100%) was found between the conditions for pass/fail on the screener, although individual item comparisons were not made.

The remaining two studies (36, 37) measured concordance between telepractice and in-person conditions for full articulation assessment, and reported somewhat conflicting results. Waite et al. (36) found high levels of overall agreement (92%) between the conditions, whereas Eriks-Brophy et al. (37) reported only 80% mean agreement. Both studies noted poor judgment via telepractice for some individual speech sounds, including difficulties detecting voicing (whether the vocal cords vibrate during speech production) (36, 37) and poor concordance for sounds without visible articulation (e.g. the sounds /k/ and /g/ are made at the back of the mouth) (36). Assessment of high frequency sounds (such as /s/ and voiceless /th/), and consonant clusters (a combination of two or more consonant sounds) also had poor accuracy via telepractice (37).

Speech intelligibility rating (SIR)

Two of the studies rated speech intelligibility using telepractice (34, 36). These studies reported high levels of agreement between the telepractice and in-person conditions, with 100% close agreement (within 1 point on the rating scale) found in both studies. Exact agreement was 70% in the second study, with a weighted kappa of 0.86 (34).

Evaluation of cleft palate speech

Only one study investigated cleft palate speech assessment (33). This study concluded that telepractice and in-person assessment were equivalent for evaluation of oral muscle tone (100% agreement; $\kappa = 1$; $p = 0.001$), resonance (100% agreement; $\kappa = 1$; $p = 0.003$), tongue lateralisation (89% agreement, $\kappa = 0.5$; $p = 0.001$), oral pressure (67% agreement; $\kappa = 0.4$; $p = 0.037$), and dentition (56% agreement; $\kappa = 0.5$; $p = 0.0008$). There was a positive correlation between the telepractice and in-person results for tongue elevation, nasal/facial grimacing, palate movement, and nasal air emission, although these results were not statistically significant ($p = 0.05 – 0.7$).

Validity of language assessment

A total of six studies examined the validity of language screening or assessment. Ciccia et al. (38) measured concordance between telehealth and in-person language screening, and found 100% agreement for pass/fail status, although agreement for individual items was not described. Two related papers by Guiberson et al. (40) and Guiberson (39) examined the accuracy of language screening via telepractice for toddlers and preschool-aged children by comparing pass/fail status on a screening test with results from a comprehensive in-person assessment. They concluded that some telepractice screening tasks were significantly correlated with standardised language scores, including non-word repetition ($r = 0.55$, $p < 0.01$), narrative retell ratings ($r = -0.38$, $p < 0.01$) (40) and various language sampling measures ($r = 0.47$-0.70, $p \leq 0.001$) (39). There was only a small correlation between play and gesture ratings completed by telepractice, and language scores (play: $r = 0.10$-0.17; gesture: $r = 0.17$) (39). The diagnostic accuracy of telepractice screening was calculated, and the authors concluded that individual screening tasks do not provide adequate diagnostic accuracy. However, logistic regression calculations found stronger diagnostic accuracy when SLPs administered tasks in combination for toddlers ($R^2 = 0.63$, $p \leq 0.01$) and preschool-aged children ($R^2 = 0.54$, $p \leq 0.01$).

The remaining studies examined full language assessment (35, 37, 41). All of these studies reported high levels of concordance between telepractice and in-person assessments. Waite et al. (35) found

no significant difference between telepractice and in-person subtest scores on the *Clinical Evaluation of Language Fundamentals, 4th Edition (CELF-4)* (188), and Eriks-Brophy et al. (37) found agreement of 98-100% between telepractice and in-person conditions for the same assessment. Sutherland et al. (41) also investigated concordance between telepractice and in-person administration of the *CELF-4*, and strong correlations between the two modalities (correlation coefficient = 0.96-1.00; $p < 0.001$), with high levels of agreement for severity ratings (96%). Eriks-Brophy et al. (37) found very good agreement (98-100%) between telepractice and in-person conditions for scores on the *PLS-4* (187), the *Peabody Picture Vocabulary Test, 3rd Edition (PPVT-III)* (186), and the *Expressive One-Word Picture Vocabulary Test (EOWPVT)* (189). Discrepancies between telepractice and in-person conditions found across these studies included difficulty differentiating between similar sounding words (e.g. cook-book) (35), difficulty hearing pluralisation (37), and the need to repeat test instructions (37, 41).

Reliability

Four studies (34-36, 40) conducted intra- and inter-rater reliability analyses to examine the reliability of telepractice assessment. Intra- and inter-rater reliability was very good for rating intelligibility (intra-class correlation coefficient, ICC $\geq$ 0.80) (34) and language assessment via telepractice (ICC > 0.80) (35). Guiberson et al. (40) calculated percentage agreement for inter- and intra-rater reliability, and found high agreement for Spanish-language screening tasks (92-97% agreement between raters). Waite et al. (36) also used percentage agreement to examine inter- and intra-rater reliability, and found high agreement for articulation assessment (intra-rater agreement = 94% and inter-rater agreement = 87%). However, Waite et al. (34) found that reliability for OMA was variable across both telepractice and in-person modalities, ranging from moderate to very good for both intra-rater (ICC = 0.53-1.00) and inter-rater reliability (ICC = 0.36-0.63).

Satisfaction

Only three of the studies presented satisfaction data (33, 38, 41). Both Ciccia et al. (38) and Whitehead et al. (33) reported high levels of overall satisfaction. Parents interviewed in these studies indicated they would be willing and interested in using telepractice services again, and expressed satisfaction with the audio and image quality. Sutherland et al. (41) found that parents and their children were comfortable with telepractice assessment. Although most parents made positive comments about telepractice assessment, a small number of parents (2/13) voiced concerns about telepractice and stated that they did not wish to access telepractice services in the future. In contrast to this, parents surveyed by Ciccia et al. (38) indicated that they would prefer to access screening via telepractice during an existing health appointment rather than attend an in-person appointment.

Sutherland et al. (41) surveyed clinicians regarding telepractice audio and image quality, and issues associated with child, clinician, and technological factors. Overall, clinicians reported no child, clinician, or technological issues that affected assessment. Clinicians rated telepractice audio quality as good 74% of the time, and image quality was rated as good 83% of the time. Clinicians identified audio quality issues including low volume, and words cutting out. Clinicians reported that they remedied these issues by repeating instructions and speaking more loudly.

Child behaviour

Only one study considered child behaviour during telepractice assessment (41). In this study, a behaviour checklist was completed related to the child's compliance, activity/restlessness, attention/distractibility, fatigue, boredom, frustration, and anxiety. No statistically significant differences were found for child behaviour between the in-person and telepractice assessment modalities.

4.3 Discussion

This review found that formal research into speech and language assessment of children via telepractice has been limited. All identified studies aimed to assess telepractice efficacy, and there were no studies that assessed the effectiveness of telepractice in routine care. Nine informal method comparison studies were identified, and most of these had small sample sizes. All of the identified studies examined the validity or reliability of speech and/or language assessment or screening via telepractice. Test-retest bias was eliminated by simultaneous scoring by two SLPs (a telepractice and an in-person SLP); or by using two different assessment tools for the telepractice and in-person conditions. Most papers did not randomly allocate participants to assessment conditions, which introduced possible bias (33, 36-41). Two studies eliminated assessment condition bias by randomly allocating the participants to different conditions, and these studies also reduced clinician bias by randomly allocating SLP roles (34, 35).

Comparison between studies was difficult due to the variation in participant characteristics. Most studies included older children. Thus, results from these studies cannot necessarily be generalised to toddlers or preschool-aged children as behaviour, attention, and listening skills differ between age groups. Only three studies specifically examined younger children, and all of these used screening tests rather than full assessments (38-40). These studies all concluded that telepractice screening was valid and reliable for younger children. However, screening tests are brief so this does not necessarily provide support for full speech and language assessment within this age group. It is best practice to

diagnose speech and language difficulties before children start school, so they can receive appropriate early intervention. Therefore, further research is required to validate telepractice speech and language assessment with toddler and preschool-aged children.

There was also variation between studies in terms of statistical analysis. Many papers used weak or inappropriate methods for measuring concordance, such as percentage agreement, kappa statistics, or Pearson's *r*. Percentage agreement is an informal measure; kappa may be difficult to interpret; and Pearson's *r* indicates correlation between measurements, which does not necessarily indicate agreement between the methods of measurement (196). Only two studies used a more rigorous method for calculating agreement (the Bland-Altman Limits of Agreement procedure) (40, 41). More rigorous statistical methods for calculating agreement such as the Bland-Altman Limits of Agreement (196) or Lin's Concordance Correlation Coefficient (197) should be considered for future studies.

The studies identified also varied in terms of telepractice equipment used. All studies except one (39) used systems that were primarily synchronous; although four papers used a hybrid approach consisting of both synchronous and asynchronous elements (34-36, 40). Asynchronous methods may help to overcome poor audio and image quality when Internet connection is slow (34-36). In some studies, the online SLP scored the assessment via telepractice, and then again from a high-quality digital video recording of the child's assessment (35, 36). This may improve the accuracy of assessment results, but it effectively doubles the amount of time that the SLP spends on each assessment, which reduces efficiency for the service provider. Custom-built hardware-based telepractice systems were described in four of the studies (33-36). A feature of these systems was the ability to remotely present assessment stimuli. Sutherland et al. (41) also remotely presented stimuli via web-based interface. Telepractice systems that allow remote presentation of stimuli may potentially save salary costs, by removing the need for an assistant to be present at the child's end. Remote presentation of stimuli also means that services can be provided more easily to the child in their own home.

Four studies used software-based telepractice systems with consumer-grade equipment (38-41). Systems that use consumer-grade equipment can offer advantages over hardware-based systems in terms of cost, access, and usability, however, it is possible that audio and image quality will be inferior. Sutherland et al. (41) noted issues with audio and image quality including low volume and interruptions, however, despite this most telepractice sessions were rated as "good" for audio and video quality. The authors of the other studies did not report any video or image disturbances during videoconferencing (38, 40). This is surprising in the case of Skype, as used by Ciccia et al. (38),

which has been reported to have limitations in terms of speed, quality, and reliability (198-200). Guiberson et al. (40) conducted videoconferencing using Apple iPads, but the authors did not specify whether connection was via Internet or mobile data, which may affect connectivity, image quality, and sound quality. To date, few studies have investigated iPads for telepractice, and there is variable evidence regarding feasibility. One study (201) reported good audio and video quality during videoconferencing with an iPad when mobile data was used, although other studies (202, 203) have reported issues with connectivity, audio quality, and image quality. It is possible that disturbances did occur during videoconferencing with Skype and the iPads, but that these were either unreported or did not affect the SLP's ability to complete a brief screening test. More research into the feasibility and quality of easily accessible consumer-grade equipment is needed.

This literature search found some evidence to validate OMA, speech intelligibility rating (34, 36), cleft palate speech assessment (33), language screening (38-40) and full language assessment (35, 37, 41) via telepractice. Guiberson (39) found that language screening tools involving observation of gesture and play were not valid for identifying language disorder among toddlers via telepractice, possibly because these observations cannot be accurately completed during a brief, one-off screening interaction. Telepractice reliability was good for all speech and language tasks, with the exception of OMA (34). However, the subjective nature of oromotor rating may be to blame, as in-person reliability was also found to be poor. Articulation screening was found to be valid via telehealth (38), although results for full articulation assessment varied (36, 37). Conflicting results in these studies may be due to different criteria for acceptable concordance, or different statistical analysis used to determine agreement. Alternatively, the positive results for telehealth validity in the study by Waite et al. (36) may be associated with the use of store-and-forward technology.

Some studies reported discrepancies between telepractice and in-person conditions for individual speech and language tasks, possibly due to poor audio and image quality. Two papers observed that poor audio quality was associated with increased repetition requests (37, 41). Many standardised assessments have strict repetition rules, therefore, poor audio quality may invalidate assessment findings. Accurate judgement of individual tasks is essential, as the goal of an assessment is to determine which skills have and have not been mastered by the child. Errors associated with the telepractice environment have the potential to affect standardised scores, severity ratings, diagnosis, and therapy planning. In the case of children who score close to borderline, this may affect eligibility for therapy services or funding schemes. Changes to equipment (e.g. store-and-forward, increased Internet connection speed, pre-recording of assessment instructions) may improve audio and video quality.

Only three of the studies examined caregiver satisfaction, and none of the studies looked at child satisfaction. Overall, caregivers were satisfied with telepractice screening and assessment (33, 38, 41), and in one study parents even showed a preference for telepractice services (38). These results are consistent with research into adult speech pathology clients, which has also reported high satisfaction with telepractice assessment (204-208). However, telepractice may not be satisfactory for all caregivers. A small number of caregivers expressed concerns in one study, and indicated that they would prefer to access speech pathology assessment in a traditional, in-person model in the future (41).

Sutherland et al. (41) were the only researchers that evaluated clinician satisfaction with telepractice assessment. They asked the SLPs to rate their satisfaction with audio and image quality for each telepractice session. Clinicians rated audio and image quality as "good" for the majority of telepractice sessions. A number of adult studies have investigated clinician satisfaction, and most of these studies have found clinicians to be less satisfied with telepractice services than their patients (199, 204, 208, 209). A study by Ward et al. (204) reported that only 20% of clinicians felt able to assess adult patients to the best of their ability via telepractice. This is concerning, as reduced clinician confidence is likely to be associated with low uptake of telepractice services among SLPs. Future research into clinician satisfaction with telepractice assessment for children needs to take into account a range of factors that influence satisfaction, such as clinician preference, usability, and confidence in assessment accuracy. Research into clinician satisfaction will help guide the development of strategies to increase telepractice adoption.

Children's behaviour during telepractice assessment was only reported in one study, which found no significant difference between telepractice and in-person assessment modalities for factors including compliance, distractibility, fatigue, or anxiety (41). Although this finding is promising, this study included a limited number of 8-12 year old children. Further research into child behaviour is needed, particularly among younger children and those with developmental or medical complexity. These groups of children are more likely to demonstrate challenging behaviours that may affect the validity of telepractice assessment. Other characteristics of paediatric assessment such as rapport building and behaviour management should also be investigated.

Only one paper included CMC (33). Findings from this paper provide preliminary support for telepractice assessment of children with cleft palate, however, more studies that specifically consider the broader CMC population are required. In particular, studies are required to validate a telepractice model for assessment of unusual speech errors, oral anatomy, and oromotor function, for example,

among children with craniofacial anomalies or those with dysarthria associated with brain tumours. Research should consider the effects of medical, developmental, and psychosocial complexity on attention, fatigue and behavioural issues; and how medical equipment and movement disorders (e.g. CP) may affect visualisation of the child during assessment. Caregiver, child, and provider satisfaction with telepractice is an important area to investigate, given the potential that telepractice had to improve service access for CMC patients.

4.4 Chapter conclusion

The aim of this chapter was to critically appraise evidence relating to the use of telepractice for paediatric speech and language screening or assessment, including studies with CMC. Despite a rapid increase in the number of studies that relate broadly to speech pathology telepractice, only a small number of studies have investigated the use of telepractice for paediatric speech and language assessment, and only one study included children with complex conditions.

These studies provide early support for the acceptability, validity, and reliability of some speech and language screening and assessment tasks via telepractice. Although positive, this current evidence is probably not yet sufficient to meaningfully influence clinical practice or policy development, and further research is needed to support telepractice screening and assessment before its routine adoption. The field would be advanced by publication of well-designed studies that examine validity and reliability of telepractice screening and assessment tools for the general paediatric population, and for CMC. Studies should consider a wider age-range, and the effects of the telepractice environment on behaviour and rapport building. The feasibility and quality of software-based systems that use consumer-grade equipment should be investigated, and studies must describe equipment and procedures in sufficient detail to allow reduplication.

The knowledge gaps outlined in this chapter will be used to guide the design of a method comparison study that will compare in-person screening with telepractice screening. This study will be described in Chapter 6. However, first it is important to understand current use of telepractice for patients with medical complexity. We know that telepractice adoption is low among SLPs, although no data exists to describe use of telepractice among SLPs who work with CMC, or what the specific challenges and opportunities are for telepractice service development with this group of children. The following chapter will describe my first research study: a survey of tertiary SLPs.

Table 1 Summary of included studies

Study	Intervention	Participants	Methods	Outcome
Waite et al. (2006) (36)	Speech assessment: Single word articulation test (SWAT) SIR OMA	n=6 4-6 years with diagnosed speech disorder English-speaking	Study design: a method comparison study reporting concordance between telepractice and in-person conditions, and intra- and inter-rater reliability for telepractice condition (criterion=70% for SWAT and OMA; +/- 1 point on rating scale for SIR). Equipment: custom-built, hardware-based telepractice system with real-time videoconferencing, store-and-forward, remote display of images and video, 128kbit/s Internet link. Procedure: assessment led by telepractice SLP, simultaneously scored by telepractice and in-person SLPs. The telepractice SLP completed scoring online and from a video recording of the assessment. Telepractice intra-rater reliability was calculated by comparing scores between initial rating and re-rating of the assessment 4 weeks later. Telepractice inter-rater reliability was calculated by comparing scores found by the telepractice SLP and an independent SLP.	High overall agreement between conditions for the SWAT (92%), OMA (91%), and SIR (100%). Agreement did not reach criterion for some speech sounds or OMA tasks. Intra-rater reliability: SWAT=94%; SIR=100%; OMA=90%. Inter-rater reliability: SWAT=87%; SIR=83%; OMA=76%.
Eriks-Brophy et al. (2008) (37)	Speech assessment: *Goldman-Fristoe Test of Articulation, 2nd Edition* (*GFTA-2*) (185) Language assessment: *PPVT-III* (186) *PLS-4* (187) *CELF-4* (188) *EOWPVT* (189)	n=7 4-12 years with suspected speech or language disorder English-speaking	Study design: a method comparison study reporting concordance between telepractice and in-person conditions (criterion=85% for speech; 95% for language). Equipment: not described. Procedure: assessment led by the telepractice SLP, simultaneously scored by telepractice and in-person SLPs.	High mean percentage agreement between conditions for language assessment (98-100%). Mean percentage agreement did not reach criterion for *GFTA-2* (80%). Discrepancies noted in *CELF-4* (detection of plurals), and *GFTA-2* (judgement of individual speech sounds).

Waite et al. (2010) (35)	Language assessment: *CELF-4* (188)	n=25 5-9 years with diagnosed or suspected language disorder English-speaking	Study design: a method comparison study with a randomised component reporting concordance between telepractice and in-person conditions using paired t-test, unweighted kappa, and weighted kappa statistics (criterion based on Altman). Intra- and inter-rater reliability calculated using ICC (criterion based on Shrout & Fleiss (210). Equipment: custom-built, hardware-based telepractice system with real-time videoconferencing, store-and-forward, remote display of images and video, 128kbit/s Internet link, remote camera control, touch screen. Procedure: participants randomly allocated to telepractice-led or in-person-led condition, simultaneously scored by telepractice and in-person SLPs (randomly assigned to roles). Telepractice SLPs also reviewed video recording of the assessment to aid scoring. Intra-rater reliability: telepractice (n=8) and in-person (n=8) assessments re-rated by the SLP 4 weeks after initial rating. Inter-rater reliability: telepractice (n=8) and in-person (n=8) assessments rated by independent SLP.	No significant difference found between conditions for subtest scores. Very good agreement for individual test scores (κ=0.88-0.98), core language score (κ=0.99) and severity level (κ=0.99). Intra-rater reliability: very good for telepractice (ICC=0.91-1.00) and in-person (ICC=0.87-1.00). Inter-rater reliability: very good for telepractice (ICC=0.84-1.00); good to very good for in-person (ICC=0.74-0.99).
Ciccia et al. (2011) (38)	Speech screening: *PLS-4* Articulation Screener (187) Language screening: *Receptive-Expressive Emergent Language Test, 3rd Edition* (*REEL-3*) (190) *Screening Kit of Language Development* (*SKOLD*) (191) *Preschool Language Scales Screening Test, 4th Edition* (*PLS-4 Screening Test*) (211)	n=263 Under 6 years with suspected speech or language disorder (Year 2, n=10 for in-person condition) English-speaking	Study design: a method comparison study reporting concordance between telepractice and in-person conditions (criterion for agreement not described). Satisfaction survey completed by parents (rated on 5 point scale, 1=strongly disagree, 5=strongly agree). Equipment: a software-based system using commercial-grade equipment (two laptops with built-in webcams, Skype 3.8 for Windows). Internet connection not described. Procedure: 2 year study Year 1: all participants screened via telepractice, no comparator. Year 2: age-matched participants (n=10) selected for in-person condition (led by in-person SLP, simultaneously scored by telepractice and in-person SLPs).	100% agreement between telepractice and in-person conditions for pass/fail on the screener. No analysis given for individual test items. Satisfaction: high overall satisfaction regarding telepractice (scores=4.5-4.6/5).

Waite et al. (2012) (34)	Speech assessment: Informal OMA SIR	n=20 4-9 years with diagnosed or suspected speech disorder English-speaking	Study design: a method comparison study with a randomised component reporting concordance between telepractice and in-person conditions using percentage agreement (criterion=80% close agreement, CA) and weighted kappa statistic (criteria based on Fleiss (51). Intra- and inter-rater reliability calculated using percentage agreement and ICC. Equipment: custom-built hardware-based telepractice system with real-time videoconferencing, store-and-forward, remote display of images and video, 128kbit/s Internet link, remote camera control. Procedure: participants randomly allocated to telepractice-led or in-person-led condition, simultaneously scored by telepractice and in-person SLPs (randomly assigned to roles). Intra-rater reliability: telepractice (n=8) and in-person (n=8) assessments re-rated by SLP 4 weeks after initial rating. Inter-rater reliability: telepractice (n=8) and in-person (n=8) assessments rated by independent SLP.	High agreement between conditions for SIR (70% exact agreement, EA, and 100% CA) and OMA (73% EA, 96% CA). Poor to fair agreement (κ=0.12-0.36) for some oromotor tasks. Intra-rater reliability for telepractice: SIR: very good (ICC=0.83; 38% EA; 100% CA) OMA: moderate to very good (ICC=0.53-1.00; 76% EA; 100% CA) Intra-rater reliability for in-person: SIR: good (ICC=0.64; 50% EA; 100% CA) OMA: poor to good (ICC=0.19-0.69; 74% EA; 99% CA). Inter-rater reliability for telepractice: SIR: very good (ICC=0.86; 63% EA; 100% CA) OMA: poor to good (ICC=-0.17-0.66); 55% EA; 94% CA) Inter-rater reliability for in-person: SIR: very good (ICC=0.81; 63% EA; 100% CA) OMA: poor to good (ICC=0.36-0.63; 61% EA; 100% CA).
Whitehead et al. (2012) (33)	Cleft palate speech assessment: *Medida Espanola de Articulacion*	n=9 5-14 years Spanish-speaking	Study design: a method comparison study reporting concordance between telepractice and in-person conditions using percentage agreement (criterion not given) and Cohen's kappa statistic (criterion not given). Satisfaction survey completed by parents (5 point scale, 1=strongly disagree, 5=strongly agree). Equipment: hardware-based telemedicine system with real-time videoconferencing on a dedicated Internet link (unspecified bandwidth). Procedure: assessment led by the telepractice SLP, simultaneously scored by telepractice and in-person SLPs.	No statistically significant differences between telepractice and in-person assessment results for evaluation of oral muscle tone (100% agreement; κ=1; p = 0.001), resonance (100% agreement; κ=1; p=0.003), tongue lateralisation (89% agreement; κ=0.5; p=0.0001), oral pressure (67% agreement; κ=0.4; p = 0.037), and dentition (56% agreement; κ=0.5, p=0.0008). Positive correlation found between telepractice and in-person evaluation for tongue elevation, nasal/facial grimacing, palate movement, and nasal air emission, although not statistically significant (p=0.05-0.7). Satisfaction: high satisfaction.

Guiberson et al. (2015) (40)	Language screening: Spanish non-word repetition (NWR) task Language sample *Spanish Developmental Language Questionnaire* (*SDLQ*) (40) Language assessment: *Preschool Language Scales, Spanish Edition, 4th Edition* (*SPLS-4*) (192)	n=82 3-5 years Spanish-speaking	Study design: a method comparison study reporting concordance between telepractice screening results and in-person assessment. Diagnostic accuracy calculated using area under the curve, sensitivity, specificity, positive and negative likelihood ratios (criterion=≥0.80). Equipment: a software-based system using commercial-grade equipment (videoconferencing between Apple iPads, pre-recorded e-book played on the iPad and recorded by video). Internet connection not described. Procedure: participants completed the NWR task via videoconferencing. An assistant played a pre-recorded e-book and stimulus questions to gather language sample (video recorded for later transcription). Parents completed the *SDLQ* in-person. The assistant gave the video tape and *SDLQ* to the SLP for analysis. The *SPLS-4* was administered/scored in-person. Inter-rater reliability: 25% of assessments were rated by an independent SLP.	The telepractice screening tasks (NWR and language sample) were significantly correlated with *SPLS-4* expressive language standard scores ($r=0.55$, $p<0.01$). Individual screening tasks did not have adequate diagnostic accuracy. Diagnostic accuracy was improved when NWR and a language sample were used in combination ($R^2=-0.38$, $p < 0.01$), although sensitivity (0.79) and specificity (0.79) did not reach criterion (≥0.80). Inter-rater reliability was 92-97% for screening measures.
Guiberson et al. (2016) (39)	Language screening: Nicoladis' gesture coding system (166) Westby's *Symbolic Play Scale* (*SPS*) (193) and Linder's complexity of play subscale (212) Language sample *MacArthur Inventarios del Desarrollo de Habilidades Communicativas. Inventario II: Palabras y Enunciados* (*INV-II*) (parent checklist) (213) Language assessment: *SPLS-4* (154)	n=62 2-2;11 years Spanish-speaking	Study design: a method comparison study reporting concordance between telepractice screening results (i.e. identification of normal/impaired language) with results from a comprehensive in-person assessment. Diagnostic accuracy of screening tasks was calculated using area under the curve, sensitivity and specificity, positive and negative likelihood ratios (criterion=≥0.80 for desirable values). Equipment: a software-based, asynchronous telepractice model using commercial-grade equipment (video recording of facilitated play activities and an e-book on an Apple iPad). Procedure: parents engaged the child in play using standard stimulus items and showed the child an e-book on an iPad. This was video recorded and reviewed by an SLP who completed gesture, play, and language ratings. The parent completed a pen-and-paper checklist (*INV-II*). The *SPLS-4* was administered/scored in-person.	Reported vocabulary and language sample were significantly correlated with *SPLS-4* expressive language scores ($p \geq 0.001$). Both measures had desirable diagnostic accuracy values (reported vocabulary: AUC=0.90, $p<0.001$, sensitivity=0.86, specificity=0.88; number of words produced: AUC=0.82, sensitivity=0.73, specificity=0.88), although language sample sensitivity was below criterion of 0.80. A combination of reported vocabulary and telepractice language sample provided the highest diagnostic accuracy ($R^2=0.63$, $p<0.001$). Gesture and play ratings via telepractice were not significantly correlated with *SPLS-4* scores, and did not have desirable diagnostic accuracy.

Sutherland et al. (2017) (41)	Language assessment: *CELF-4* (188)	n=23 8-12 years English-speaking	Study design: a method comparison study reporting concordance between telepractice and in-person conditions using Bland-Altman analyses and Pearson's correlation, and measuring difference in behaviour between conditions using paired t-tests. Feasibility was investigated by measuring the number of discontinued sessions in each condition, and by rating audio and image quality on a scale of 0-2 (0=poor, 2=good). Satisfaction survey completed by parents (parents asked a number of questions and answered yes/no). Equipment: software-based system using commercial-grade equipment (videoconferencing using a web-based telepractice interface between two standard computers with webcams, remote display of stimuli). Internet connection not described. Procedure: assessment led by the telepractice SLP, simultaneously scored by the in-person SLP. The in-person SLP administered another 2 subtests (not observed or scored by the telepractice SLP) either before or after the telepractice session. The in-person SLP completed behaviour observations during the telepractice session and the traditional in-person session, and also completed audio and image ratings during the telepractice session.	Bland-Altman analyses of the *CELF-4* subtests found no clear trend in difference between telepractice and in-person scores, and variance did not appear to differ with the mean. Strong correlations were found between conditions (r=0.96-1.0). No significant difference found between conditions for behaviour (p=0.069-0.231). No telepractice sessions were discontinued due to technological or other difficulties. Audio was rated as "good" for 74% of sessions, image quality was rated as "good" for 83% of sessions. Satisfaction: 100% of parents felt comfortable with the assessment, 2/13 parents expressed concern and would prefer in-person assessment.

CHAPTER 5 Telepractice use among speech-language pathologists who provide services to children with medical complexity: An international survey

So far in this thesis I have examined the availability and accessibility of paediatric speech pathology services across Australia, and the existence of unmet allied health needs among the CMC population. In response to these findings, I have identified that telepractice screening has potential to improve children's access to services. In the previous chapter I systematically reviewed the pertinent literature and concluded that early support exists for some telepractice screening and assessment tasks with children, although research into the use of telepractice with CMC is sparse. Despite the potential benefits and growing evidence to support telepractice, adoption remains very low across the profession, and studies have identified various barriers that prevent SLPs from using telepractice.

Although these background chapters have identified a likely problem with speech pathology service accessibility for CMC, we do not know the particular issues of access experienced by CMC who require tertiary speech pathology support. We also lack understanding regarding the current rate of telepractice adoption among SLPs who work with CMC, and specific barriers that prevent this group of clinicians from using telepractice. This chapter will present the methods, results, and implications of the first component of this project: a survey of tertiary SLPs.

5.1 Research questions

This study aimed to answer the following primary research questions:

1. What are tertiary SLPs' experiences in providing accessible services to CMC?
2. What is the rate of telepractice use among SLPs who work in tertiary children's hospitals in 2015?
3. Has the rate of telepractice use among tertiary SLPs changed between 2011 and 2015?
4. What are tertiary SLPs' experiences in providing telepractice services to CMC?
5. What are tertiary SLPs' attitudes towards telepractice services for CMC?
6. What are tertiary SLPs' opinions regarding the suitability of patient groups and services for telepractice service delivery?
7. What are the barriers and facilitators for telepractice adoption among tertiary SLPs?

5.2 Methods

Ethical approval for this study was received from The University of Queensland (#2011000492; #2015000925) and from Children's Health Queensland (Queensland Health) (HREC/11/QRCH/26). Ethics approval documents can be found in Appendix A.

Study design

To achieve the aims of this study I surveyed SLPs who work in tertiary children's hospitals. No published studies to date have investigated telepractice use among this group of SLPs. The survey was completed via an online questionnaire, which was created using Survey Monkey®. The questionnaire was first distributed in July-August 2011. It was again distributed in October-November 2015 to allow comparison of telepractice data over time. This particular time period was chosen for the following reasons:

- Practice guidelines and technical reports were published by ASHA (214, 215) and SPA (136) during this time period
- The body of evidence to support speech pathology telepractice grew during this time period, with 39 new research papers published (32).
- In 2015, SPA identified a growing professional interest into telepractice, and that there had been significant advancements in technology and connectivity for telepractice purposes (136).
- Hill and Miller (182) suggest that a three to four year timeframe would allow researchers to monitor changes in telepractice adoption over time.
- A four year period fitted within the timeframe for completion of a part-time MPhil higher research degree.

I used an online survey in preference to an in-person interview or phone interview as it allowed me to invite many SLPs across a wide geographic area, and was more time- and cost-effective. Only a small number of SLPs work in tertiary children's hospitals, therefore, an online questionnaire helped to maintain confidentiality. An online questionnaire reduced bias that may have occurred during a phone or in-person interview with a known colleague.

The 2011 questionnaire contained 58 questions, including yes/no and multiple choice questions. Speech-language pathologists could also leave free text responses to some questions. Information was gathered regarding:

- respondent demographics
- patient caseload characteristics
- speech pathology accessibility
- current and prior telepractice use
- attitudes towards telepractice
- SLPs' willingness to use telepractice for different purposes and patient groups
- barriers and facilitators for telepractice adoption.

The questionnaire was pre-tested by two tertiary SLPs to ensure adequate content and construct validity. Minor changes to question wording and order were made following their feedback. Free-text responses from the 2011 survey were analysed, and consequently some questions regarding patient access issues and telepractice barriers were expanded for the 2015 survey. The 2015 questionnaire had a total of 64 questions. The 2011 and 2015 questionnaires can be found in Appendix B.

Participants

Speech-language pathologists who work in tertiary children's hospitals were invited to participate in this study. There are only eight dedicated children's hospitals in Australia, thus, to boost the number of respondents, the study was opened to SLPs who work in Canada, New Zealand, and the USA in 2011. Speech-language pathologists who work in the United Kingdom (UK) were also included in the 2015 survey (although they were not included in the 2011 survey). These countries were chosen as they are majority English-speaking countries with high-income economies, similar to Australia.

Study details were emailed to professional contacts of Olivia Taylor and Dr Pamela Dodrill in all countries. If there were no professional contacts in a particular children's hospital in Australia, New Zealand, or Canada, a covering letter and information sheet was posted to the speech pathology department at that hospital. Thus, all children's hospitals in Australia, Canada, and New Zealand received an invitation to participate in the study. As the number of tertiary children's hospitals is much larger in the UK and the USA only professional contacts who could be recruited via email were included for these countries. To further increase the response rate, respondents were asked to forward the study information to colleagues who also met the inclusion criteria (snowball sampling).

Statistical analysis

Simple descriptive statistics were used to summarise respondent demographics; patient caseload characteristics; accessibility; current and prior telepractice use; attitudes towards telepractice; willingness to use telepractice; and telepractice barriers and facilitators. These variables were tabulated in descending order according to the most recent survey year.

Pearson's chi-squared test (Stata 14; chi2) and Fisher's exact test (Stata 14; exact) were used to test for differences in proportions between categorical data from the 2011 and 2015 surveys. Stata 14 (Statcorp, College Station, TX) was used to conduct these analyses. The following analyses were completed:

- comparison of demographic data and patient caseload characteristics from 2011 and 2015 to compare the two groups of respondents
- comparison of data from 2011 and 2015 relating to speech pathology accessibility, telepractice use, attitudes towards telepractice, willingness to use telepractice, and telepractice barriers and facilitators to examine any changes that had occurred with time.

5.3 Results

Respondent demographics

Forty-seven responses were received in 2011, and 49 responses in 2015. One response in 2011 and two responses in 2015 were discounted due to incomplete submission, thus, a total of 46 responses were included for 2011, and 47 responses were included for 2015. As surveys were completed anonymously, the number of respondents who participated in both survey years is not known. Respondent demographics were similar between the survey years in terms of age, gender, and years of experience (see Table 2). However, distribution of respondents by country of practice was different between the two surveys ($p < 0.001$). This difference was due to a decrease in responses from the USA in 2015, and the inclusion of UK SLPs in 2015. For both surveys, the most common country of practice was Australia. The majority of respondents across the two surveys were female. Respondents were mostly aged between 25-44 years, with small numbers of respondents aged under 25 or over 45 years. Most respondents across both surveys were experienced SLPs who had practised for longer than 10 years (see Figure 8).

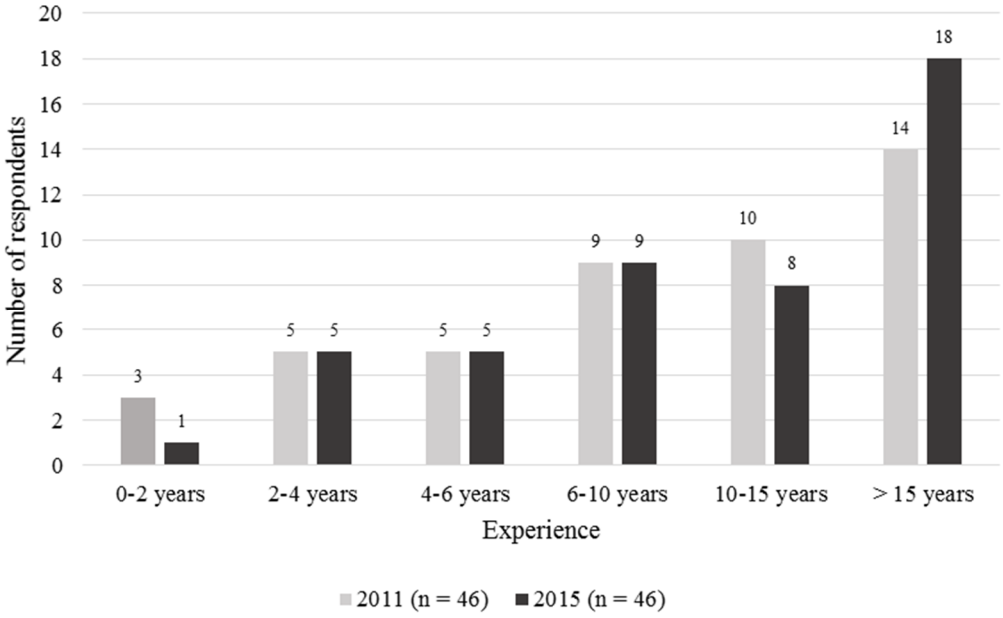


Figure 8 Respondents' experience in years: comparison between survey years

Table 2 Respondent demographics: comparison between survey years

Demographics	2011 (n = 46)	2015 (n = 47)	P-value
Country			
Australia	25	25	<0.001*
Canada	1	4	
New Zealand	0	0	
UK	-	15	
USA	20	3	
Gender			
Female	43	47	ns*
Male	3	0	
Age (years)			
<25	3	1	ns*
25-34	20	20	
35-44	15	16	
45-54	6	8	
≥55	2	2	
Experience (years)			
<2 years	3	1	ns*
3-4 years	5	5	
5-6 years	5	5	
7-10 years	9	9	
11-15 years	10	8	
>15 years	14	18	
Missing	-	1	

*Fisher's exact test

Patient caseload characteristics

Patient caseload characteristics were similar between the two surveys (see Table 3). Most SLPs worked primarily with children. Services for children with speech and language impairment were the most commonly provided in 2011. In 2015 a significant decrease was observed in the number of respondents who provided services to children with speech impairment ($p < 0.05$) and language impairment ($p < 0.01$), although a substantial number of respondents continued to work in these clinical areas. There was also a significant decrease in the number of SLPs who provided fluency services in 2015 ($p < 0.05$), with only 2 respondents providing fluency services. Respondents reported that they work with children who have a range of complex medical diagnoses, with complex developmental disorders being the most commonly reported diagnostic group for both survey years. The range of diagnostic groups remained similar from 2011 to 2015, although a significant decrease was noted over time in the number of SLPs who worked with neurology patients ($p < 0.05$) and rehabilitation patients ($p < 0.01$).

Speech pathology service accessibility

Accessibility of tertiary speech pathology services

One hundred percent of respondents in both survey years identified that they work with CMC who have difficulty accessing tertiary speech pathology services. Barriers that affect service accessibility were similar between the two surveys (see Table 4). In 2015, financial issues were the most commonly identified access barrier. Living in a rural or remote area was another common access barrier, as reported by 77.3% of respondents in 2011 and 83.0% of respondents in 2015. Additional access barriers that were identified through free text responses included missed school time, parking difficulties, and poor family functioning and organisation.

Accessibility of local speech pathology services

Specific questions regarding local speech pathology accessibility were added to the 2015 survey. Forty respondents (n = 40/47; 85.1%) reported that they work with patients who access local speech pathology services in addition to tertiary speech pathology services. However, the majority of respondents (n = 40/47; 85.1%) also reported that their patients experience difficulty accessing local speech pathology support. A number of barriers to local service access were reported (see Figure 9) including long waiting lists for local services, and that local SLPs may lack specialist skills and experience necessary to manage CMC. Additional free-text responses identified two further barriers: many insurance companies will not cover local services in addition to tertiary services (duplication of services), and many local therapists do not prioritise CMC if they are already receiving tertiary speech pathology support.

Table 3 Reported patient caseload characteristics: comparison between survey years

Caseload characteristics	2011 (n = 46)	2015 (n = 47)	P-value
Time working with children			
<25%	4	0	ns*
25-49%	3	4	
50-74%	4	4	
75-100%	33	39	
Missing	*2*	-	
Patient age groups			
Infants	41	42	ns*
Toddlers	44	45	ns*
Preschool-aged	43	45	ns*
School-aged	40	45	ns*
Adolescents	33	40	ns†
Missing	*2*	-	
Clinical services			
Swallowing/feeding	39	35	ns†
Speech	40	31	<0.05*
Videofluoroscopic Swallow Study (VFSS) ‡	28	30	ns†
Language	41	29	<0.01*
Voice and resonance	22	20	ns†
Pragmatic language	24	17	ns†
Literacy	19	13	ns†
Fluency (stuttering)	14	2	<0.05*
Missing	*2*	*2*	
Medical diagnostic group			
Complex developmental disorders	31	37	ns†
Craniofacial anomalies	25	31	ns†
Respiratory diseases	25	31	ns†
CP	27	26	ns†
Gastrointestinal diseases	24	25	ns†
Neurological disorders	31	23	<0.05†
Autism spectrum disorder (ASD)	20	22	ns†
Metabolic disorders	15	19	ns†
Cancer and haematological disorders	13	17	ns†
Special Care Nursery	-	16	-
Allergies and immunological diseases	13	15	ns†
Rehabilitation medicine	26	15	<0.01†
CI	8	7	ns†
Burns	7	4	ns*
Missing	*2*	-	
Other patient factors			
Cognitive impairment/II	29	25	ns†
Non-English speaking background	11	17	ns†
Hearing impairment	11	15	ns†
Visual impairment	9	10	ns†
Missing	*2*	-	

*Fisher's exact test, †Pearson's chi-squared test, ‡ For VFSS n = 40 (2011) and n = 40 (2015)

Table 4 Reported patient access barriers: comparison between survey years

Reported access barriers	Number of respondents 2011 (n = 46)	2015 (n = 47)	P-value
Financial difficulties	-	40	-
Patient lives in a rural or remote area	34	39	ns†
Caregiver unable to take time off work	-	39	-
Mobility issues	30	37	ns†
Travel or transport difficulties	37	35	ns†
Distance from tertiary children's hospital	32	35	ns†
Nobody to care for siblings during appointment	-	34	-
Patient has compromised immunity	32	32	ns†
Infection control risk	20	26	ns†
Missing	*2*	-	

†Pearson's chi-squared test

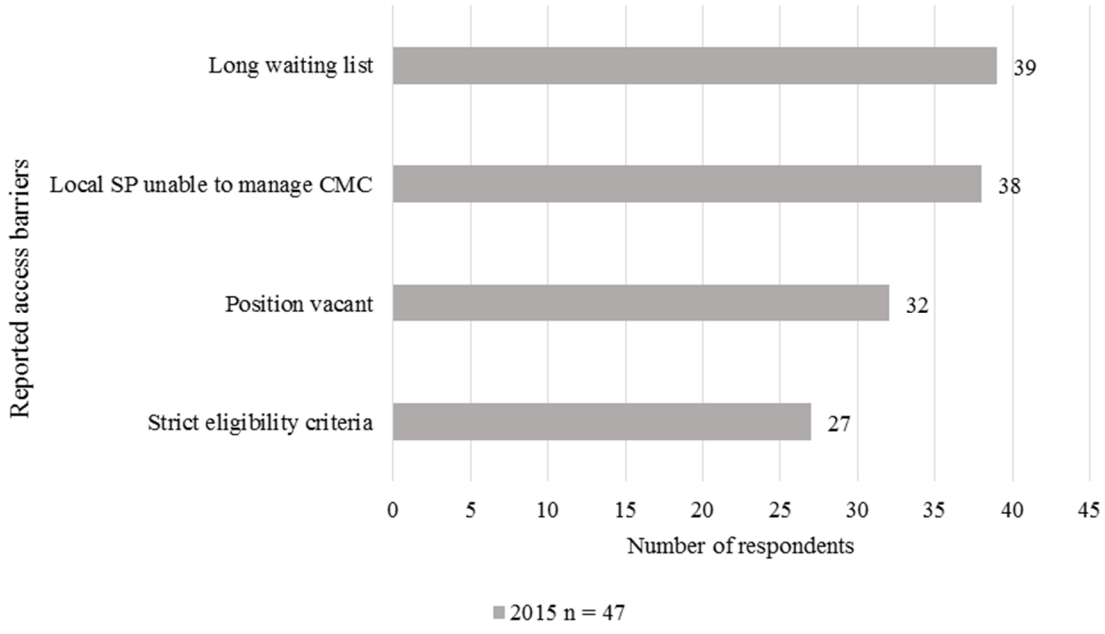


Figure 9 Access barriers to local speech pathology services, as reported by respondents in 2015

Current and past telepractice use

In 2011, 15.9% of respondents (n = 7/44) reported that they currently or had previously used telepractice with CMC. A significant increase was observed by 2015, with 40.4% (n = 19/47) of respondents reporting current or prior telepractice use ($p < 0.05$). Respondents with current or prior telepractice experience were asked further questions regarding their experiences with providing telepractice services.

Services provided via telepractice

The types of clinical services that had been provided via telepractice were similar between the two survey years. Across both surveys, SLPs had most commonly used telepractice to provide services to children with speech, swallowing/feeding, and language needs. Fewer therapists had provided voice/resonance, pragmatic language, or literacy services, and none of the SLPs in either year had provided fluency services using telepractice. Despite a significant reduction in the overall provision of services for children with speech and language difficulties (see Table 3), there was no corresponding decrease in the provision of telepractice services to these children. Speech-language pathologists in both surveys were most likely to have used telepractice to provide consultative or parent education services, and fewer SLPs had used telepractice to provide screening/assessment, therapy, or monitoring services (see Table 5).

Table 5 Telepractice services previously or currently provided by respondents: comparison between survey years

Telepractice services previously or currently provided	**Number of respondents** 2011 (n = 7)	2015 (n = 19)	**P-value**
Clinical areas serviced via telepractice			
Speech	4	11	ns*
Swallowing/feeding	5	10	ns*
Language	4	9	ns*
Voice and resonance	1	4	ns*
Pragmatic language	2	2	ns*
Literacy	1	2	ns*
Fluency	0	0	-
Missing	-	*1*	
Services provided via telepractice			
Consultative services	5	12	ns*
Parent education	5	11	ns*
Informal screening/assessment	2	8	ns*
Therapy	2	7	ns*
Monitoring	1	7	ns*
Formal screening/assessment	2	5	ns*
Education for teachers and other professionals	3	4	ns*
Missing	-	*1*	

*Fisher's exact test

Telepractice equipment and procedures used

For both surveys, 100.0% of respondents reported that they had used hardware-based telepractice to provide services (see Table 6), and a small number of respondents had also used software-based telepractice. Three respondents in the 2015 survey had provided telepractice services using a videophone or mobile phone with video calling capabilities. Respondents in the 2011 survey had used low-technology methods to display stimulus materials to the child, such as holding up materials or emailing/posting materials ahead of the session. Most respondents in the 2015 survey reported using low-technology methods to display materials, although a small number of SLPs had used high-technology methods such as screen sharing or document cameras.

Table 6 Telepractice equipment and procedures used by respondents: comparison between survey years

Equipment and procedures used by respondents	**Number of respondents** 2011 (n = 7)	2015 (n = 19)	**P-value**
Type of telepractice system			
Hardware-based telepractice system	7	15	-
Software-based telepractice system	1	8	ns*
Videophone/FaceTime	0	3	ns*
Missing	-	*4*	
Stimulus material display			
Hold up stimulus materials to show child	3	11	ns*
Post or email stimulus materials	4	5	ns*
Display stimulus materials using screen sharing	0	3	ns*
Display stimulus materials using document camera	0	1	ns*
Missing	-	*1*	

*Fisher's exact test

Perceived usefulness of telepractice

Across both surveys, 100.0% of the SLPs with prior telepractice experience reported that they had found telepractice to be somewhat or very useful (see Table 7). There was no significant change in respondents' attitudes towards telepractice usefulness between the surveys.

Table 7 Perceived usefulness of telepractice, as reported by respondents: comparison between survey years

Perceived usefulness	**Number of respondents** 2011 (n = 7)	2015 (n = 19)	**P-value**
Not useful	0	0	ns*
Somewhat useful	3	10	
Very useful	4	8	
Missing	-	*1*	

*Fisher's exact test

Speech-language pathologists' attitudes towards telepractice

All respondents were asked to reflect upon their willingness to provide telepractice services, and their understanding and confidence in using telepractice.

Willingness to provide telepractice

In 2011, a total of 95.2% of SLPs indicated that they would be willing to provide telepractice services to CMC. This number remained high in 2015, with a total of 89.1% of SLPs reporting that they would be willing to provide telepractice services to their patients (difference was not significant). The majority of respondents across both years reported that they are also willing to use telepractice to provide remote support to local SLPs during joint sessions or during specific education and mentoring sessions (see Table 8).

Table 8 SLPs' willingness to provide telepractice services: comparison between survey years

Reported willingness	**Number of respondents**				**P-value**
	2011 (n = 46)		2015 (n = 47)		
	Yes	*No*	*Yes*	*No*	
Overall willingness	40	2	41	5	ns*
Missing	*4*		*1*		
Willing to support local SLP via telepractice	40	2	42	1	ns*
Missing	*4*		*4*		

*Fisher's exact test

Understanding and confidence in using telepractice

No significant change was observed between the survey years for respondents' understanding of telepractice, or confidence in using telepractice. Most respondents reported low or moderate understanding of telepractice (see Figure 10), and moderate confidence in using telepractice (see Figure 11). Few of the SLPs reported high levels of understanding or confidence in using telepractice.

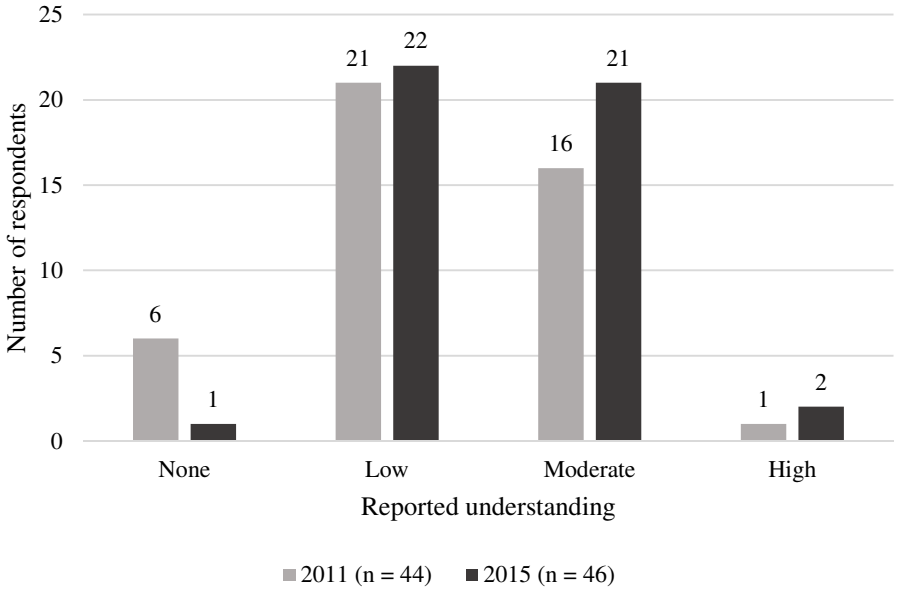


Figure 10 Respondents' reported understanding of telepractice: comparison between survey years

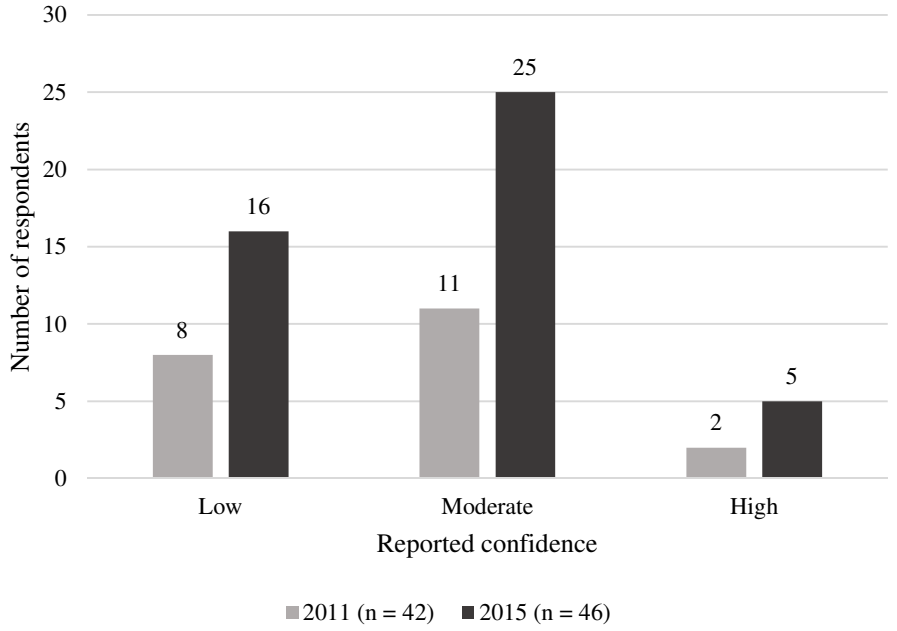


Figure 11 Respondents' reported confidence in using telepractice: comparison between survey years

Suitable patients and services for telepractice

Respondents were asked to reflect upon the types of patients who they believed were suitable for telepractice services, and the types of services that they believed could be provided using telepractice.

Suitable patients

The majority of respondents in both survey years were willing to use telepractice to provide services to children with speech impairment, language impairment, voice/resonance disorders, and literacy impairment. Over time there was a significant increase in the number of SLPs who were willing to use telepractice to provide services to children with swallowing/feeding disorders ($p < 0.001$) and pragmatic language difficulties ($p < 0.05$). However, additional free-text responses in 2015 indicated that many SLPs still had concerns regarding the use of telepractice for patients with swallowing/feeding or pragmatic language difficulties. One respondent stated that she would not use telepractice with children who had pragmatic language difficulties as she did not believe a therapist could adequately assess or teach non-verbal social skills remotely. Another respondent expressed concerns that remote swallowing assessment would be unsafe because the SLP is unable to palpate the swallow and may have difficulty hearing signs of aspiration (e.g. voice and respiration changes).

Over time respondents indicated greater willingness to provide telepractice services to children across the age range, with a significant increase observed in 2015 in the number of SLPs who considered children of all age groups to be suitable for telepractice services. Notably, 100.0% of respondents in 2015 considered school-aged children ($p < 0.01$) and adolescents ($p < 0.001$) to be suitable for telepractice services (see Table 9).

Respondents were asked to consider the use of telepractice with various diagnostic groups, for children for whom English is a second language, and for children with cognitive or sensory impairments. A small number of respondents in each survey indicated that there were some diagnoses and impairments that would preclude them from using telepractice (see Table 9). However, the majority of SLPs in both surveys indicated that their decision to use telepractice is not influenced by patient diagnosis, primary language, or the presence of cognitive or sensory impairments. Free-text comments revealed that many therapists believed that telepractice suitability should be considered on a case-by-case basis, taking into account each child's unique presentation (e.g. attention, cognition, type of disorder, age group).

Table 9 Patient types considered suitable for telepractice services, as reported by respondents: comparison between survey years

Patient types suitable for telepractice	Number of respondents						P-value
	2011 (n = 46)			2015 (n = 47)			
	Yes	*No*	*Missing*	*Yes*	*No*	*Missing*	
Communication/feeding diagnosis							
Speech impairment	36	6	*4*	37	5	*5*	ns†
Swallowing/feeding disorder	23	19	*4*	35	3	*9*	< 0.001*
Language impairment	37	5	*4*	32	1	*14*	ns*
Voice/resonance disorder	35	7	*4*	21	3	*23*	ns*
Pragmatic language impairment	27	15	*4*	19	2	*26*	< 0.05*
Literacy impairment	35	7	*4*	18	0	*29*	ns*
Fluency disorder	36	6	*4*	10	1	*36*	ns*
Age groups							
Infants	20	22	*4*	27	11	*9*	< 0.05†
Toddlers	26	16	*4*	32	6	*9*	< 0.05†
Preschool-aged	32	10	*4*	36	2	*9*	< 0.05†
School-aged	33	9	*4*	38	0	*9*	< 0.05*
Adolescents	30	12	*4*	38	0	*9*	< 0.001*
Medical diagnosis							
Allergies and immunological diseases	41	1	*4*	30	1	*16*	ns*
Burns	41	1	*4*	30	1	*16*	ns*
CP	41	1	*4*	30	1	*16*	ns*
Complex developmental disorders	41	1	*4*	30	1	*16*	ns*
Cancer and haematological disorders	41	1	*4*	30	1	*16*	ns*
Metabolic disorders	40	2	*4*	30	1	*16*	ns*
Rehabilitation medicine	40	2	*4*	30	1	*16*	ns*
Gastrointestinal diseases	38	4	*4*	30	1	*16*	ns*
Neurological conditions	40	2	*4*	29	2	*16*	ns*
Craniofacial anomalies	35	7	*4*	28	3	*16*	ns*
CI	36	6	*4*	27	4	*16*	ns*
Respiratory diseases	36	6	*4*	27	4	*16*	ns*
ASD	32	10	*4*	26	5	*16*	ns†
Other patient factors							
Cognitive impairment/II	40	2	*4*	27	4	*16*	ns*
Visual impairment	38	4	*4*	26	5	*16*	ns*
Hearing impairment	37	5	*4*	26	5	*16*	ns†
Non-English-speaking background	40	2	*4*	25	6	*16*	ns*

*Fisher's exact test, †Pearson's chi-squared test

Suitable services

Services considered to be suitable for telepractice delivery were considered under the classifications of direct and indirect care. Direct care, as defined by the Nursing Interventions Classification is "a treatment performed through interaction with the patient", and indirect care is "a treatment performed away from the patient" (213). Speech-language pathologists in both survey years were most willing to use telepractice to provide indirect services, such as parent education and consultative services (see Table 10). Respondents were less interested in using telepractice to provide direct services (e.g. screening, assessment, and therapy). Only one third (approximately) of respondents in both survey

years considered formal screening and assessment to be suitable for telepractice delivery. Willingness to provide services remained fairly similar between years, however, there was a significant increase in the number of respondents who were willing to conduct patient monitoring via telepractice ($p < 0.05$), and to provide videofluoroscopic swallow study (VFSS) services via telepractice ($p < 0.05$). Of the SLPs who provided VFSS services, few were willing to direct a VFSS via telepractice (n = 5/30; 16.7%), however, a larger number would be willing to interpret VFSS results via telepractice if another SLP was able to direct the study in person (n = 18/29; 62.1%).

Table 10 Service types considered suitable for telepractice delivery, as reported by respondents: comparison between survey years

Services suitable for telepractice	**Number of respondents**				**P-value**
	2011 (n = 46)		2015 (n = 47)		
	Yes	*No*	*Yes*	*No*	
Parent education	37	5	42	2	ns*
Consultative services	32	10	38	6	ns†
Monitoring services	26	16	37	7	<0.05†
Teacher education	32	10	35	9	ns†
Informal screening/assessment	32	10	31	13	ns†
Therapy	18	24	22	22	ns†
Formal screening/assessment	16	26	13	31	ns†
Missing	*4*		*3*		
VFSS	8	20	18	12	< 0.05†
Missing	*18*		*17*		

*Fisher's exact test, †Pearson's chi-squared test

Reasons to use telepractice

Respondents identified a number of reasons to use telepractice with their patients. Most commonly, SLPs would choose to provide telepractice services for patients who live in rural or remote areas, or if the local SLP was unable to manage their complex needs. Another common reason to use telepractice was to assist families who have transport difficulties (see Figure 12). The reasons remained fairly constant across the survey years, although respondents in 2015 were more likely to consider telepractice services for patients with poor mobility ($p < 0.05$).

Telepractice preferences

Respondents were asked to consider their preferences for telepractice services. Across both surveys, SLPs indicated that they would prefer their clients to access telepractice services from their home, rather than travelling to a local hospital or school to use telepractice equipment (see Figure 13). Speech-language pathologists also indicated that they would prefer to provide telepractice services if

a trained assistant could be present with the child. The most desirable assistant was a local SLP, followed by an allied health therapy assistant or the child's caregiver. No significant difference was noted between the two surveys for assistant preference (see Table 11). In cases where an assistant is not available, an important factor that would influence an SLP's decision to use telepractice is the caregiver's willingness and competence to assist during the telepractice session (see Table 12).

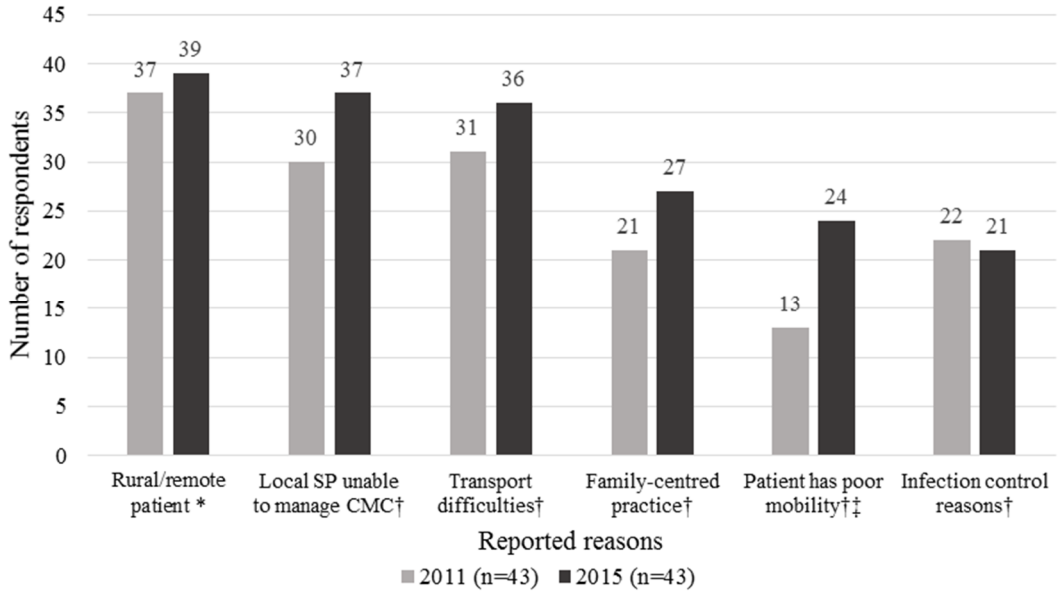


Figure 12 Reasons to use telepractice, as reported by respondents: comparison between survey years

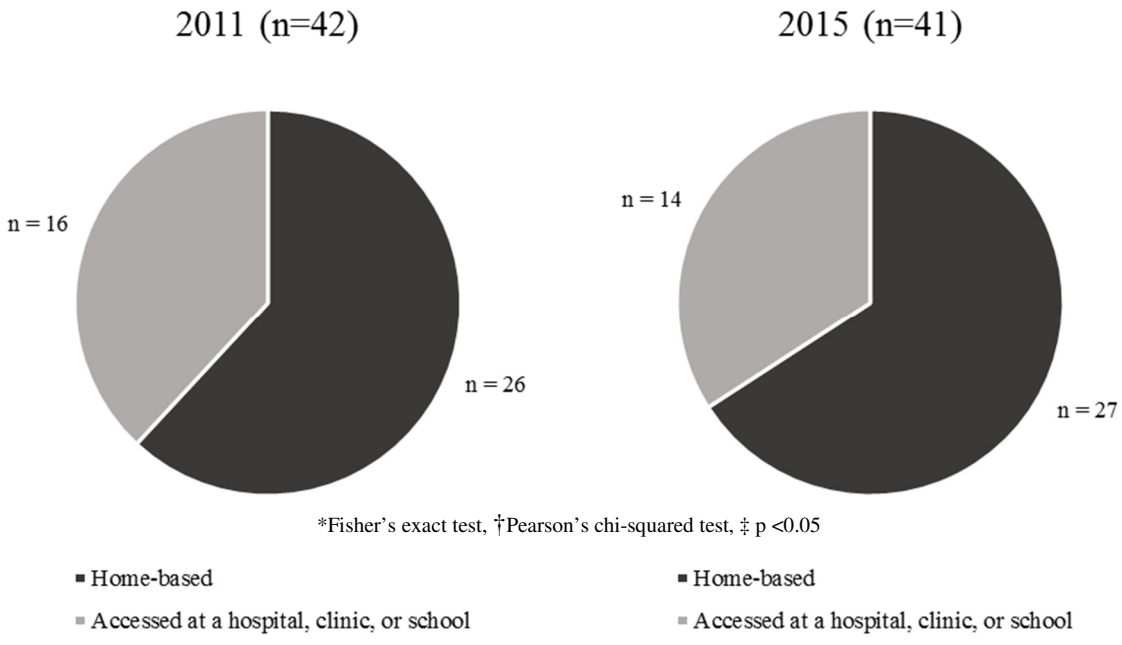


Figure 13 Preferred type of telepractice services, as reported by respondents: comparison between survey years

Table 11 Suitable telepractice assistants, as reported by respondents: comparison between survey years

Suitable telepractice assistant	Number of respondents				P-value
	2011 (n = 46)		2015 (n = 47)		
	Yes	*No*	*Yes*	*No*	
Local SLP	40	2	41	2	ns*
Allied health therapy assistant	30	12	34	9	ns†
Caregiver	29	13	33	10	ns†
Other allied health practitioner	28	14	30	13	ns†
Teacher	20	22	29	14	ns†
Nurse	23	19	23	20	ns†
Administrative assistant	4	38	6	37	ns*
Missing	*4*		*4*		-

*Fisher's exact test, †Pearson's chi-squared test

Table 12 Factors that influence SLPs' decision to use telepractice, as reported by respondents: comparison between survey years

Factors that influence respondents' decision to use telepractice	Number of respondents		P-value
	2011 (n = 46)	2015 (n = 47)	
Caregiver willingness	36	37	ns†
Caregiver competence	34	37	ns†
Missing	*4*	*4*	-

†Pearson's chi-squared test

Telepractice barriers and facilitators

One hundred percent of the SLPs for both years identified at least one barrier that prevents them from using telepractice with their patients. The most commonly identified barriers in 2015 were an inability to use hands-on techniques during therapy and assessment (n = 33/45; 73.3%), and concerns about poor audio and image quality (30/45; 66.7%). Telepractice audio and image quality was also the most commonly identified barrier in 2011 (27/42; 64.3%), along with a lack of personal experience with telepractice (27/42; 64.3%). Only one barrier varied significantly between years: concerns regarding the willingness and ability of caregivers to assist during telepractice consults. This was the third most commonly reported barrier in 2011 (26/42; 61.9%), however, significantly fewer SLPs had concerns about this in 2015 (18/45; 40.0%; $p < 0.05$). Across both years, respondents were least likely to express concerns regarding confidentiality and security, insufficient evidence or professional guidelines, a lack of support in the workplace, or issues relating to cost (e.g. cost to workplace, cost to patient, billing and reimbursement).

Respondents were also asked to identify facilitators that would help them to implement telepractice with their patients. The most commonly identified facilitators in 2011 included training in telepractice (n = 31/42; 73.8%) and a how-to guide (n = 31/42; 73.8%). In 2015, training was also

rated as the most important facilitator (n = 30/43; 69.8%), followed by a how-to guide (n = 27/43; 62.8%) and adapted tools for assessment and therapy (n = 27/43; 62.8%). Reported facilitators remained fairly constant across both survey years. However, a greater number of SLPs in 2011 identified that funding to allow families to purchase telepractice equipment would be a facilitator ($p < 0.05$). A total of three respondents in both surveys stated that there are no facilitators that would encourage them to try telepractice with their patients.

Table 13 Barriers to telepractice use, as reported by respondents: comparison between survey years

Reported barriers	**Number of respondents**		**P-value**
	2011 (n = 46)	2015 (n = 47)	
Unable to use hands-on techniques	-	33	-
Poor audio and image quality	27	30	ns†
Lack of personal experience using telepractice	27	27	ns†
Difficulty managing behaviour	16	21	ns†
Difficulty administering formal assessment tools	22	19	ns†
Caregivers' willingness and ability to act as assistant	26	18	< 0.05†
Time required to establish telepractice service	20	17	ns†
Lack of adapted assessment and therapy tools	21	16	ns†
Inadequate IT support at my workplace	22	15	ns†
Difficulty demonstrating therapy tasks	19	15	ns†
Difficulty building rapport	13	15	ns†
Caregiver satisfaction	17	13	ns†
Increased time to deliver services	15	12	ns†
No access to telepractice in my workplace	13	12	ns†
Insufficient evidence, professional standards, and guidelines	5	11	ns†
Security and confidentiality concerns	7	10	ns†
Cost to patient and family	7	8	ns†
Lack of support from colleagues and management	7	8	ns†
Difficulty with billing and reimbursement	12	6	ns†
Cost to workplace	8	5	ns†
No barriers to telepractice	0	0	-
Missing	*4*	*2*	

*Fisher's exact test, †Pearson's chi-squared test

Speech-language pathologists' overall preference for telepractice versus in-person services

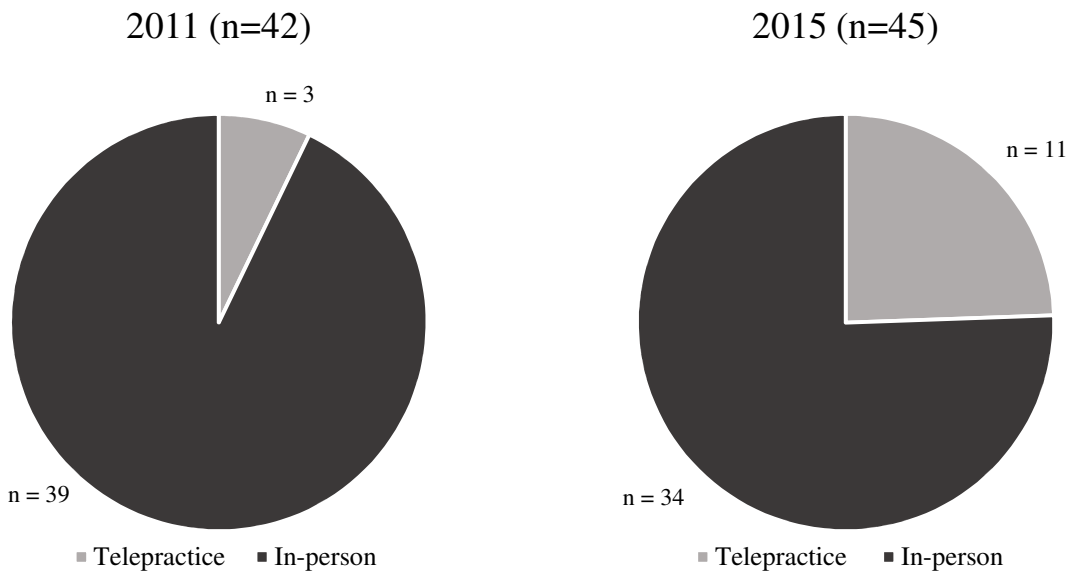
Finally, respondents were asked the following question: if all of your concerns regarding telepractice were addressed, would you prefer to provide in-person or telepractice services to CMC? In 2011, only 7.1% (n = 3/42) of SLPs indicated that they would choose telepractice services. This number grew significantly by 2015 ($p < 0.05$), with almost a quarter of respondents (n = 11/45; 24.4%) reporting that they would choose to provide telepractice services to CMC if all of their concerns had been resolved. However, the majority of SLPs (n = 34/45; 75.6%) reported that they would continue to prefer in-person services irrespective of improvements to telepractice. Free-text responses revealed that some SLPs continued to have reservations regarding the use of telepractice for CMC, such as one

SLP who stated "I would need a lot of persuasion that (telepractice) is the right way of providing (speech pathology) input from a tertiary centre".

Table 14 Telepractice facilitators, as reported by respondents: comparison between survey years

Reported facilitators	**Number of respondents**		**P-value**
	2011 (n = 46)	2015 (n = 47)	
Specific telepractice training	31	30	ns†
How-to guide	31	27	ns†
Adapted assessment and therapy tools	22	27	ns†
Improved audio and image quality	24	26	ns†
Work-shadow experienced colleague	24	25	ns†
Designated telepractice room in my workplace	24	22	ns†
Funding for families to purchase telepractice equipment	29	20	< 0.05†
Development of professional standards and guidelines	23	20	ns†
Increased IT support	20	18	ns†
Improved access to telepractice equipment	23	17	ns†
More research into telepractice	18	17	ns†
Funding to purchase telepractice equipment for my workplace	18	15	ns†
Increased support for telepractice in my workplace	12	12	ns†
Improved security and confidentiality	10	10	ns†
Nothing would encourage me to try telepractice	3	3	ns†
Missing	*4*	*4*	

*Fisher's exact test, †Pearson's chi-squared test



*Fisher's exact test, p <0.05

Figure 14 Reported preference for telepractice or in-person services: comparison between survey years

5.4 Discussion

There is a growing evidence-base for speech pathology telepractice, however, studies to date have found low telepractice adoption among the general speech pathology profession. Results from this survey indicated that SLPs who work in tertiary children's hospitals used telepractice at higher rates than previously reported. Moreover, significant growth was observed in telepractice adoption between 2011 and 2015, along with a significant increase in the range of patient types and services considered to be suitable for telepractice service delivery. The majority of tertiary SLPs viewed telepractice positively, and were interested and willing to use it. This survey identified widespread service access issues for CMC who need speech pathology support, thus, increased adoption of telepractice among this group of professionals may be an attempt to alleviate patient access issues.

This study is the first survey to describe telepractice use among SLPs who work in tertiary children's hospitals; to investigate the attitudes and opinions of these SLPs regarding the use of telepractice with CMC; and to explore speech pathology service accessibility for CMC. Conclusions that can be drawn from this study are limited by a small sample size and significant variation between respondents' country of practice between the survey years. Changes in telepractice adoption and practices between survey years may have been affected by respondents' country of practice, as it is assumed that service practices differ between countries. It is also possible that some countries have different levels of telepractice funding and support. However, all other respondent demographics were consistent between survey years, and the sample appears to be representative of the general speech pathology population, as respondents were demographically similar to the speech pathology populations of Australia and the USA (216, 217). Respondents in this survey were mostly experienced SLPs with more than 10 years of experience, which fits with the specialist nature of their role within tertiary paediatric facilities. I will now discuss the findings from this research in relation to the research questions.

Service accessibility

As stated above, SLPs commonly reported that CMC had difficulty accessing both tertiary and local speech pathology services. Although this is the first study to specifically address speech pathology service accessibility for CMC, poor service access was not surprising. Access barriers for CMC who require tertiary medical services have been previously reported in the literature (31, 130, 132), and a large body of evidence has described poor availability and accessibility of speech pathology services for the general paediatric population (17, 112-118, 120, 125, 126, 218).

Access barriers reported by the survey respondents were mostly consistent with those previously identified in the literature. However, one identified barrier was specific to the CMC population: many respondents reported that CMC patients are unable to access local services because the local SLP lacked specialist skills required to manage complex patients. More than 95% of SLPs in both survey years were willing to use telepractice to support local therapists. Thus, telepractice may be a tool that can support high quality shared-care arrangements, by facilitating skill development for local therapists.

Rate of telepractice use

Previous surveys of SLPs have reported adoption rates of only 2-9% (174-176), thus, SLPs who work in tertiary children's hospitals use telepractice at higher rates than the general profession. It is likely that these SLPs have adopted telepractice in response to access issues experienced by their patients. Unfortunately, we cannot know this for sure, as respondents were not asked any questions regarding their reasons for using telepractice. However, when all respondents (including those who do not use telepractice) were asked to report on reasons that would encourage them to use telepractice, improved service access seemed to be a critical motivator. Many respondents reported that they would choose to provide telepractice services for children who live in rural and remote areas, those with transport difficulties, those with restricted mobility, and those without access to local services.

The rate of telepractice adoption among tertiary SLPs more than doubled between 2011 and 2015, which represented a significant increase in adoption over a short period of time. An increase in telepractice utilisation was expected, given technological progress and the release of professional documents and research studies during this time period. However, the magnitude of the increase was larger than anticipated. Demographic differences may have contributed to the increase, as the two survey populations differed significantly according to country of practice (mainly due to decreased numbers of US respondents and the inclusion of UK respondents in the second survey).

Speech-language pathologists' experiences of providing telepractice services to CMC

Speech-language pathologists with prior telepractice experience viewed telepractice services positively, and 100% of these respondents considered telepractice to be useful. This is consistent with other studies that have found that exposure to telepractice is associated with more positive beliefs regarding its use (175, 176, 182, 183, 219). Tucker (175) has suggested that SLPs with greater awareness, experience, and confidence in the use of telepractice will be more willing to implement it with their patients.

Speech-language pathologists had provided a range of different services via telepractice, and the proportions observed were similar to those reported by Hill and Miller (182), who surveyed Australian speech pathologists in 2012. In the current study, speech pathologists were more likely to have used telepractice for indirect services (e.g. consultative or parent education services) than direct interventions (e.g. assessment and therapy). Further, some speech pathologists considered direct services such as therapy and assessment to be unsuitable for the telepractice environment. These findings are consistent with other studies that have found that speech pathologists prefer to provide indirect services via telepractice (176, 220).

Analysis of reported patient characteristics revealed that SLPs most commonly worked with children who have swallowing/feeding, speech, and language disorders, and these were also the most commonly provided services via telepractice. This is consistent with ASHA's 2002 survey which found that the most commonly provided telepractice services were for patients with speech, language, and swallowing/feeding disorders (176). These clinical areas have also been the topic of a number of research studies. A systematic review into telepractice research before August 2014 found that more than 40% of all speech pathology telepractice research investigated the use of telepractice for provision of speech, language, and swallowing services (32).

An interesting finding of this survey was that none of the respondents in either survey had provided fluency services via telepractice. A number of papers have confirmed the efficacy of fluency management via telepractice (211, 221-226), and previous surveys by ASHA (176) and Tucker (175) found that 46% and 29% of SLPs (respectively) have provided fluency services via telepractice. Although a third of this survey's respondents worked with fluency in 2011, this number decreased significantly by 2015, when only 4.4% of respondents worked with fluency. With such a small proportion of respondents working in the area, it was not surprising that none of the SLPs had used telepractice for stuttering services. This observed change in patient caseload characteristics may be associated with different respondent demographics (i.e. country of practice), or it could reflect changing policies regarding fluency management, where fluency services are provided in the community rather than the tertiary hospital.

Most respondents had used custom-built hardware-based equipment, presumably because most large tertiary hospitals have access to this technology. Fewer respondents had used software-based systems (e.g. web-based videoconference platforms, Skype) or videophones, and there was no growth in the use of this technology between years, despite advances in videoconferencing technology over time.

This may be due to organisational policies, which often prevent access to these telepractice systems due to security and confidentiality concerns (180). Despite technological advancements, most SLPs reported that they hold up stimulus materials to the child, rather than using screen sharing or document cameras. It is not clear why SLPs are not using these features, as there were no questions that probed respondents' reasons for using particular telepractice systems.

Speech-language pathologists' attitudes towards telepractice services for CMC

The vast majority of respondents across both surveys would be willing to use telepractice with their patients, and most SLPs were willing to use telepractice to support local therapists. Thus, tertiary SLPs appear to have a positive view of telepractice, irrespective of whether they are telepractice users or non-users. This positive attitude contrasts with previously published papers by Tucker (175) and Iacono et al. (220), who found that most non-users have negative or neutral attitudes towards telepractice, and in some cases are strongly resistant to the use of telepractice for patient care. It is possible that SLPs are developing more positive attitudes towards telepractice technology over time, in response to improved technology, new research evidence, and a greater focus on telepractice by professional organisations. Alternatively, tertiary-based SLPs may feel more positively towards telepractice due to its potential to improve service access for CMC.

Despite an increase in telepractice adoption over time, respondents' self-reported understanding and confidence in telepractice did not change, and very few respondents reported high levels of understanding and confidence. Low levels of confidence have been well-documented among non-users of telepractice (179, 180, 220), however, previous studies have also found that SLPs' understanding and confidence usually grows once they start implementing telepractice (183). Careful consideration of reported barriers and facilitators will be required to help increase tertiary SLPs' understanding and confidence in using telepractice with CMC.

Suitability of patient groups and services for telepractice service delivery

Previous studies have found that many SLPs are unwilling to provide telepractice services to patients with swallowing difficulties, voice disorders, sensory impairments, ASD, II, complex communication needs, and cultural and linguistic diversity, as well as being reluctant to use telepractice for children under school-age (175, 180). However, tertiary SLPs in this survey were willing to provide services to most CMC irrespective of age, medical diagnosis, sensory and cognitive impairments, or cultural and linguistic diversity. Over time there was a significant increase in the range of patient types and patient age groups that respondents considered to be suitable for telepractice services. In 2015 the respondents were significantly more likely to consider telepractice services for children with

swallowing/feeding and pragmatic language difficulties, and to believe that telepractice could be used for all age groups, from infancy to adolescence. Thus, in comparison to previous research studies, tertiary SLPs appear to be more flexible and open when considering the suitability of patients for telepractice service delivery. This is likely to be associated with more positive attitudes towards telepractice and tertiary SLPs' awareness of the potential telepractice has to alleviate access difficulties for their patients.

Speech-language pathologists preferred to provide indirect services via telepractice than direct screening, assessment, and therapy. This is consistent with other papers (176, 220). These studies report that SLPs are often reluctant to provide direct services due to concerns regarding the efficacy of assessment and therapy interventions delivered via telepractice. It is interesting that this perception continues despite a growing evidence base in the area of speech pathology telepractice (32, 147-161).

With time, SLPs changed their opinions regarding the appropriateness of using telepractice for two types of service delivery: patient monitoring and VFSS. A limitation of this study is that the term monitoring was not defined. Monitoring can be direct or indirect, depending on the circumstances, thus it is possible that differences between the years may be due to variations in SLPs' personal understanding of what monitoring is. With respect to VFSS, although remote direction of VFSS would be a direct assessment service, closer analysis of the responses revealed that most SLPs are not willing to do this. Instead, SLPs are willing to assist in interpretation of the study while an in-person therapist conducts the study. As skills in VFSS are considered to be advanced skills (227, 228), this model could be useful in upskilling local therapists. Few studies have been published in this area (229-231), although a paper in 2016 found that adult swallowing could be reliably assessed via telepractice. Future studies into paediatric VFSS via telepractice are warranted to further develop the potential of this model.

Telepractice preferences

Speech-language pathologists across both surveys expressed a preference for home-based telepractice services over services from a hospital, clinic or school. Home-based services are family-friendly, save families travel time and cost, and allow the SLP to view the child in their own environment. In some cases, home-based services may require the organisation to buy or loan telepractice equipment for the family to use, however, studies have found that most families already own equipment and technology required for a telepractice consult (137, 179).

Most SLPs reported that they would feel more comfortable delivering telepractice services if a trained assistant was present with the child. This is consistent with other studies that have identified an

assistant as an important facilitator for telepractice adoption (182, 183). However, the desire for a trained assistant could complicate delivery of home-based telepractice services, as the trained assistant (e.g. therapy assistant or local therapist) will need to travel from their base location to the patient's home for consults. This may minimise the advantages that a telepractice approach offers to the service provider in terms of time and cost savings. One solution to this is to train the child's caregiver to assist. It was positive to find in this study that many respondents consider caregivers to be an appropriate assistant, contingent upon their willingness and competence to assist.

Barriers and facilitators to telepractice adoption

Most barriers identified in this survey are consistent with those that have been previously reported, including concerns about building rapport, which have been reported in paediatric studies (175-183). Three barriers which have not been previously identified in the literature are likely to be specific to paediatric clinicians: difficulty managing patient behaviour, difficulty demonstrating therapy tasks, and concerns regarding the caregiver's ability to assist. The caregiver's ability and willingness to assist during telepractice was identified as a concern by significantly fewer respondents in 2015. It is likely that SLPs are aware of the public's growing confidence and experience with the Internet and common videoconferencing applications (e.g. Skype, FaceTime), and that this has reduced their concerns in this area.

Previous studies have reported that costing issues, and confidentiality and security concerns were important barriers to telepractice adoption for many SLPs (175, 176, 178-180, 182), however, few tertiary SLPs had these concerns. It is possible that concerns regarding security and confidentiality has decreased as SLPs become more familiar and confident with videoconferencing technology. Fewer concerns regarding cost may reflect the fact that there are now more cost-effective options on the market, and that most families (137) and hospitals already own the equipment necessary for telepractice consults. With respect to billing and reimbursement, the majority of respondents worked in countries supported by publically funded health systems, where many speech pathologists do not bill for services (e.g. Australia, Canada, and the UK). Concerns regarding billing and reimbursement may have been more significant if there had been a greater number of respondents from the USA, where therapists are more likely to bill for services

Facilitators identified by the survey respondents were similar to those already reported in the literature (175, 176, 182, 183). Only one facilitator changed significantly between survey years, as funding for families to purchase telepractice equipment was only identified as a facilitator by a small number of respondents in 2015. This isn't surprising, as over time more families have gained access to the

Internet and own equipment required for telepractice consults (137). Thus, few families now need funding to help them purchase equipment and technology for telepractice.

The most commonly reported facilitators fell into two main groups: professional development and training, and improved resources and technology. A number of research papers have investigated the training needs of SLPs who want to use telepractice. Overby and Baft-Neff (232) have identified that SLPs require knowledge and competencies that are specific to the telepractice environment, including an understanding of the evidence, confidence in solving technical issues, and an understanding of how non-verbal behaviours, lighting, and clothing choices affect the telepractice interaction. Studies into university programs across the USA have found that many programs do not provide direct telepractice teaching, although many universities intend to introduce this (233, 234). As a result, most SLPs learn telepractice skills on the job (232), and investigation into telepractice training methods has found that direct demonstration (e.g. role-playing and work-shadowing) is the most effective, followed by specific telepractice workshops, and telepractice manuals (235). At least two hours direct telepractice instruction has been recommended as a minimum standard for telepractice training (232). Organisations can increase adoption by supporting clinicians to work-shadow experienced colleagues, and role-play with telepractice equipment.

It was not surprising that SLPs identified improved resources and technology as a major facilitator, given that important barriers to telepractice adoption included concerns about audio and image quality and a lack of adapted resources. Technology continues to improve year by year, so it is anticipated that quality concerns will be addressed over time. Currently, SLPs who want to use telepractice for direct patient work are required to create their own telepractice resources. There are no specifically adapted telepractice assessment tools yet available, as standardisation studies are still ongoing (236). Speech-language pathologists require advance permission from the publisher before they can modify assessment materials for the telepractice environment, which is another barrier (236). Development of telepractice-specific resources will help to encourage SLPs to introduce telepractice into clinical practice.

Overall preference for telepractice versus in-person services

Overall, most SLPs in both years prefer in-person services, even if all of their concerns about telepractice were addressed. This is consistent with the findings of other surveys (175, 176, 179, 180). Some studies have highlighted that many SLPs view in-person contact as the gold standard, with telepractice as a supplemental method to improve access or increase service frequency (179, 180). In this survey, it was interesting to see that over time there was a significant increase in the

number of SLPs who would prefer telepractice services. In 2015, almost a quarter (24.4%) of SLPs identified that they would choose to provide telepractice services in preference to in-person services if all of their concerns were resolved. This may represent a shift in SLPs' beliefs regarding telepractice: rather than viewing telepractice as an adjunct method, therapists may be starting to view it as an effective alternative to in-person service delivery.

Limitations and future research

This study's limitations relate to survey distribution and design. Only a small number of tertiary SLPs participated, many of whom practiced in Australia; and some countries were not represented in one or both survey years. Although all tertiary children's hospitals in Australia, Canada, and New Zealand were invited, a convenience sample was used for the UK and USA (and UK SLPs were only invited to participate in the second survey). This has contributed to significant variation between survey years for country of practice, which limits conclusions that can be drawn regarding changes to telepractice adoption and practices over time. For ethical reasons survey respondents were able to skip questions, however, this meant that the sample was even smaller for some questions, which further limits ability to generalise these findings.

In an effort to increase the response rate of this survey, a snowball sampling method was used. Thus it is impossible to know what the rate of return was, as the total number of SLPs who received a survey invitation is unknown. Snowball sampling also limited the opportunity to use other strategies that can increase response rate, such as contacting people ahead of time, addressing potential respondents by name, and sending reminders or follow-up surveys (237). Snowball sampling in non-random, so it may also result in selection bias (238).

Another form of bias that may have affected this survey is nonresponse bias, or the bias that occurs when respondents and non-respondents differ according to demographics or attitudes (239). As stated above, a snowball sampling method means that the number of non-respondents is not known. However, it is possible that SLPs with strong positive or negative attitudes towards telepractice were more likely to participate, which may have affected survey results.

Another limitation of this survey is use of closed questions in preference to qualitative, open-ended questions. Closed questions helped to maintain brevity and improved the ease of analysis, however, this type of question should be used when the researcher is aware of all possible replies to a question (240). In the case of access difficulties, telepractice barriers, and telepractice facilitators it is possible that qualitative, open-ended questions may have yielded higher quality responses and identified

additional factors specific to CMC. This survey also sought to describe service access difficulties from the perspectives of tertiary SLPs, which may not truly reflect the experiences of CMC and their families.

Future research should sample a larger number of tertiary SLPs, using more rigorous sampling methods. Hill and Miller (182) suggested that survey repetition every three to four years should capture changes in telepractice adoption across the profession. Statistical analysis to investigate the relationship between telepractice adoption and SLPs' demographics (e.g. age, years of experience) and patient characteristics (e.g. age group, diagnosis) would be valuable. In particular, it would be interesting to learn whether there are differences in attitudes towards telepractice and use of telepractice between countries. Further investigation into the reasons that SLPs use telepractice with CMC, and the types of telepractice technology preferred by SLPs would be useful in understanding telepractice adoption among this group. Qualitative survey methods may gather interesting information regarding the specific challenges and opportunities for telepractice use with CMC, and may also be useful in investigating service accessibility from the perspective of CMC and their families.

5.5 Chapter conclusion

This chapter has presented the results from the first component of this research project: a survey of SLPs who work in tertiary children's hospitals. This survey is the first of its kind, and has drawn attention to widespread access difficulties experienced by many CMC, thus highlighting a need for alternative service delivery models such as telepractice. Tertiary SLPs already use telepractice at higher rates than the general speech pathology profession, possibly in response to these access difficulties, and significant growth has been observed in telepractice adoption over time. Tertiary SLPs are willing to use telepractice with their patients, and they consider a wide range of patient groups and service types to be appropriate for telepractice service delivery. A number of barriers to telepractice adoption were identified, commonly related to concerns about telepractice technology and resources. Many SLPs are also reluctant to use telepractice for direct interventions, including screening. A positive finding of this survey is that a growing number of SLPs would consider telepractice in preference to in-person services should barriers be addressed and resolved. This may represent a shift in the perceptions of SLPs from viewing telepractice as an augmentative service to viewing it as an alternative to traditional in-person services. Introduction of facilitators such as training, adapted assessment resources, and trained assistants will help to further increase SLPs'

confidence in using telepractice and telepractice adoption, thereby alleviating access difficulties experienced by CMC.

In summary, this chapter has confirmed widespread access difficulties for CMC patients who need speech pathology support, and highlighted that tertiary SLPs are willing and interested to provide telepractice services to CMC. As discussed in the previous chapter, there is preliminary evidence to support paediatric speech and language screening and assessment via telepractice. However, there is insufficient evidence to confirm the feasibility and efficacy of telepractice screening for CMC, and many SLPs are reluctant to conduct screening via telepractice. Consequently, the following chapter will describe the second component of this research project: a method comparison study to investigate the efficacy and feasibility of using telepractice for speech and language screening with CMC.

CHAPTER 6 Speech and language screening via telepractice for children with medical complexity: A method comparison study

The previous chapter of my thesis described results from the first component of my project: a survey of tertiary SLPs. This survey identified that CMC often experience difficulty accessing tertiary and local speech pathology support. Previously in this thesis I identified that telepractice screening has potential to reduce access issues for these children. It was positive to see that tertiary SLPs who work with CMC are already using telepractice at higher rates than the general speech pathology profession. This group of professionals are interested and willing to use telepractice with their CMC patients for a range of tertiary-level services, although some therapists remain reluctant to use telepractice for direct service provision, despite a growing evidence base.

So far there is only preliminary evidence for speech and language screening and assessment via telepractice. Most studies have focused on school-aged children, and only one study has included CMC. Most papers describe the efficacy of using custom-built telepractice systems for screening and assessment, and there is little evidence so far for the use of low-cost and readily available consumer-grade videoconference equipment (i.e. using off-the-shelf hardware and software). Another notable gap in the literature relates to consumer satisfaction with telepractice screening: there is little evidence to describe carer satisfaction, and no data to describe children's satisfaction with this method.

In summary, we lack an understanding of the feasibility and efficacy of speech and language screening for CMC using low-cost, readily available telepractice systems. We also have limited knowledge regarding the usefulness of telepractice methods for screening preschool-aged children, and we need more information on consumer satisfaction with telepractice screening. This chapter will present the methods, results, and implications of the second component of this research project: a study to investigate the feasibility, validity, and acceptability of telepractice speech and language screening for CMC. This project will also have specific goals relating to the use of consumer-grade equipment for telepractice screening, and the efficacy and feasibility of using telepractice with preschool-aged children.

6.1 Research questions

This study aimed to answer the following primary research questions:

1. What is the practical and technical feasibility of speech and language screening via readily-accessible telepractice methods for CMC aged 3-12 years?
2. In CMC aged 3-12 years, how does the duration of telepractice screening compare with in-person screening duration?
3. In CMC aged 3-12 years, is speech and language screening via telepractice valid when compared with in-person screening?
4. Is telepractice speech and language screening acceptable to caregivers of CMC, when compared to in-person screening?
5. Is telepractice speech and language screening acceptable to CMC aged 6-12 years, when compared to in-person screening?

I was interested to know whether there was any difference in feasibility, validity, and acceptability of telepractice screening for children according to age group (i.e. preschool-aged versus school-aged) or telepractice type (i.e. custom-built versus consumer-grade telepractice). Thus, two further questions were:

6. Is there an association between Questions 1, 3, or 4 and age group?
7. Is there an association between Questions 1-6 and telepractice type?

6.2 Methods

Ethical approval for this study was received from The University of Queensland (Project Number 2011000492) and from Children's Health Queensland (Queensland Health) (Approval Number HREC/11/QRCH/26). Ethics approval documents can be found in Appendix A.

Study design

To achieve the aims of this research project, an exploratory method-comparison study was conducted. Method-comparison studies are used to determine equivalence between a new technique or approach and one that is already used clinically. The new technique may have advantages over the existing method (e.g. cheaper, quicker to administer, more convenient). If the method-comparison study concludes that the techniques are equivalent, the new method can be introduced into clinical care (241). This study design has previously been used in a number of studies into the use of telepractice for speech and language assessment or screening for paediatric clients (33-41) and adult clients (199, 204, 205, 207, 242-245). In my study, the new technique evaluated was speech and language screening via telepractice. Two telepractice approaches were evaluated: hardware-based telepractice

(HBT), and software-based telepractice (SBT) using consumer-grade equipment. These two novel methods were compared with the existing method: in-person speech and language screening.

Hanneman (241) states that a method-comparison approach is not suitable if the methods to be compared do not measure the same thing. For example, it would be inappropriate to use a method-comparison approach to compare in-person assessment of receptive language with telepractice assessment of expressive language. Although a correlation between in-person and telepractice results may occur (as most children experience language difficulties across both receptive and expressive domains), this correlation would not provide evidence of equivalence between the in-person and telepractice assessment approaches. For this study, the same speech and language screening tasks were conducted using in-person and telepractice methods, thus, they were measuring the same outcome and a method-comparison approach was appropriate.

Hanneman also discusses the importance of measuring the outcome simultaneously using the new and existing methods (241). If the outcome is not measured simultaneously, it is difficult to know whether differences that occur are due to non-equivalence of the measurement techniques, or have occurred as a result of elapsed time. Hanneman (241) states that "the definition of simultaneous is determined by the rate of change of the variable". For example, if the variable does not change rapidly, it may be appropriate to measure the variable sequentially. A child's speech and language performance is unlikely to change quickly, thus, for this study it was appropriate to screen speech and language sequentially (on one day) across the three conditions. When sequential measurement is used, randomising the order of measurements is good design practice. This ensures that any differences associated with time, fatigue, or attention will be spread across the methods. In this study, the order of conditions for each participant was randomised using a free web-based randomisation tool.

When sequential measurements are used for a method-comparison study, participants receive multiple interventions throughout the course of the study, similar to a crossover design. This may result in carryover effects. Carryover effects occur when effects from the first intervention influence the next intervention. For example, in a crossover study to compare the effectiveness of two drugs, researchers may believe they are measuring the effect of one drug, when in fact they are observing the effects of a previously administered drug. In this study, there was a risk that carryover effects may occur due to repeated administration of the same language screening tools across the three methods. This is also known as a practice effect, defined as "improvements in cognitive test performance due to repeated exposure to test materials" (246). Adapted screening tests were devised

to avoid carryover effects in this study. Further information can be found below under the *Adapted Screening Tools* heading.

Setting

This study was carried out in the telehealth departments at the Royal Children's Hospital (RCH) and the Lady Cilento Children's Hospital (LCCH) in Brisbane, Australia. Remote screening was simulated by conducting screening via telepractice between rooms, with the participant and their caregiver in one room and the SLP in another room.

Participants

The size and scope of this study were affected by practical constraints including time and funding limitations, and the availability of staff and participants. Thus, participants were recruited using a convenience sampling method, with sampling completed once the time limit was reached. Children with medical complexity aged between 3-12 years were eligible to participate in the study, and due to difficulties with recruitment, the study was also opened to the general paediatric population. A diagnosed speech and/or language impairment was not required to participate in the study.

Children were excluded from the study if they:

- were medically unstable or receiving palliative care
- did not speak English as their primary language. Assessments used during this study have been validated for use with children whose primary language is English, thus, results from children who speak English as a second language may be invalid.
- were unsuitable for standardised assessment (e.g. non-verbal, significant cognitive deficits, severe attention deficits)
- had a significant hearing or visual impairment.

Children with medical complexity were recruited in two ways:

1. Speech-language pathologists at the RCH and LCCH approached suitable patients during appointments at the hospital or on the inpatient wards, and invited them to participate in the study.
2. Speech pathology patients at the RCH and LCCH were approached by the primary investigator by phone or in-person during visits to the hospital, and were invited to participate in the study.

Children from the general paediatric population were recruited by:

- advertising in The University of Queensland (UQ) staff newsletter
- circulating information about the study to staff at the RCH and LCCH.

Written consent was obtained from the participants' caregivers. Please see Appendix C for the caregiver information sheet and consent form.

Screening tasks and comprehensive assessment tasks were completed by the principal investigator (Olivia Taylor), an SLP who had between six to eight years of paediatric experience at the time of data collection. Training in telepractice equipment and procedures was provided by staff from the Centre for Online Health at the RCH prior to data collection.

Apparatus

The experimental apparatus consisted of:

- HBT system
- SBT system using consumer-grade equipment
- speech and language screening tools
- child-sized table and chairs located in the participant's room
- reward items (e.g. bubbles, stickers, stamps) located in the participant's room
- two digital video cameras (Sony HDR-XR160E) on tripods, one located in each room

The HBT and SBT systems used in this research study are both readily accessible to SLPs. These systems are described below:

Hardware-based telepractice (HBT) system

For the HBT condition, point-to-point videoconferencing was conducted via the Queensland Health Statewide Telehealth Network. This system is similar to those commonly found in health and education systems. At the RCH, videoconferencing was conducted using Sony PCS-G70 and Sony PCS-11P videoconferencing systems with a connection rate of approximately 0.5Mbps and standard definition (SD). At the LCCH, videoconferencing was conducted using Cisco TelePresence System Quick Set C20 systems, with a connection rate of approximately 512Mbps and high definition (HD). Cameras in both systems could be controlled remotely.

Software-based telepractice (SBT) system using consumer-grade equipment

For the SBT condition, videoconferencing was conducted between two laptops (Dell Vostro 3550) with external webcams (Logitech QuickCam Pro 9000) using free videoconferencing software (Logitech Vid HD, Cisco Jabber Video for Telepresence). The equipment and software used in this system is available to most families and SLPs, and is low cost. Assessment stimuli pictures were scanned and saved as a PowerPoint file, and displayed on the participants' laptop screen using free screen sharing software (Mikogo). For ease of use an external mouse was plugged into the participants' computer to bypass the laptop's touchpad. At the RCH, laptops were connected by Ethernet cable to an ADSL2+ modem router to simulate a home connection. This network has a typical theoretical maximum speed of 24 Mbps download and 1.4 Mbps upload, however, ADSL2+ speeds are typically lower than this due to factors such as distance from the telephone exchange, network congestion, and telephone line quality (247). It was estimated that this connection ranged between 8-15 Mbps. At the LCCH, the computers were connected by Ethernet cable to a corporate local area network (LAN) of at least 100 Mbps. See Table 16 for software bandwidth specifications.

Table 15 Software specifications

Videoconferencing Software	Maximum incoming bandwidth	Maximum outgoing bandwidth
Logitech Vid HD	1.536 Mbps	1.536 Mbps
Cisco Jabber Video for Telepresence	512 Kbps	512 Kbps

Speech and language screening tools

Speech and language screening tools were chosen based upon commercial availability and current practice in Australia.

The following screeners were used for participants aged 3-5 years:

1. The *PLS-4 Screening Test* (248).

   The *PLS-4 Screening Test* is a norm-referenced tool used to screen the communication of children aged between 3 years – 6 years and 11 months. It takes approximately 5 – 10 minutes to administer. This test contains a language and articulation screener, as well as checklists for connected speech, pragmatic language, fluency, and voice. Only the language screening items were used in this study. If the child's total score is below the pass criterion for their age, a referral for comprehensive language assessment is indicated. Criterion scores were developed by comparing results on the *PLS-4 Screening Test* with findings from a full language

assessment, the *PLS-4* (187). Diagnostic accuracy and reliability data for this test are presented in Table 16.

2. The *Diagnostic Evaluation of Articulation and Phonology* (*DEAP*) (249)
   The *DEAP* is a battery of five standardised assessments used to conduct differential diagnosis of speech disorders among children aged 3 years – 6 years 11 months. For the purposes of this study, the *Diagnostic Screen* and *Oro-motor Assessment* were used.

   The *Diagnostic Screen* identifies children who require further articulation, phonology, or inconsistency assessment. During this screen, the child names ten pictures twice (trials 1 and 2). The SLP compares word productions across the trials, and further inconsistency assessment is indicated if 50% or more of the words were produced differently. The SLP also evaluates the child's speech, and a referral for further articulation or phonology assessment is indicated if the child presents with any delayed or abnormal speech errors for their age.

   The *Oro-motor Assessment* screens oromotor function by evaluating the child's performance in two areas: 1) ability to produce sound sequences (DDK tasks) and 2) ability to perform isolated and sequenced oral movements. Children are scored by the SLP according to criteria that relate to the accuracy, fluency, and range of movements. Children are given three scores: a DDK score, an I-M score (isolated movement), and an S-M score (sequenced movement). If the child presents with delayed oromotor skills a referral for further assessment of oromotor function is indicated.

   Normative data for the *DEAP* were developed following standardisation on a representative sample of children in the UK and Australia. Diagnostic accuracy and reliability data for the *DEAP* are tabulated in Table 16.

The following screeners were used for participants aged 6-12 years:

1. The *Clinical Evaluations of Language Fundamentals Screener, 4th Edition (CELF-4 Screener)* (250)
   The *CELF-4 Screener* is a screening tool for ages 5 years – 21 years 11 months. It takes approximately 15 minutes to administer. Further language testing is indicated if the child's total test score falls below the criterion for their age. The criterion scores were developed by administering the screener to two groups of children: those with a diagnosed language disorder and those with normal language abilities. The distribution of raw scores for these two groups

was plotted, and criterion scores were estimated by examining where the distributions overlapped. Sensitivity and specificity were then calculated to verify the criterion scores. Diagnostic accuracy and reliability data can be found in Table 16.

2. The *DEAP* (249)

   Children aged 6 – 12 years were also screened using the *Diagnostic Screen* and the *Oro-motor Assessment* from the *DEAP* (see above for details). No normative data is available for children aged over 7 years, however, the *DEAP* manual states that this assessment can still be used to describe the speech and oromotor function of older children. Ninety percent of children over 7 years of age have error-free speech, thus, children aged 7 years or older with speech errors should be referred for comprehensive speech assessment. Scores for the *Oro-motor Assessment* can be interpreted with reference to the performance of younger children.

Figure 15 Assessments used in this study, clockwise from top left: the PLS-4 Screening Test, the CASL, the DEAP, the CELF-P2, and the CELF-4 Screener

Adapted screening tools

As previously discussed, there was a risk that carryover or practice effects may occur in this study due to repeated administration of the language screening tools across the three methods. To avoid carryover effects, a washout period can be used. This is a period of time between interventions that is long enough to rule out a carryover or practice effect (251). Unfortunately, the language screening tools used in this study did not provide information on how long the test-retest interval should be to avoid practice effects. Examination of technical information for the two screening tools (248, 250) revealed that the shortest test-retest period included in reliability testing was 24 hours (see Table 16). Thus, it was assumed that a washout period of at least 24 hours would be required before re-administering these screening tools.

If a washout period of greater than 24 hours had been used, participants would have needed to visit the hospital for screening on three separate days. This is a significant time commitment and there were concerns this would lead to recruitment difficulties. Therefore, I decided to use adapted language screening tests that could be administered consecutively on the same day, rather than re-administering the same screening tool three times with a washout period. Permission was granted by the publishers to match items from the *PLS-4 Screening Test* (248) and the *CELF-4 Screener* (250) to similar items from the full *PLS-4* (187) and the full *CELF-4* (188). Thus, each participant was screened once using the original screening test, and once using each adapted screening test. The *DEAP* could be administered multiple times on one day without requiring any adaptation, as a child's performance during speech assessment should not be affected by "remembering" answers from previous administrations of the same test (252).

Table 16 Screening tool technical information

Language Screening Tool	Diagnostic Accuracy	Sensitivity	Specificity	Test-retest Reliability (r)	Test-retest Time Period (days)
PLS-4 Screening Test	82-91%	0.82	0.79	0.86	1-14
DEAP	87-90%	1.00	0.50	PCC†=0.94 DDK=0.60 I-M§=0.81 S-M¶=0.67	14
CELF-4 Screener	84-97%	0.88	0.88	5;0-8;11 years=0.89 9;0-12;11 years=0.90	1-33

†PCC = percentage consonants correct;§I-M = isolated movements; ¶S-M = sequenced movements.

Telepractice modification

Because there are not yet any published speech pathology assessment tools specifically designed for telepractice administration, ASHA's telepractice guidelines suggest that assessment resources and procedures should be modified for the telepractice environment (135). The screening tools selected for this study were analysed by stimulus and response type so that they could be appropriately modified for the two telepractice screening methods. Analysis of the screening tool items found that stimulus and response types fell into three main categories: verbal, picture-based, and motor.

Telepractice requirements for each of these categories are discussed below:

Verbal stimuli and responses:

Good audio quality ensures that the child can hear task directions, and that the SLP can hear the child's responses, which is particularly important for speech sound screening. Good image quality is also important, to ensure that the child and SLP can view non-verbal cues (e.g. observing lip and tongue movements during speech). A zoom function may help the SLP to observe non-verbal cues during speech and oromotor screening.

Picture-based stimuli:

Good image quality and the ability to display pictures in a larger format (zoom) ensures the child can easily see the stimuli. A document sharing function may be used to display stimuli to the child during videoconferencing.

Motor stimuli and responses (e.g. oromotor movements and pointing):

Good image quality and an adequate frame rate without transmission delay will ensure that the SLP and child can view each other's movements. The ability to zoom in on the child's face during an OMA will allow the SLP to closely see oral movements. Camera pre-sets could be helpful to allow the SLP to easily switch views during screening. If the child is required to point to a picture displayed on the screen, the SLP must be able to see where they are pointing. This could be achieved using a touch screen, or by using screen-sharing software and asking the child to point using a mouse. Alternatively, a mirror positioned behind the child will allow the SLP to view a reflection of their responses.

Research protocol

As previously discussed, this method-comparison study was designed to evaluate screening via two novel telepractice approaches by comparing them with the existing method, in-person screening. To do this, participants were screened using all three methods:

1. in-person screening
2. screening using the HBT system
3. screening using the SBT system.

The participant, their caregiver, and the SLP were co-located in one room for in-person screening. Remote screening was simulated for the two telepractice conditions by conducting videoconferencing between rooms, with the participant and their caregiver in one room, and the SLP in another room.

Screening was conducted sequentially. Thus, the order of conditions was randomised using a free web-based randomisation tool to ensure that any differences associated with time were spread across the three screening methods. Each participant was screened first using the original language screener, irrespective of the order of conditions, followed by the first adapted screener and then the second adapted screener. By keeping screening tool order consistent, differences associated with the screening tools were also spread across the three screening methods. Detailed information about the research process for each condition will be described below.

Condition 1: in-person screening

For in-person screening the SLP and participant were present in the same room. The child and SLP sat around the corner from each another at a child-sized table, with screening tool stimulus materials placed on the table between them (see Figure 16 and Figure 17). The child's caregiver was also present in the room during testing. The SLP asked the caregiver not to provide any prompting or assistance to their child during testing. All screening tools were conducted in the standard manner, as outlined in the relevant test manuals. Scoring was completed by the SLP during test administration. The SLP used reward items to provide positive reinforcement to the participant, if required.

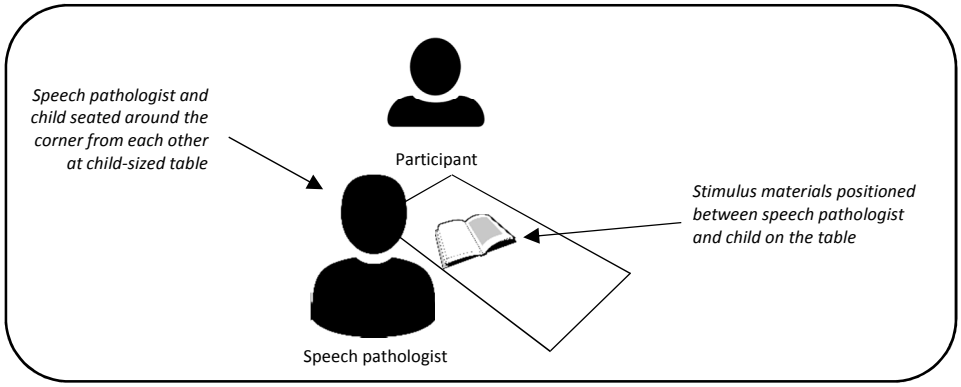


Figure 16 In-person condition: room set-up

Figure 17 In-person screening set-up

Condition 2: HBT system

During HBT screening the SLP and participant were located in separate rooms. The caregiver was present with the child during the telepractice session. Before testing, the SLP entered the room with the child and caregiver to provide a brief orientation to the room set-up and telepractice equipment. The participant was seated on a child-sized chair approximately one metre in front of the videoconferencing unit (the unit was positioned on height adjustable trolley). The mirror and easel was positioned behind the child (see Figure 18 and Figure 19).

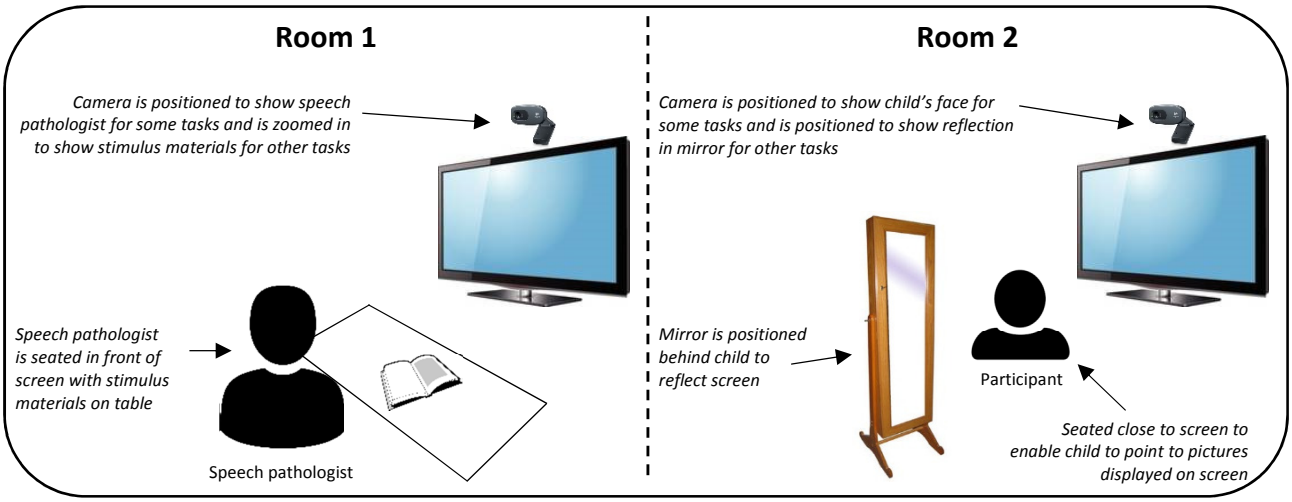


Figure 18 HBT condition: room set-up

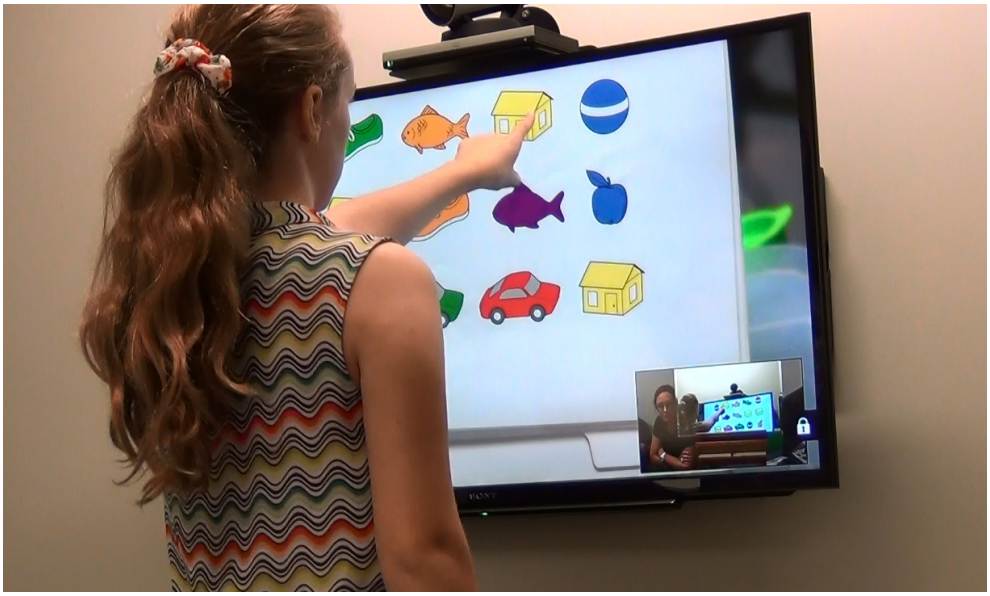


Figure 19 HBT screening set-up, showing a participant completing the CELF-4 Screener. Note the SLP has zoomed into the mirror to observe a reflection of what the child is pointing to.

The SLP returned to the other room and initiated videoconferencing once the child was settled. The auto-answer feature was enabled so that there was no need for the participant or caregiver to accept the call. At the beginning of the videoconferencing session, the cameras were focused on the SLP's and child's faces. The SLP confirmed with the child and caregiver that they could see and hear adequately. At this point the SLP also asked the caregiver not to give the child any prompting or assistance during screening.

As previously outlined, the screening tools used in this study contain tasks with different instruction/stimuli and response types. For the HBT condition there were three display options that changed to suit the specific task requirements of different screening items (see Table 17). For the first two display options the child was required to sit in the chair, however, for the third display option the child was asked to stand in front of the videoconferencing unit in order to point to pictures displayed on the screen. Pre-set zoom settings allowed the SLP to easily switch between views, however, to avoid switching views too often, the order of test item administration within the *PLS-4 Screening Test* and the *CELF-4 Screener* was adapted.

Table 17 HBT: display options

Display option	What does the child see?	What does the SLP see?
Option 1	Camera is zoomed in closely to show the SLP's face and shoulders	Camera is zoomed in closely to show the child's face and shoulders
Option 2	Camera is focused on the assessment stimulus book which was positioned on the table in front of the SLP	Camera is zoomed in closely to show the child's face and shoulders
Option 3	Camera is focused on the assessment stimulus book which was positioned on the table in front of the SLP	Camera is focused on the mirror behind the child, so that the SLP can see a reflection of the child pointing to images displayed on the screen.

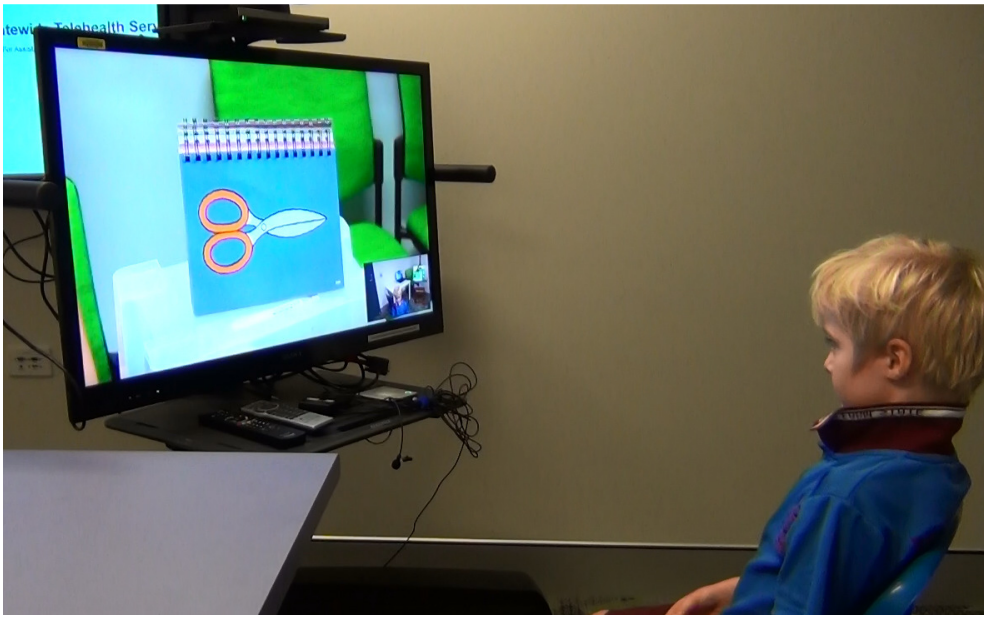


Figure 20 HBT screening set-up, showing a participant completing the DEAP

The screening session procedure was as follows:

1. *DEAP Oro-motor Assessment* (option 1)
2. *DEAP Diagnostic Screen* (option 2)
3. *PLS-4 Screening Test* (ages 3-5 years) or *CELF-4 Screener* (ages 6-12 years):
    a. Items that require the child to respond verbally to picture-based stimuli (option 2)
    b. Items that require the child to respond motorically to picture-based stimuli (option 3)
    c. Items that do not require the stimulus book (option 1)

If the child required reinforcement during the session, the SLP directed the caregiver to provide a reward (e.g. bubbles, stamp, sticker). Once all screening tasks were completed the SLP terminated the videoconference.

Condition 3: SBT system

For this condition the SLP and child were located in separate rooms. Screening was conducted using free videoconferencing software between two laptop computers with external webcams. The caregiver was present with the child during the telepractice session. The SLP briefly entered the room with the child and caregiver to provide orientation to the room set-up and equipment. In the participant's room, the laptop computer and external mouse were set up on the child-sized table with two chairs for the child and the caregiver. The SLP left a selection of reward items (bubbles, stamps, stickers) with the caregiver.

The SLP returned to the other room and initiated videoconferencing and screen-sharing once the child was settled. The caregiver answered the videoconferencing call on the participant's computer, and accepted the Mikogo connection. Before testing started, the SLP took some time to ensure that the participant was correctly positioned within the camera view, and that the participant and caregiver could see and hear the SLP. The SLP also asked the caregiver not to provide any assistance or prompting to the child during screening.

For the SBT condition there were three display options that changed to suit the specific task requirements of different screening items (see Table 18). For display options 2 and 3 the assessment stimuli was displayed on the participant's computer as a PowerPoint file using screen sharing software (Mikogo). There was often a delay at the participant's end when transitioning between images. To avoid confusion, the SLP confirmed with the caregiver that the new image was visible before administering each new item. For assessment items that required the child to point at pictures, the child used the mouse to point at the image on their screen (display option 3). To prevent the child becoming distracted by the mouse, the SLP asked the child to take their hands off the mouse and place them on the table between each test item. The child was asked to keep their hands on the table

until the SLP had finished giving task instructions. Children who were unable to use a mouse were asked to point at the screen using their fingers, and their caregiver reported the response verbally to the SLP.

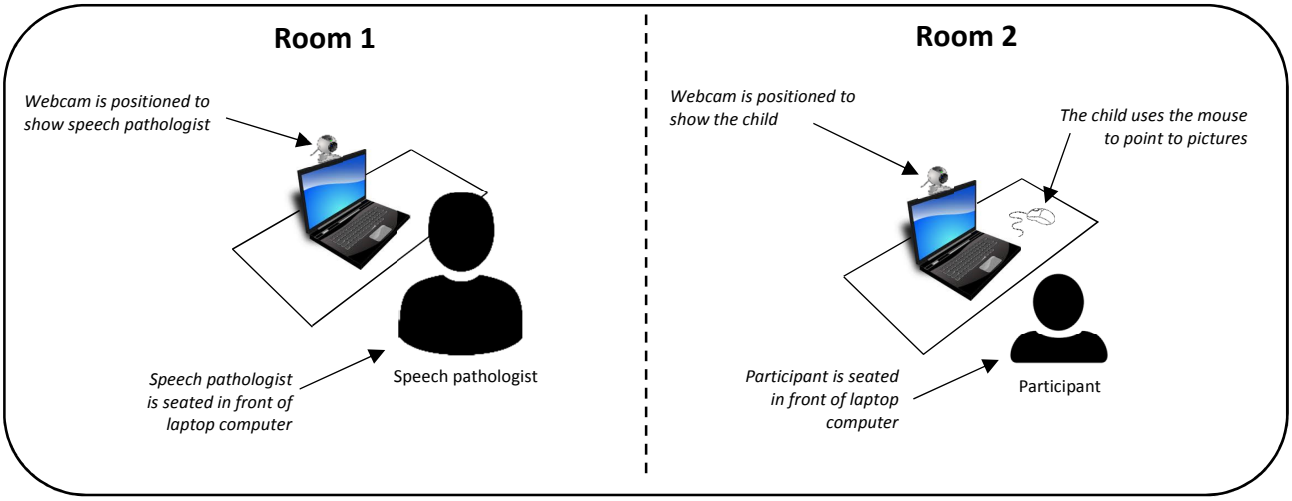


Figure 21 SBT condition: room set-up

Table 18 SBT: display options

Display option	What does the child see?	What does the SLP see?
Option 1	Webcam is zoomed in closely to show the SLP's face and shoulders.	Webcam is zoomed in closely to show the child's face and shoulders.
Option 2	The SLP used Mikogo to remotely display the assessment stimuli on the child's laptop.	Webcam is zoomed in closely to show the child's face and shoulders.
Option 3	The SLP used Mikogo to remotely display the assessment stimuli on the child's laptop. The participant uses the mouse to point to images on the screen.	The SLP also views the assessment stimuli, and is able to observe the child's mouse movements.

The screening session procedure was as follows:

1. *DEAP Oro-motor Assessment* (option 1)
2. *DEAP Diagnostic Screen* (option 2)
3. *PLS-4 Screening Test* (ages 3-5 years) or *CELF-4 Screener* (ages 6-12 years):
    a. Items that require the child to respond verbally to picture-based stimuli (option 2)
    b. Items that require the child to respond motorically to picture-based stimuli (option 3)
    c. Items that do not require the stimulus book (option 1)

The SLP directed the caregiver to provide rewards throughout the session, as required. Once all screening tasks were completed the SLP terminated the videoconference.

Figure 22 SBT screening set-up

Caregiver and child satisfaction

The opinions of caregivers regarding each screening condition were evaluated using a 10 item questionnaire. Each question was answered on a five-point scale (strongly disagree, disagree, undecided, agree, and strongly agree). Please see Appendix D for satisfaction survey forms. This questionnaire was completed following each condition. For each screening condition, the questionnaire gathered information on:

- caregiver satisfaction
- whether the caregiver would be willing to access future services using this service delivery model
- whether the caregiver would recommend this service delivery model to others
- the caregiver's confidence in screening result accuracy
- whether the caregiver felt nervous or apprehensive before screening
- how comfortable the caregiver and child felt during screening
- the SLP's ability to build rapport with the child
- the SLP's ability to manage the child's behaviour

- whether the caregiver had any concerns about confidentiality.

There was also space at the end of each questionnaire for parents to write further comments (optional).

Once all three screening conditions were completed, the caregiver was asked to complete another questionnaire. This questionnaire asked caregivers to rate the three conditions in order of overall preference. This questionnaire also asked caregivers to think about various factors that might influence their decision to access telepractice services versus in-person services, and to rank these in order from most important to least important. Space was also available at the end of this questionnaire so that parents could add extra comments (optional).

Participants aged 6-12 years also completed a brief questionnaire following each screening method. This questionnaire contained three items that gathered information on image quality (how easy it was to see the SLP and to see the pictures) and audio quality (how easy it was to hear the SLP). Participants rated each question on a three-point scale (bad, ok, good). Once all three screening conditions were complete the participants were given a brief two-item questionnaire, which asked the children to identify the screening methods they considered to be the best and the worst.

Quality and child behaviour observations

Video recordings of each participant's screening were reviewed by the SLP, and the following observations were made:

- the presence of any behaviour or compliance issues
- whether the child moved out of view during telepractice screening
- whether the participant or their caregiver requested repetition during screening
- whether the SLP requested repetition during screening
- whether there was any distortion in audio signal
- whether there was any image distortion
- duration of each screening session.

Full assessment

Children who were identified as needing further speech and/or language assessment received a full, in-person assessment with the SLP. This assessment was conducted on a different day. After this appointment, a report containing results, diagnoses, and recommendations was provided. Speech and language assessments were chosen based upon current practice in Australia.

Children aged 3-5 were assessed using the following tests:

- the *Clinical Evaluation of Language Fundamentals – Preschool, 2nd Edition* (*CELF-P2*) (253)
- the *DEAP* (249).

Children aged 6-12 were assessed using the following tests:

- the *Comprehensive Assessment of Spoken Language* (*CASL*) (254)
- the *DEAP* (249).

Statistical analysis

Stata 14 (Statacorp, College Station, TX) was used to conduct all statistical analyses. Simple descriptive statistics were used to summarise the participants' demographics, the number of completed and uncompleted screening sessions, and the incidence of major or minor technical issues.

Binary ratings for child behaviour, audio and video quality, and the presence/absence of repetition requests were completed from video recordings of the screening sessions. Pearson's chi-squared test (Stata 14; chi2) and Fisher's exact test of independence (Stata 14; exact) were used to test for differences in proportions between binary data from the in-person and telepractice conditions. Where data were insufficient, no statistical tests were conducted.

The following analyses were completed for in-person versus HBT and in-person versus SBT:

- comparison of child compliance ratings
- comparison of repetition requests by the child or their caregiver
- comparison of repetition requests by the SLP.

The following analyses were completed for HBT versus SBT:

- comparison of the number of sessions in which the child moved out of view
- comparison of audio quality ratings, and the presence of echo and audio delays/cut-outs
- comparison of image quality ratings, and the presence of blurring, image jitter/jerky images, and image delays.

Screening duration was timed for each participant across all three conditions. Simple descriptive statistics were used to summarise total screening time, and this was tabulated and plotted in box plots. The Wilcoxon signed-rank test was used to compare the distributions of screening duration (in-person versus HBT, in-person versus SBT, and HBT versus SBT).

The validity of speech screening via telepractice was evaluated by calculating percentage agreement for individual speech sounds between in-person screening and each telepractice screening method. Percentage agreement for each individual sound was then compared with in-person test-retest data within the *DEAP* test manual (249). Agreement within ten percent of the published test-retest data was considered to demonstrate adequate percentage agreement. Children who had been identified with inconsistent speech were excluded from these analyses, as poor agreement in these cases may be due to inconsistent speech errors rather than reduced concordance between methods. The *Diagnostic Screen* evaluates a number of consonant clusters, however, no test-retest reliability data was provided for these clusters so these were not included in analysis.

Each child was given a score of pass/fail for inconsistency (i.e. children with an inconsistency score of greater than 50% were rated as "fail"). Validity was evaluated by calculating percentage agreement between the conditions for pass/fail ratings. This is the first study to investigate inconsistency screening via telepractice, therefore, there were no published criteria for acceptable agreement. Previous studies that used percentage agreement to validate telepractice speech assessment have set their criteria for acceptable agreement at 70-85% (36, 37). Inconsistency is a component of speech, thus it was determined to use these published criteria to guide development of the criterion. It was determined to use the more conservative figure of 85% to characterise adequate percentage agreement for inconsistency.

Validity of oromotor screening was evaluated by using Pearson's product-moment correlation coefficient (Stata 14; pwcorr) to determine the level of agreement between oromotor scores gathered during in-person and telepractice conditions. Pearson's product-moment correlation coefficient was also used to validate language screening via telepractice, by assessing the strength of the relationship between in-person and telepractice language scores. Correlation is used to assess the existence of a linear relationship between two variables, and ranges from -1 (a perfect negative correlation) to 0 (no correlation exists) to +1 (a perfect positive correlation) (255). Cohen's conventions state that a correlation coefficient of 0.1 indicates a small effect, a correlation coefficient of 0.3 indicates a medium effect, and a correlation coefficient of 0.5 indicates a large effect (256). Scatter plots were produced to illustrate the relationship between scores gathered during in-person and telepractice conditions. Data from the oromotor and language screening tests were continuous, but data was not normally distributed, so a paired sample t-test could not be used. Correlation was used in preference to other statistical tests (e.g. the Wilcoxon signed rank test) as the *DEAP*, *PLS-4 Screening Test*, and *CELF-4 Screeners* used Pearson's product-moment correlation coefficient to calculate test-retest

reliability, and these data are provided in the test manuals. Thus, results from this study could be compared with these data from the manuals.

Each caregiver and school-aged child completed a satisfaction rating scale following each screening condition. Only data from each participants' first screening condition were included in satisfaction analyses, to minimise bias that may have occurred due to the influence of preceding screening methods. Rating scale categories were collapsed to disagree, undecided, and agree due to small numbers within some of the categories. Caregiver and child satisfaction data were summarised using simple descriptive statistics, and plotted in diverging stacked bar charts. Due to small numbers, no further statistical analyses were conducted. Some parents made comments on the satisfaction survey sheets, and these comments were analysed qualitatively.

After screening had been conducted across all three conditions, the caregivers and school-aged children rated all three methods in order of preference. These data were summarised using descriptive statistics and plotted using bar charts. Caregivers were also asked to rank nine factors that might influence their decision to use telepractice in order of importance. Descriptive statistics were used to summarise these data.

6.3 Results

Thirty-four children participated in the study, aged from 3-12 years (mean 5.5 years, median 5 years). The majority of participants were male (n = 23, 67.6%). Due to recruitment difficulties only eight CMC participated (23.5%), with remaining participants recruited from a general paediatric population. Following comprehensive assessment, nine participants (26.5%) were diagnosed with a speech impairment, and four participants (11.8%) were diagnosed with a language impairment.

Practical and technical feasibility

Overall, 100.0% (n = 34/34) of the in-person and HBT screening assessments were completed. However, two SBT screening sessions (5.9%) could not be completed due to an Internet outage. Major technical difficulties affected a total of eleven (32.4%) SBT sessions. Videoconferencing failed in six (17.6%) of those sessions, and re-connection was required. Screen-sharing software (Mikogo) failed in another six sessions (17.6%), and stimulus materials were displayed by holding them up to the camera. Mikogo also required updating mid-way through four sessions (11.8%), which interrupted screening. No major technical difficulties interrupted the HBT sessions.

Participants' compliance and behaviour was rated from video recordings of the screening sessions. Not all screening sessions were recorded due to issues with the video camera. Recordings were gathered for 26 in-person sessions, 26 HBT sessions, and 25 SBT sessions, although there were some missing data. The incidence of difficult behaviours was compared between the in-person and telepractice screening methods. Analysis indicated that children were significantly more likely to demonstrate reduced compliance during HBT ($p < 0.05$) and SBT ($p < 0.01$) conditions than they were during in-person screening (see Table 19). Children were significantly more likely ($p < 0.05$) to move out of view during HBT screening than they were during SBT screening (see Table 20).

Table 19 Comparison of participant behaviour (poor compliance) during screening

Poor compliance	**In-person screening**		**HBT screening**		**SBT screening**		**P-value**	
	n	%	n	%	n	%	IP vs HBT	IP vs SBT
Whole group	6/26	23.1	9/26	34.6	8/25	32.0	<0.05*	<0.01*
Preschool-aged children	5/15	33.3	8/15	53.3	6/14	42.9	ns*	ns*
School-aged children	1/11	9.1	1/11	9.1	2/11	18.2	-	-

*Fisher's exact test, where data were insufficient no statistical tests were conducted

Table 20 Comparison of participant behaviour (child moves out of view) during screening

Child moves out of view	**HBT screening**		**SBT screening**		**P-value**
	n	%	n	%	
Child moves out of view	14/24	58.3	6/24	25.0	<0.05*
Preschool-aged children	8/13	61.5	3/13	23.1	-
School-aged children	6/11	54.5	3/11	27.3	-

*Fisher's exact test, where there were insufficient data to calculate statistics a p-value was not reported

The presence of audio or image distortions was noted from the video recordings. There was some form of audio distortion observed in 60.9% of recorded HBT sessions, and in 73.9% of recorded SBT sessions (difference not significant). However, the nature of audio distortions varied between the two telepractice methods. Echo was noted in more than half of the recorded HBT sessions, but it did not occur during any of the SBT screening sessions. Conversely, audio delay/cut-out was common during SBT sessions, but was rarely noted during HBT sessions (see Table 21).

Video distortions were very common during the SBT sessions (91.7%). The most commonly observed types of video distortion during SBT sessions included image jitter/jerky images and image

delay, which were observed in over 70% of the recorded sessions. Video distortions occurred far less frequently during HBT screening, although some form of video distortion was identified in 29.2% of recorded sessions. The most common distortion noted during HBT screening was blurring. Image jitter/jerky images and image delays rarely occurred during HBT screening (see Table 21).

Table 21 Comparison of audio and image distortions during telepractice screening

Presence of distortion	HBT screening		SBT screening		P-value
	n	%	n	%	
Any audio distortion	14/23	60.9	17/23	73.9	ns*
Echo	13/23	56.5	0/23	0.0	-
Audio delay/cut-out	1/23	4.3	17/23	73.9	-
Any image distortion	7/24	29.2	22/24	91.7	-
Blurring	7/24	29.2	5/24	20.8	ns*
Image jitter/jerky images	2/24	8.3	17/24	70.8	-
Image delays	1/24	4.2	17/24	70.8	-

*Fisher's exact test, where data were insufficient no statistical tests were conducted

Videos were reviewed to determine whether the participant, caregiver, or SLP requested repetition during screening. Children and caregivers were more likely to request repetition during HBT ($p < 0.05$) and SBT ($p < 0.05$) screening methods than they were during in-person screening. However, no significant relationship was identified between screening method and the likelihood that the SLP would request repetition.

Table 22 Repetition requests during screening

Person who made the request	Age group	In-person screening		HBT screening		SBT screening		P-value	
		n	%	n	%	n	%	IP vs HBT	IP vs SBT
Child or caregiver	Whole group	5/22	22.7	7/22	31.8	13/22	59.1	<0.05*	<0.05*
	Preschool-aged children	0/14	0.0	0/14	0.0	5/13	38.5	-	-
	School-aged children	5/8	62.5	7/8	87.5	8/9	88.9	ns*	ns*
SLP	Whole group	9/22	40.9	16/22	72.7	14/22	63.6	ns*	ns*
	Preschool-aged children	9/14	64.3	11/14	78.6	11/13	84.6	ns*	-
	School-aged children	0/8	0.0	5/8	62.5	5/9	55.6	-	-

*Fisher's exact test, where data were insufficient data no statistical tests were conducted

Total time

Screening duration was compared across the three conditions. Different screening batteries had been administered according to age group, therefore, the age groups were analysed separately. As stated previously, only 26 participants had available video footage due to issues with the video recording. Two of these participants did not have footage available across all three conditions, thus they were excluded. There were 13 children included in analyses for the preschool-aged group, and 11 children included in analyses for the school-aged group.

Screening duration was plotted in a box plot for the preschool-aged children (see Figure 23) and for the school-aged children (see Figure 24). No outliers were identified for the preschool-aged group for either telepractice condition, however, inspection of the data revealed one outlier of 14.3 minutes for the in-person condition. This participant was at the younger end of the age group (3 years, 5 months), and had listening and attention difficulties, which likely accounted for increased duration. Children with these types of difficulties are likely candidates for screening, thus this outlier was retained. No outliers were identified for any of the screening conditions for the school-aged group.

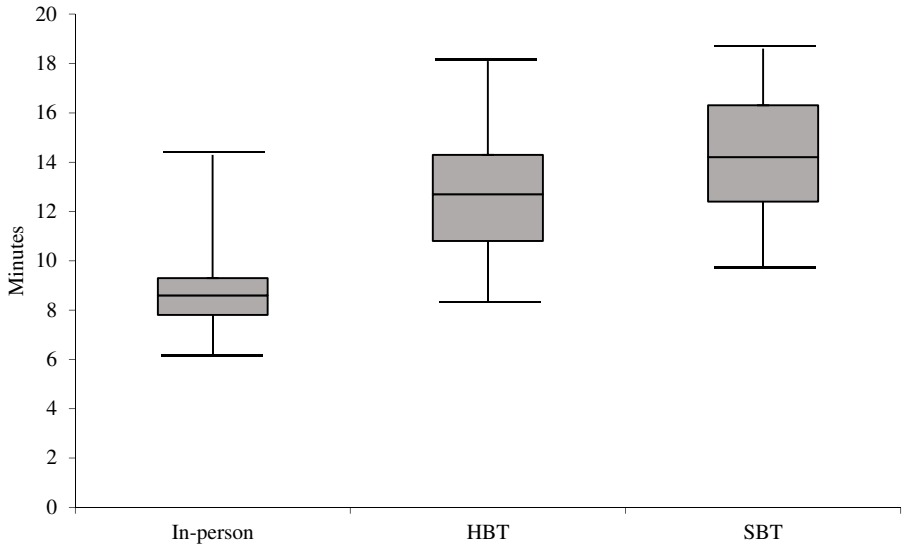


Figure 23 Screening duration for preschool-aged children

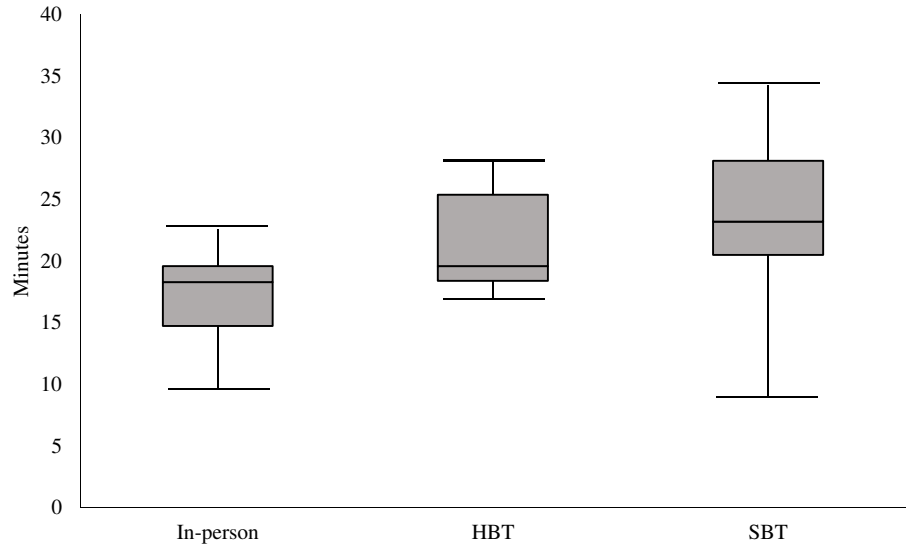


Figure 24 Screening duration for school-aged children

There was a statistically significant difference in duration for in-person versus telepractice screening. This difference was present across both age groups, and for both telepractice screening methods (see

Table 23). However, the differences between median times for in-person and telepractice screening duration were small, and unlikely to be clinically important. When comparing screening duration by the two methods of telepractice (HBT versus SBT), no significant difference was found for either age group.

Table 23 Total duration of screening

Age group	In-person screening duration (minutes)			HBT screening duration (minutes)			SBT screening duration (minutes)			P-value		
	Mean	Median	Range	Mean	Median	Range	Mean	Median	Range	IP vs HBT	IP vs SBT	HBT vs SBT
Preschool-aged children	8.9	8.6	6.1-14.3	12.9	12.7	8.3-18.1	14.1	14.2	9.7-18.6	<0.05*	<0.005*	ns*
School-aged children	16.9	18.3	9.7 - 22.6	22.0	19.6	17.0 - 28.0	23.7	23.2	20.5 - 34.3	<0.05*	<0.05*	ns*

*Wilcoxon signed-rank test

Screening validity

Speech

Percentage agreement for individual speech sounds ranged from 54.2-100.0% between in-person and telepractice screening methods. Out of 16 individual speech sounds assessed, agreement was adequate between in-person and HBT screening for 13 sounds (81.3%) (see Table 24), and agreement was adequate between in-person and SBT screening for 14 sounds (87.5%) (see Table 25). Sounds that did not reach criterion during HBT screening included /θ/ (thank you), /ʃ/ (fishing), and /tʃ/ (watch). Sounds that did not reach criterion during SBT screening were /θ/ and /tʃ/.

Table 24 Concordance between in-person and HBT screening for individual speech sounds

Target sound	Level of agreement (%) n = 24	In-person test-retest agreement percentages (from manual)
p	95.8	100.0
d	100.0	100.0
k	100.0	100.0
m	91.7	100.0
ŋ*	100.0	100.0
f	100.0	100.0
θ*	54.2	91.1
s	87.5	94.6
z	95.8	89.3
ʃ*	70.8	89.3
h	100.0	100.0
tʃ*	75.0	98.2
dʒ*	91.7	96.4
l	83.3	87.5
w	100.0	100.0
j*	95.8	100.0

Table 25 Concordance between in-person and SBT screening for individual speech sounds

Target sound	Level of agreement (%) n = 24	In-person test-retest agreement percentages (from manual)
p	91.7	100.0
d	95.8	100.0
k	100.0	100.0
m	91.7	100.0
ŋ*	100.0	100.0
f	100.0	100.0
θ*	54.2	91.1
s	87.5	94.6
z	91.7	89.3
ʃ*	87.5	89.3
h	95.8	100.0
tʃ*	87.5	98.2
dʒ*	91.7	96.4
l	91.7	87.5
w	100.0	100.0
j*	100.0	100.0

*ŋ (e.g. fishing), θ (thank you), ʃ (fishing), tʃ (watch), dʒ (bridge), j (you).

Inconsistency

There was high percentage agreement between the in-person and HBT conditions for inconsistency screening (90.6%), and agreement remained above criterion (≥85%) once age group was taken into account. Percentage agreement between the in-person and SBT conditions did not reach criterion (79.3%). However, analysis by age group revealed an age-related difference: agreement was not adequate for preschool-aged children (66.7%), however, agreement was high for school-aged children (92.9%) (see Table 26).

Table 26 Concordance between screening methods for pass/fail ratings on the inconsistency screener

Age group	Level of agreement In-person vs. HBT screening		Level of agreement In-person vs. SBT screening	
	n	%	n	%
Whole group	29/32	90.6	23/29	79.3
Preschool-aged children	17/19	89.5	10/15	66.7
School-aged children	12/13	92.3	13/14	92.9

Oromotor

Correlation between in-person and telepractice conditions was calculated for the three oromotor scores: DDK, I-M, and S-M. Scatter plots were produced to illustrate the relationship between scores (see Figure 25 to Figure 30). One outlier was identified among the S-M scores for the HBT screening method (participant 11) (see Figure 29). This participant had participated willingly during the in-person and SBT conditions, but had refused to complete oromotor screening during the HBT condition. Thus, this outlier was removed from further analysis.

There was a large positive correlation between in-person and SBT screening methods for all three scores (r = 0.70-0.93), although the relationship was small for school-aged children's S-M scores (r = 0.14). Correlation was also large and positive between in-person and HBT screening methods for all three scores (r = 0.5-0.81). Further analysis of DDK scores by age group revealed that the correlation between conditions was strengthened when school-aged children were considered separately (r = 0.76). A small relationship was evident between the conditions for school-aged children's S-M scores (r = 0.22). Correlation coefficients were compared with those provided within the DEAP test manual (test-retest reliability) (see

Table 27). Most were comparable, apart from DDK scores for preschool-aged children during HBT screening, and school-aged children's S-M scores across both telepractice methods.

Table 27 Correlation coefficients (r) for DEAP scores

***DEAP* score**	**Age group**	**In-person vs. HBT screening**			**In-person vs. SBT screening**			**Test-retest reliability *(from test manual)***
		n	Correlation (r)	p-value	n	Correlation (r)	p-value	Correlation (r)
DDK	**Whole group**	30	0.50	<0.01	28	0.91	<0.001	0.60
	Preschool-aged	16	0.40	ns	14	0.93	<0.001	
	School-aged	14	0.76	<0.01	14	0.90	<0.001	
I-M	**Whole group**	32	0.81	<0.001	30	0.93	<0.001	0.81
	Preschool-aged	18	0.80	<0.001	16	0.93	<0.001	
	School-aged	14	1.00	<0.001	14	1.00	<0.001	
S-M	**Whole group**	31	0.81	<0.001	30	0.70	<0.001	0.67
	Preschool-aged	17	0.81	<0.001	16	0.74	<0.01	
	School-aged	14	0.22	ns	14	0.14	ns	

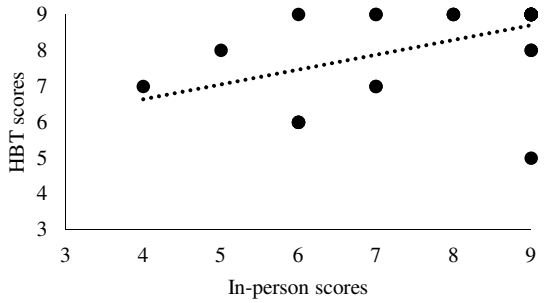


Figure 25 DDK scores - scatter plot illustrating the relationship between in-person and HBT screening

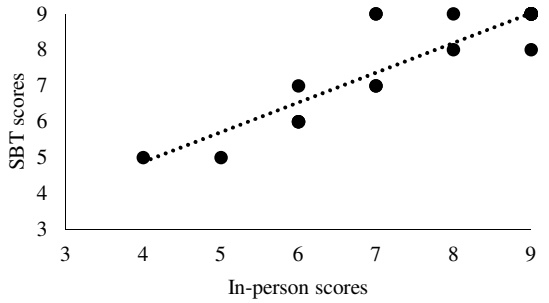


Figure 26 DDK scores - scatter plot illustrating the relationship between in-person and SBT screening

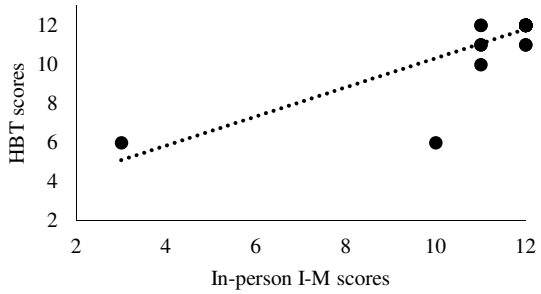


Figure 27 I-M scores - scatter plot illustrating the relationship between in-person and HBT screening

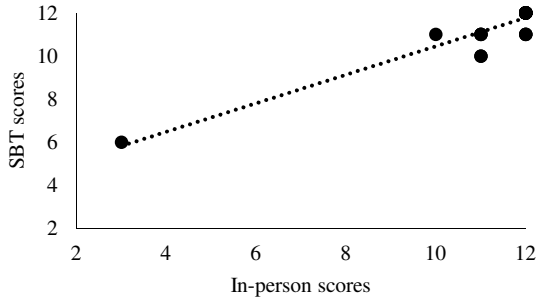


Figure 28 I-M scores - scatter plot illustrating the relationship between in-person and SBT screening

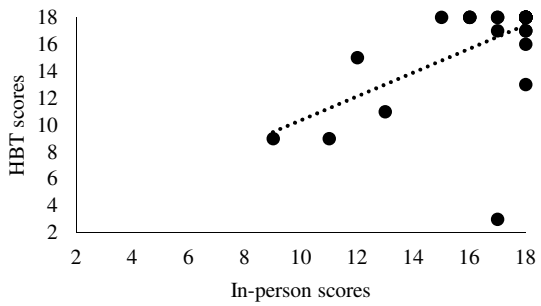


Figure 29 S-M scores - scatter plot illustrating the relationship between in-person and HBT screening

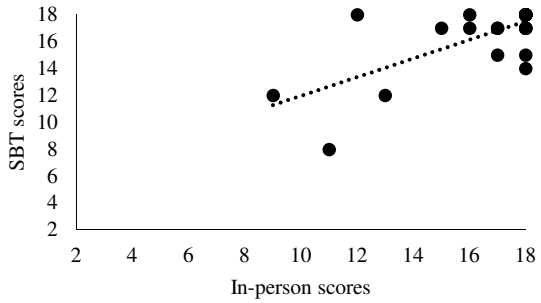


Figure 30 S-M scores - scatter plot illustrating the relationship between in-person and SBT screening

Language

Correlation coefficients were calculated for language scores between the in-person and telepractice conditions, and scatter plots were produced. No outliers were identified. Correlation was medium for screening using the *PLS-4 Screening Test* using HBT (r = 0.39), however, there was large correlation for the *CELF-4 Screener* (r = 0.68). In contrast, correlation was large using the SBT method for the *PLS-4 Screening Test* (r = 0.65), and medium for the *CELF-4 Screener* (r = 0.44). Correlation coefficients were compared with those published within the test manuals (test-retest reliability) (see Table 28). Coefficients from the test manuals for test-retest reliability were very large (> 0.80) for both of the language assessments, and all correlations from the present study were lower than data found in the manual.

Table 28 Correlation coefficients (r) for language screening

Language screening test	**In-person vs. HBT screening**			**In-person vs. SBT screening**			**Test-retest reliability (from test manual)**
	n	Correlation (r)	p-value	n	Correlation (r)	p-value	Correlation (r)
PLS-4 Screening Test	20	0.39	ns	18	0.65	<0.01	0.86
CELF-4 Screener	14	0.68	<0.01	13	0.44	ns	0.82-0.90

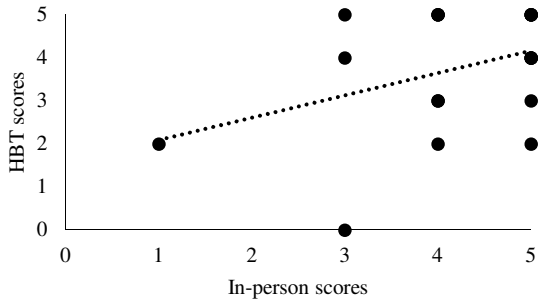


Figure 31 PLS-4 Screening Test scores - scatter plot illustrating the relationship between in-person and HBT screening

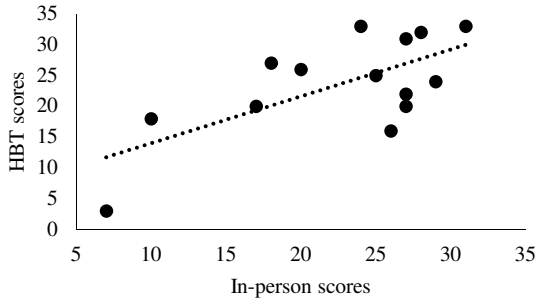


Figure 32 CELF-4 Screener scores - scatter plot illustrating the relationship between in-person and HBT screening

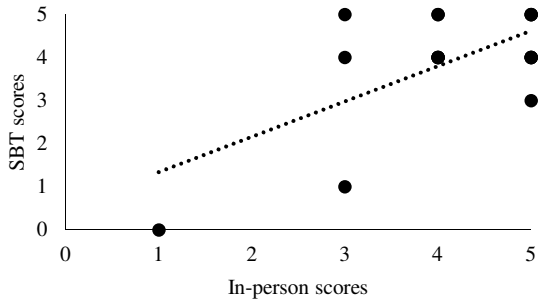


Figure 33 PLS-4 Screening Test scores - scatter plot illustrating the relationship between in-person and SBT screening

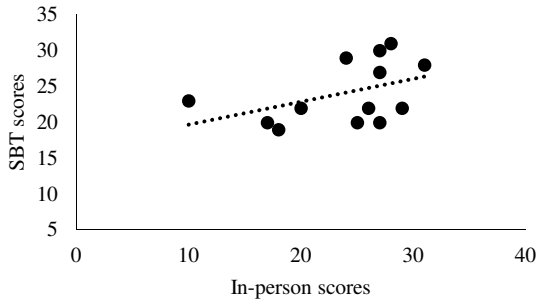


Figure 34 CELF-4 Screener scores - scatter plot illustrating the relationship between in-person and SBT screening

Satisfaction

Caregiver Satisfaction

Data from each participants' first screening condition were included in these analyses. Eleven participants received in-person screening first, 11 participants received HBT screening first, and 12 participants received SBT screening first. Comments from all parents (i.e. not just relating to the first screening method) were analysed qualitatively.

Overall, caregivers' expressed high satisfaction with all three screening methods (see Table 28). One caregiver indicated that she was not sure whether or not she would access SBT screening again for her child, however, all other caregivers were willing to use in-person, HBT, and SBT screening again in the future. Most caregivers would recommend telepractice screening to other parents.

Many caregivers expressed positive attitudes towards telepractice in their comments, and some caregivers commented that telepractice screening had exceeded their expectations:

> *"[It] was great!"* – caregiver of Participant 6, regarding HBT.

> *"I'm surprised at the great quality… would be happy to use it"* – caregiver of Participant 27, regarding HBT.

> *"I would recommend and have my child participate in this again"* – carer of Participant 8, regarding SBT.

Table 29 Responses to caregiver satisfaction survey

Survey question	**In-person screening (n = 11)**			**HBT screening (n = 11)**			**SBT screening (n = 12)**		
	Agree	Undecided	Disagree	Agree	Undecided	Disagree	Agree	Undecided	Disagree
I am satisfied with the service my child received	11	0	0	10	1	0	12	0	0
I would be willing to use this screening method again	11	0	0	11	0	0	11	1	0
I would recommend this screening method to others	11	0	0	10	1	0	11	1	0
The SLP could accurately screen my child's speech and language	11	0	0	9	1	1	10	2	0
I was nervous before my child's screening assessment	1	3	7	3	1	7	0	1	12
I felt comfortable before my child's screening assessment	10	1	0	11	0	0	12	0	0
My child felt comfortable during screening	9	1	1	9	2	0	11	1	0
The SLP developed a good rapport with my child during screening	10	1	0	9	1	1	11	0	0
The SLP could adequately manage my child's behaviour during screening	10	1	0	8	3	0	11	1	0
I was concerned about confidentiality and security during screening	0	0	11	0	0	11	0	0	12

Caregivers reported high levels of confidence in the accuracy of in-person screening (see Table 28), however, a small number of caregivers expressed lower confidence in the accuracy of HBT and SBT screening results.

Some caregivers commented on the presence of audio and image quality issues during SBT screening, which may have affected screening accuracy:

> *"It was sometimes more difficult for [the SLP] to hear [my child's] responses than had she been in the room"* – carer of Participant 23, regarding HBT screening.

> *"If I was really concerned about my child's speech I don't think I would have been confident that [the SLP] got an accurate picture of his abilities"* – caregiver of Participant 20, regarding SBT screening.
>
> *"My child sometimes takes longer to process information, it was difficult for the therapist to determine this due to technology delays"* – carer of Participant 9, regarding SBT screening.

> *"The service wasn't working well. Screen kept freezing, sometimes difficult for my child to understand. [The SLP] sometimes misheard my child's answers – probably wouldn't happen face-to-face"* – carer of Participant 10, regarding SBT screening.

Caregivers were asked whether they had felt nervous or apprehensive prior or during screening. A small number of parents reported that they had felt nervous before screening, most commonly for the HBT screening method (n = 3/11) (see Table 28). All caregivers felt comfortable during telepractice screening, although one caregiver reported that she did not feel comfortable during in-person screening. This same caregiver also reported that her child did not feel comfortable during in-person screening, however, most of the other caregivers reported that their children had been comfortable throughout all screening methods.

Some parents commented that their child was initially shy or uncomfortable, and needed some time to "warm-up" to the telepractice screening methods:

> *"[My child] was initially shy speaking, but confidence grew"* – carer of Participant 13, regarding HBT screening.

> *"Some children may require more of a "warm-up" to try to build rapport and encourage the child to open up more"* – carer of Participant 26, regarding HBT and SBT screening.

Some caregivers expressed that their child had been much more at-ease during a particular method of screening:

> *"Definitely felt more comfortable"* – carer of Participant 26, regarding in-person screening.

> *"Comparing [HBT] and [SBT] – he seemed more comfortable when using the computer [SBT], as in not shy"* - carer of Participant 13, regarding SBT screening.

> *"I think my child performed best in this assessment – I think he was more at ease with "no one" around"* – carer of Participant 22, regarding HBT screening.

One caregiver expressed concerns about how her child had coped with the HBT screening method:

> *"My child didn't respond well to this type of screening. He became very anxious and withdrawn and wouldn't respond. I think the concept is good and I would encourage others to use this service if their child was more outspoken and confident. Unfortunately I don't think this way would be beneficial for my child"* – carer of Participant 8, regarding HBT screening.

Most caregivers believed that the SLP had been able to develop a good rapport with their child during in-person and HBT screening, and all caregivers agreed that the SLP had developed rapport with their child during SBT screening (see Table 28). A small number of caregivers were undecided regarding the SLP's ability to manage behaviour during in-person (n = 1) and SBT screening (n = 1), and three caregivers were undecided regarding behaviour management for the HBT screening condition. All other caregivers believed that the SLP could adequately manage their child's behaviour throughout screening.

One caregiver commented that she believed her child had benefited from meeting the SLP first during the in-person method, which helped build rapport that carried over into the telepractice methods:

> *"We had the advantage of already during face-to-face [screening] first, would have been more difficult to build rapport if we hadn't. May need to establish rapport first [before telepractice]"* – carer of Participant 10, regarding SBT screening.

Some caregivers commented that they needed to assist with behaviour management and task instructions during telepractice screening:

> *"I felt that I possibly needed to take a greater role in behaviour management than [I would have] had the clinician been in the room with us"* – carer of Participant 23, regarding HBT screening.

> *"I needed to help keep him on track. I'm not sure all parents would be able to do so"* – carer of Participant 20, regarding HBT screening.

> *"I felt I had to assist or prompt my child to either answer a question or to speak louder"* – carer of Participant 15, regarding SBT screening.

> *"I think a parent would definitely be needed to manage the child and to keep them on task"* – caregiver of Participant 6, regarding SBT screening.

Other caregivers commented that their child was distracted or bored during SBT screening, which affected their ability to attend to the task:

> *"The delay in between items meant it was difficult to keep him on track. He got a bit bored"* – carer of Participant 20, regarding SBT screening.

> *"I felt the mouse was a slight distraction for [my child]"* – carer of Participant 17, regarding SBT screening.

None of the caregivers had any concerns regarding confidentiality and screening during screening (see Table 28).

Following all three conditions the caregivers (n = 34) rated their overall preference. Caregivers expressed a preference for in-person screening, with 94.1% (32/34) ranking it as their first preference. A small number of caregivers preferred the HBT screening approach over in-person screening (n = 2/34, 5.9%), however, none of the caregivers ranked the SBT method as their first preference. A comparison of caregivers' preferences for HBT versus SBT showed that 73.5% of caregivers preferred HBT over SBT screening. There were eight CMC caregivers, and responses from these caregivers have been analysed separately. Preferences for this group were the same as the overall group: 87.5% (7/8) preferred in-person screening, and 12.5% (1/7) preferred HBT screening. None of the CMC caregivers ranked SBT screening as their first preference.

Many caregivers commented that although in-person screening is their preference, they were very open to accessing telepractice screening if required:

> *"HBT [is] preferred if in-person is not possible, but SBT [would be] useful if no other option"* – carer of Participant 24.

> *"Obviously in-person is preferred, but if I lived more than one hour from the hospital I would explore my options"* – carer of Participant 13.

> *"I think if in-person assessment is easily available it would still be my preferred option. Obviously, living in Brisbane it is realistic, but if this wasn't available SBT is my preference over HBT due to greater familiarity"* – carer of Participant 26.

Caregivers were asked to rank, in order of importance, a list of nine factors that would influence their decision to choose telepractice services for their child. Unfortunately a number of caregivers did not understand the task requirements, and did not answer this question correctly. Thus, these data have been described qualitatively, and plotted in a bar graph according to their ranking within each respondents' top 3 most important factors (see Figure 35).

Caregivers identified that the factor that would most influence their decision to choose telepractice or in-person services is efficacy of speech and language screening via telepractice. This factor remained the most important influence even when age group was taken into consideration, as it was ranked as the most important factor by parents of both preschool-aged and school-aged children. The second and third most important factors, as identified by all parents, were the SLP's ability to build rapport and to manage the child's behaviour during telepractice sessions. However, the relevant importance of these factors varied slightly once age group was considered. For caregivers of preschool-aged children, rapport-building and behaviour-management remained among the top three most important influences. However, for caregivers of school-aged children, the SLP's ability to manage the child's behaviour was not considered to be so important. For caregivers of older children the second and third most important influences were the SLP's ability to build rapport, and length of waiting periods.

Three main factors had the least influence on caregivers' decisions regarding telepractice services: infection control issues (i.e. the chance that the child will contract or pass on illnesses while visiting the hospital), security and confidentiality, and the caregivers' knowledge and prior experience with

telepractice. These three factors remained the least important once age group was taken into consideration. However, parents of school-aged children also included behaviour management among their least important factors.

The responses of CMC caregivers (n = 8) were analysed separately. The most important factor that influenced these caregivers was the efficacy of telepractice screening, which was ranked within the top three influences by seven CMC caregivers (87.5%). Three factors were ranked as next most important (ranked within top three factors by 4/8 caregivers): the SLP's ability to build rapport with the child during screening, travel distance, and reducing the child's exposure to infection during an outpatient visit. The factor that had the least influence on this group of caregivers was the length of waiting periods (see Figure 36).

Child satisfaction:

School-aged children were asked to complete a brief satisfaction survey after each screening condition, answering questions regarding how easy it was to hear and see the SLP during screening, and how easy it was to see the stimulus pictures. Only data from each participants' first screening method were used in these analyses, to avoid any bias that may occur due to the influence of preceding conditions. Six children received in-person screening first, three children received HBT screening first, and five children received SBT screening first. These data have been tabled below. There were insufficient data to conduct statistical tests or to plot the data. None of the children reported that they had found it difficult to see or hear the SLP in any of the screening methods, or to see the stimulus pictures.

Table 30 Child satisfaction survey results

Satisfaction survey question	**In-person screening (n = 6)**			**HBT screening (n = 3)**			**SBT screening (n = 5)**		
	Easy	OK	Hard	Easy	OK	Hard	Easy	OK	Hard
How easy was it to hear the SLP?	4	2	0	2	1	0	2	3	0
How easy was it to see the SLP?	5	1	0	2	1	0	2	3	0
How easy was it to see the stimulus pictures?	6	0	0	6	0	0	4	1	0

Following all three conditions, school-aged children (n = 14) were asked to rate their overall preference. Half of the children (n = 7/14, 50.0%) rated HBT as their preferred method. In-person screening was also rated by five children as their preferred method (n = 5/14, 35.7%), and two children rated SBT as their preferred method (n = 2/14, 14.3%). One participant commented that he preferred telepractice screening over in-person screening because he felt under less pressure during the HBT and SBT sessions than he did sitting across the table from the SLP. Other participants commented that they found it interesting to use the telepractice technology. However, one participant commented that he felt uncomfortable during telepractice screening.

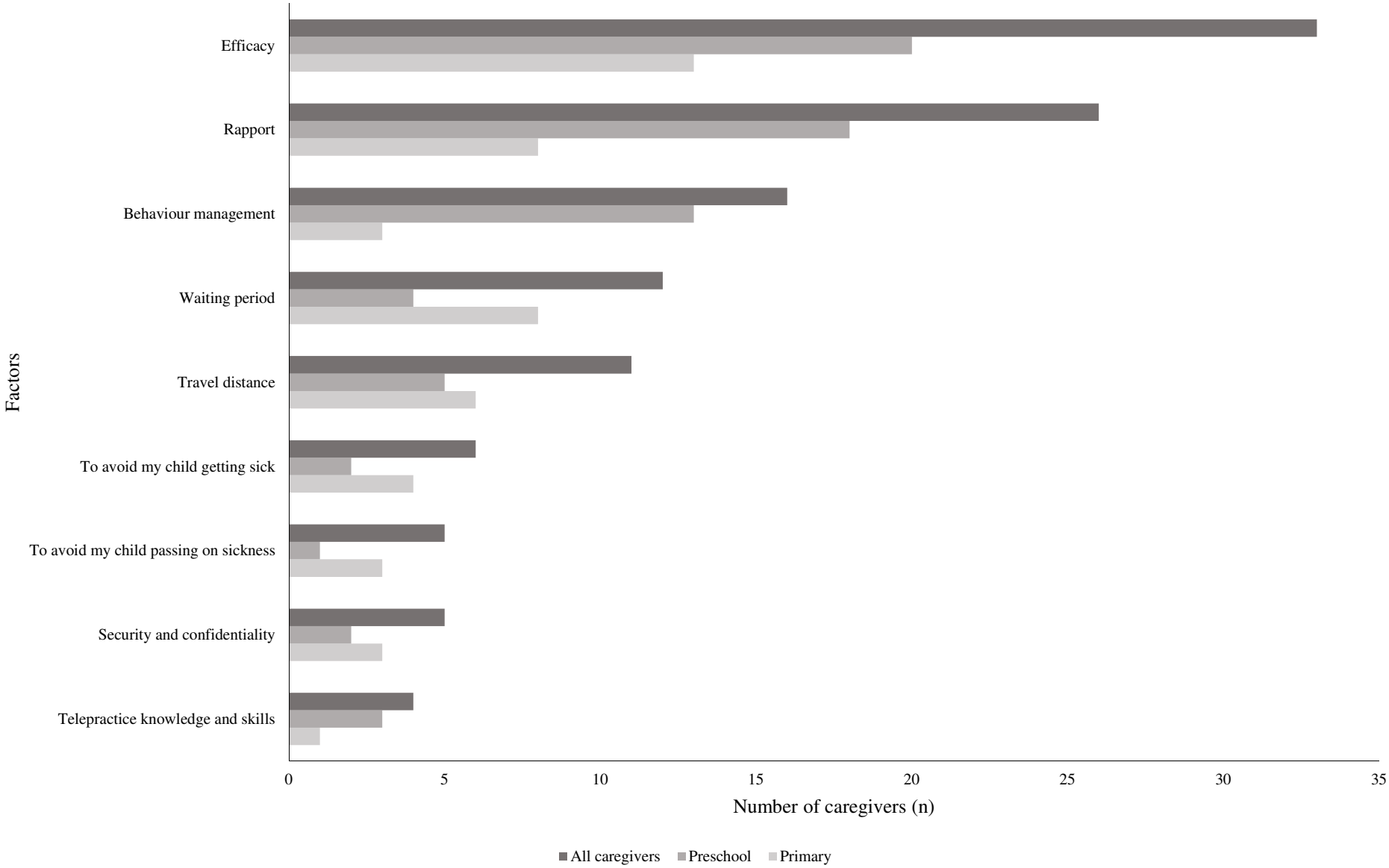


Figure 35 Factors that influence caregivers' decision to choose telepractice (top 3 rankings)

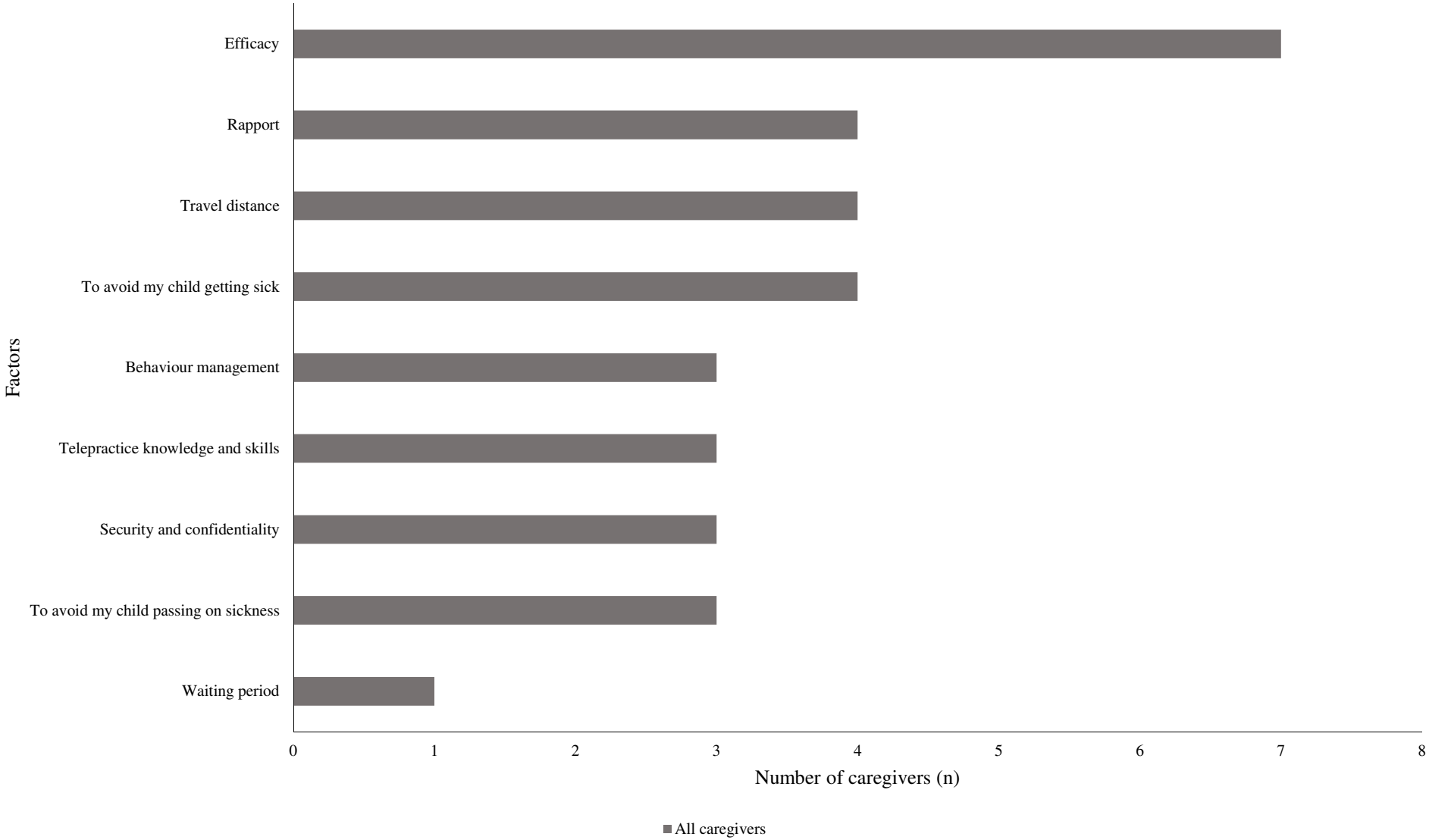


Figure 36 Factors that influence CMC caregivers' decision to choose telepractice (top 3 rankings)

6.4 Discussion

Although evidence for speech pathology telepractice is growing quickly, there is limited research to support the use of telepractice for speech and language screening/assessment. Few studies have utilised low-cost and readily accessible consumer-grade products, and there is a paucity of research into telepractice efficacy with younger children and the CMC population. This study aimed to investigate the feasibility, validity, and acceptability of speech and language screening using two readily-accessible telepractice methods: a point-to-point HBT system, and an SBT system using consumer-grade equipment and free videoconferencing software.

This study is the first to compare speech and language screening via two readily accessible telepractice methods, and provides preliminary support for the technical and practical feasibility of these methods, despite the presence of various technical and operational issues. There was high agreement between in-person and HBT scores for inconsistency, oromotor tasks, and the *CELF-4 Screener*. Agreement was also high between in-person and SBT scores for oromotor screening and the *PLS-4 Screening Test*. However, validity was reduced for some screening tasks and age groups, and a number of individual speech sounds could not be validly screened using telepractice. Caregivers were satisfied with both telepractice approaches. School-aged children also expressed satisfaction with telepractice methods, and many preferred telepractice to in-person screening. The ability to generalise this study's findings is limited by a number of factors including a small sample size (n = 34) that only included eight CMC, design flaws present in the method comparison study and satisfaction survey, and the simulation of remote screening between rooms in the same facility. I will now discuss the findings of this research project.

Feasibility

This study found good technical feasibility for speech and language screening via HBT. All of the HBT screening sessions were completed without interruption, despite minor audio and image quality issues. Image quality issues were observed more frequently during SBT screening, with image distortions evident in over 90% of sessions. In addition, a number of major technical issues were noted during SBT, leading to interrupted or discontinued sessions. Concerns with audio and image quality have been previously reported in the literature (35, 41,

149). However, Sutherland et al. (41) previously used consumer-grade equipment and web-based videoconferencing and were able to complete all sessions (0/23), which represents a higher success rate than found in the present study. It is likely that differences in success are related to the use of screen-sharing software (Mikogo) in the present study, as this software was the source of many technical issues. Unfortunately, due to time limitations, no other screen-sharing software programs were tested. In contrast, Sutherland et al. (41) used a specially designed telepractice interface that allowed SLPs to videoconference and remotely display materials, and for children to remotely point to materials. Thus, different videoconferencing software may improve the technical feasibility of this approach. Previous studies have utilised strategies to overcome technical limitations, including video recording the screening session for later reference (34-36, 39, 40), and pre-recording stimulus instructions (35, 39, 40), however, both of these strategies will lead to increased preparation and scoring time for the SLP. Overall, it is likely that advantages offered by SBT (e.g. low cost, accessibility, usability) will outweigh feasibility concerns for caregivers and SLPs. This appeared to be the case for caregivers in this study, who indicated high satisfaction and a willingness to use SBT screening again. This study did not seek the opinions of SLPs regarding SBT, however, this is an area that warrants further research.

A number of practical feasibility issues were identified during both HBT and SBT screening conditions. For example, children were more likely to demonstrate reduced compliance during telepractice screening than they were during in-person screening. Behaviour management issues were most commonly observed for preschool-aged children, which may be due to distraction (e.g. some children were distracted by the mouse), or because the SLP wasn't present in the room. Sutherland et al. (41) compared child behaviour during telepractice assessment and in-person assessment, and observed some increased behavioural issues during telepractice, although the difference was not significant. The authors of this study suspected that compliance issues were linked to poor audio and image quality, which may also be the case for the present study. Another study by Waite et al. (35) did not find any compliance or behaviour issues during telepractice assessment. Improved compliance in this study could be linked to age (this study did not include preschool-aged children), or the fact that an in-person SLP was present with the child during assessment. Strategies to improve child compliance during telepractice screening include sending rewards (e.g. stickers, bubbles) to the parent prior to screening, or using a trained assistant to sit with the child during screening.

Children were significantly more likely to move out of camera view during HBT screening than they were during SBT screening. A number of earlier studies have also reported difficulties with viewing children during telepractice, which affected SLPs' ability to accurately assess speech production and oromotor function (34, 36, 37). Differences between children's positioning during HBT and SBT screening may account for differences in screening validity for some tasks. During HBT screening children initially sat (without a table) about one metre in front of the screen, and were then asked to stand and approach the screen to complete items that required pointing. In contrast, during SBT screening the children were seated at a table with the computer screen placed directly in front of them, and they remained in this one position throughout screening. It is possible that the SBT set-up helped to hold children's attention, and that sitting at a table helped to keep children still. Strategies that helped keep children within view during HBT screening included positioning the child on their parent's lap (for younger children), and using a camera that could be moved and zoomed remotely to allow the SLP to adjust the camera view if required.

There were some other operational issues that occurred during HBT screening. Firstly, children were required to approach the screen to complete items that required pointing. During these items the SLP moved the camera to focus on the mirror, to watch the child's response in the reflection. In some cases, children stood too close to the screen and blocked the SLPs' view. A previous study by Waite et al. (35) also found that children sometimes blocked the SLP's view of the test book during telepractice assessment. A strategy that could prevent children from blocking the SLPs' view would be to mark a spot on the floor (i.e. using masking tape) to help children know where to stand. Another operational issue that should be considered is that the SLP is scoring the child's responses from a mirror image of the stimulus book, thus he/she needs to be very familiar with test items (as the image will be reversed).

Some items of the *CELF-4 Screener* required the child to point to two pictures at once. This presented a challenge during SBT screening, as children could not simultaneously point to two pictures at once using the mouse. To overcome this difficulty, the SLP asked the child to point using their fingers, and asked caregivers to report the child's response. A previous study by Waite et al. (35) used touch screen technology to record children's responses to the *CELF-4*, and they also had difficulty with these test items as the touch screen would not allow multiple touches. In this study, an in-person SLP informed the remote SLP of the child's response, however, the authors highlighted that they would need to rely on parent report if the SLP wasn't

available, which may reduce reliability. In the present study the SLP also relied on caregivers' report during SBT screening for young children who couldn't use the mouse, or if Mikogo wasn't working. To overcome reliability concerns the SLP could arrange for an assistant to be present with the child to report responses. Alternatively a video recording could be taken, or the SLP could take time prior to screening to discuss the importance of accurate reporting with caregivers.

A study by Eriks-Brophy et al. (37) reported that there was an increased need for repetition during telepractice assessment, noting that this increased the duration of assessment, and had potential to affect the validity of standardised testing (as some tests have rules that limit the number of repetitions allowed). In the present study, children and their caregivers were significantly more likely to ask for repetition during telepractice screening than in-person screening. This is possibly due to the presence of audio and image distortions. Repetition requests in this study did not appear to be related to any meaningful increase in screening duration, as telepractice screening only took slightly longer than in-person screening. However, repetition requests did affect administration of the *CELF-4 Screener*, as some test items do not allow repetition. When a child requested repetition, it was difficult for the SLP to know whether the child had heard the instruction but did not understand it, or whether the child did not hear the instruction due to audio issues (e.g. audio delays or cut-outs). This may have important implications for screening accuracy.

It is important that telepractice screening duration is not greatly longer than in-person screening, as increased screening duration may affect children's attention and behaviour, and may also drive up service costs (257). Nevertheless, a slight or even moderate increase in telepractice session duration is likely to be tolerated by SLPs and caregivers due to improved service access and travel savings. This study found that screening via HBT and SBT did take significantly longer, although the time difference was small, with telepractice screening taking 1.3-5.6 minutes longer than in-person screening on average. A difference of this magnitude is not clinically important, and is unlikely to affect SLPs' or caregivers' willingness to participate in telepractice screening.

Validity

Agreement fell below criterion for some individual sounds (all fricatives or high frequency sounds) during speech screening. This was not unexpected, as previous studies of speech

assessment via telepractice have also found judgement of these sounds to be unreliable via telepractice (36, 37). Poor accuracy for these sounds is probably due to audio and video quality issues, and may also be affected by instances where the child moved out of view during HBT screening, which prevented the SLP from using visual cues during speech screening.

In a previous study by Waite et al. (36) SLPs were able to score the assessment from a video recording. This is a strategy that may help to improve screening accuracy, although disadvantages include increased time to complete screening, and logistical issues associated with taking and sending recordings. As technology improves over time, it is anticipated that pathologists will be able to judge speech sounds with greater accuracy. Speech-language pathologists who use telepractice to screen speech should be aware that judgement of certain speech sounds is difficult via telepractice.

This is the first study to evaluate screening/assessment of speech inconsistency via telepractice. There was good agreement for pass/fail ratings using HBT, although agreement was lower for SBT. Closer analysis of the SBT condition revealed that accuracy was high for school-aged children, although agreement fell short of criterion for preschool-aged children. Reduced agreement for the SBT condition is probably associated with a greater incidence of audio and video distortions during SBT screening. Further large-scale studies are needed to validate telepractice for inconsistency screening/assessment.

This study found oromotor screening via telepractice to be valid, as large positive correlations were found between oromotor scores for both telepractice methods. Correlation between telepractice and in-person conditions was comparable to correlation between repeated in-person testing. Three previous studies have also found telepractice assessment of oromotor function to be valid and accurate (33, 34, 36). For the present study, accuracy was lower for some age groups. Agreement for DDK scores during HBT screening was only moderate for preschool-aged children, which may be linked with reduced compliance or the fact that children were more likely to move out of view during this condition. For school-aged children, the accuracy of S-M scores was reduced during telepractice screening. Poor agreement between in-person and telepractice methods for judgement of sequenced movements has been reported previously in a study by Waite et al. (36). Reduced accuracy for sequenced movements is likely to be linked with increased image distortions during SBT.

Previous studies have found good agreement between in-person and telepractice methods for language screening/assessment (35, 37, 38, 41), therefore, it was anticipated that language screening accuracy would be high. However, the accuracy of language screening was variable and somewhat contradictory. For the preschool-aged children, accuracy of scores on the *PLS-4 Screening Test* was high (large positive correlation) during SBT screening and only medium for HBT screening. For the school-aged group (*CELF-4 Screener*) the opposite was true: there was a large positive correlation between in-person and HBT scores, but the correlation was only medium for SBT. Even large correlation in this study was weaker than has been reported for repeat in-person screening (as reported in the test manuals), however, this is unlikely to prevent SLPs from using telepractice to administer these screeners, given the advantages offered by the telepractice approach.

Reduced screening accuracy during HBT for the preschool-aged children may have been affected by children moving out of camera view. However, differences in accuracy between the two telepractice methods for the school-aged children are more likely to be related to specific screening tasks than the age group. For example, image distortions such as delayed or jerky images may make it difficult for the SLP to see where the child is pointing during SBT, thus, reducing scoring accuracy. During some screening sessions the screen-sharing software did not work, and the SLP needed to position the stimulus materials in front of the camera. It is much easier to focus on pictures during HBT screening, as the camera can be easily zoomed and moved. This is not so easy during SBT, as the camera is fixed and without zoom capabilities. Therefore, it is possible that children could not see the pictures as easily during SBT sessions.

Satisfaction

This study found that caregivers were satisfied with both telepractice screening methods, which is consistent with previous studies into speech and language screening/assessment via telepractice (33, 38, 41), and with the broader telehealth/telemedicine literature (258). Within the survey, caregivers expressed confidence in the accuracy of HBT and SBT screening results. However, some caregivers' comments revealed concerns about poor audio and image quality and their effect on screening accuracy. These are valid concerns given findings regarding increased repetition and poor compliance during telepractice screening, and reduced diagnostic accuracy for some screening items.

Caregivers reported that they felt comfortable during telepractice screening and that their child was also comfortable, which is in line with previous findings (33, 38, 41). Most caregivers felt that the SLP was able to build rapport with their child during telepractice screening. This finding is supported by a recent study (259) that compared SLPs' ability to build rapport with children during in-person and telepractice interactions, and concluded that telepractice does not negatively affect rapport-building. However, analysis of caregivers' comments revealed some concerns regarding rapport-building and children's confidence during telepractice screening. As previously discussed, a flaw of this study is that remote screening was simulated between rooms in one facility, and one parent suggested that her child's confidence was improved by meeting the SLP in-person before telepractice screening. It is possible that many of the children experienced improved confidence and rapport with the SLP due to brief in-person contact that occurred prior to screening. A previous study by Eriks-Brophy et al. (37) emphasised that some children needed to "warm-up" before telepractice assessment, thus, a strategy that could improve rapport during remote screening via telepractice could be a "practice" session that gives the child a chance to become familiar with the SLP and with telepractice technology. Conversely, some caregivers reported that their child seemed more confident during telepractice screening, which is supported by one of the children's comments that he felt less pressure during telepractice testing when the SLP was not in the room.

Most caregivers were satisfied with the SLPs' ability to manage behaviour during SBT screening, although some caregivers indicated they were undecided regarding behaviour management via HBT. It is possible that reduced satisfaction during HBT screening is associated with increased child movement around the room during HBT screening. Some caregivers also expressed in their comments that they needed to take on a behaviour management role during telepractice screening. These parents' comments highlight an important issue: when deciding whether telepractice is appropriate for a child, the SLP needs to consider not only the child's behaviour, but also the parents' ability to assist in managing behaviour. Strategies to help parents with behaviour management may include posting out a "reward pack" prior to screening, and giving explicit instructions during screening (e.g. directing the parent to give the child a reward or a quick break).

Despite high satisfaction with both telepractice methods, parents continued to express a preference for in-person screening. Caregivers also preferred HBT screening over SBT screening, most likely due to increased technical issues during SBT screening. Many

caregivers commented that although they preferred in-person screening, they would be willing to use telepractice if it improved the accessibility of speech pathology screening services. Separate analysis of CMC caregivers' opinions regarding overall preference revealed that this group of parents also preferred in-person screening, followed by HBT screening. Only eight parents were caregiver to a CMC, thus, there is a very limited ability to generalise these findings.

This is the first study that has asked caregivers about factors that influence their decision to use telepractice. Parents reported that the most important factors are telepractice efficacy, and the SLPs' ability to build rapport and manage behaviour. It was interesting to note that none of these factors related to service accessibility, and instead relate to the ability of the SLP to replicate in-person services in terms of effectiveness and patient-therapist interactions. Caregivers rated shorter waiting periods and reduced travel distance as the next most important factors. Many families who participated in this study commented that they lived in Brisbane, a major metropolitan area. It is possible that accessibility issues would be rated more highly by rural and remote families.

Caregivers of CMC ranked telepractice efficacy as the most important factor, and also considered rapport-building to be very important, which is consistent with the overall group. However, two different factors were ranked within the top three most important factors by CMC caregivers: travel distance and infection control. It is possible that a greater number of CMC caregivers lived outside of the Brisbane metropolitan area, as the RCH and LCCH provide services to children from all over the state of Queensland. Unfortunately we can't determine this for certain, as data on families' addresses were not recorded. It is also possible that these families live within Brisbane, but would like to minimise their travel to the hospital to reduce disruption to their everyday routines. It is not surprising that families of CMC rated infection control issues more highly than the overall group. Caregivers may have concerns about the effect illness could have on their child's treatment, and may want to avoid inpatient admissions and additional days of missed school.

This is the first study to survey school-aged children regarding their satisfaction with speech and language screening via telepractice. There is limited ability to generalise these findings beyond the study, as the sample size was very small. None of the children reported that it was difficult to see the SLP or stimulus pictures, or to hear the SLP during telepractice screening,

despite audio and image quality issues. It is possible that children didn't appreciate the impact that these quality issues could have on the accuracy of telepractice screening. Many children were familiar with the SBT technology (e.g. using Skype at home), so it is possible that they expected audio and image quality issues to occur and did not view them as a problem. A number of children preferred telepractice screening methods over in-person methods, possibly due to the novelty factor. Many children commented that they were interested in the technology. Eriks-Brophy et al. (37) also found that children's interest and curiosity in telepractice technology improved their participation in telepractice assessment. Thus, the opinions of school-aged children regarding preferred screening method varied from the opinions of their caregivers, who preferred in-person screening. As part of family centred practice, the SLP should consider and respect the family's service preferences (260). Further research into children's satisfaction with telepractice will help SLPs to balance the service preferences of caregivers and children when planning screening services.

Limitations and future research

This study has a number of limitations. Firstly, the sample size was fairly small (n = 34), very few CMC were recruited, and most participants came from the Brisbane metropolitan area. Thus, findings cannot be generalised outside of a metropolitan context, and the ability to generalise findings to the CMC population is limited. Secondly, only one SLP conducted the screening assessments, which means that results are difficult to generalise to other SLPs, and that information on provider satisfaction could not be collected.

Previous studies in this area have conducted simultaneous assessment between the in-person and telehealth environments (i.e. an in-person SLP scores the assessment at the same time as a telepractice SLP) (34-36, 41). This approach was not used for this study as only one SLP was involved, and because three methods were being compared rather than two. It is possible that consecutive screening in this study contributed to increased behavioural issues, due to increased time taken. Consecutive screening also limits the ability to directly compare in-person and telepractice methods, as it is always possible that differences between the two methods are due to variation in performance rather than reduced accuracy of the telepractice method. To improve the study design, a future study could randomly allocate children to an in-person versus HBT group or an in-person versus SBT group, and conduct simultaneous scoring with an in-person and telepractice SLP. Randomising participants to an in-person-led or telepractice-led condition would further reduce bias, as would randomly allocated SLP roles.

Pearson's product-moment correlation coefficient was used to calculate correlation between in-person and telepractice scores for oromotor and language screening, however, a number of flaws are evident in this approach. Firstly, because Pearson's r was being used to measure correlation between measurements of the same phenomenon (i.e. two oromotor scores are being compared), a correlation of some sort is expected. Another disadvantage is that Pearson's r is sensitive to a homogenous sample. In this study nine participants had a speech delay/disorder, and four participants had a language delay/disorder. The remaining participants presented with normal speech and language development. To increase the heterogeneity of the sample, future studies should recruit participants with a variety of impairments and severities (261).

As this study was only an exploratory study, information was not gathered on cost-effectiveness. Papers by Jackson and McClean (262) and Aoki et al. (263) have identified that many telepractice studies do not include cost measures, and suggested that this should be evaluated. Children with medical complexity travel frequently for appointments which increases costs for families, and travel subsidies increase costs to the service provider. It would be useful to quantify cost-savings offered by this approach in future studies.

The satisfaction measure used in this study was devised for this project, and was not validated. Whitten and Love (258) warn that researchers who use un-validated and newly created instruments to measure patient satisfaction limit the ability to generalise their findings. They also warn that bias that may artificially boost satisfaction ratings, for example, patients may rate telepractice services highly due to the novelty of the approach, or because they are receiving a service they would not otherwise have received. This second bias applies to the current study, as many participants were recruited via an advertisement in the UQ staff newsletter. Many caregivers who responded to the advertisement had concerns regarding their child's communication development, and it is possible that these caregivers expressed high satisfaction in part because they had received a free speech and language screening service. On the other hand, some of the caregivers who responded to the advertisement may not have had particular concerns regarding their child's communication, and may have participated out of interest or a desire to help out. These caregivers may have had different perspectives on speech pathology screening, which could affect satisfaction survey validity.

6.5 Chapter conclusion

This chapter has described the design and results of a method comparison study that aimed to compare the feasibility, validity, and acceptability of telepractice speech and language screening with in-person screening. This study is the first to investigate paediatric speech and language screening using two readily accessible telepractice methods: HBT using point-to-point videoconferencing, and SBT using consumer-grade equipment. Overall, this study has provided preliminary evidence for the feasibility of these two telepractice methods, despite various technical and operational issues. This study found that oromotor screening via telepractice is valid, and that inconsistency can be validly screening for all ages using HBT, and for school-aged children using SBT. Language can be validly assessed via SBT using the *PLS-4 Screening Test*, and via HBT using the *CELF-4 Screener*. A number of individual speech sounds could not be judged reliably via telepractice. Finally, this study has found that these telepractice methods are acceptable to both caregivers and school-aged children, although caregivers would prefer to access in-person services if possible.

The next chapter concludes my thesis. In this chapter I will provide a discussion and conclusion to my body of work.

CHAPTER 7 Discussion and conclusion

Speech and language difficulties increase a child's risk of developing adverse social-emotional, behavioural, academic, and vocational outcomes. The interplay between medical complexity and communication impairment may place CMC at particular risk for these adverse outcomes. Prompt screening or assessment with an SLP is important, so treatment can be started early. Unfortunately, poor speech pathology service accessibility has been well-documented for the paediatric population, and it is likely that CMC will experience additional access issues related to their extraordinary service needs and medical complexity.

Speech and language screening via telepractice may help to improve service accessibility for CMC. Telepractice allows children to receive services from their own home or from a local hospital, clinic, or school. The use of telepractice alongside conventional service methods may reduce costs, travel time, and waiting periods. The evidence-base for speech pathology telepractice is growing, however, most studies relate to adults. No published reviews have examined evidence for telepractice speech and language screening with CMC or the general paediatric population. I conducted a review of the evidence in this area (Chapter 4), and concluded that there is early evidence supporting the efficacy of telepractice screening, although studies are limited and of variable quality. Evidence gaps related to the use of telepractice with CMC and younger children, consumer satisfaction, and the feasibility of low-cost and easily accessible telepractice equipment.

Despite an emerging evidence base and clear benefits in terms of access and cost, telepractice adoption remains low among SLPs. A number of barriers to telepractice adoption have been identified in the literature. However, no studies have examined telepractice adoption among SLPs who work with CMC, or described the barriers and facilitators for telepractice adoption among this group of professionals.

My research investigated the role of telepractice for remote speech and language screening of CMC. To achieve this aim, I devised an exploratory method comparison study (Chapter 6) to investigate feasibility, validity, and acceptability of telepractice speech and language screening for CMC. However, before I could investigate speech and language screening via telepractice, I first needed to understand whether the CMC population needed alternative services, whether SLPs were already using telepractice for CMC patients, and whether tertiary SLPs were willing

and interested to use telepractice with their patients. Thus, I surveyed tertiary SLPs regarding access difficulties, telepractice adoption, attitudes toward telepractice, and barriers to its use. The survey was conducted in 2011 and 2015 to investigate changes over time (Chapter 5).

Individual discussions regarding these studies can be found in Chapters 5 and 6. In this concluding chapter I will synthesise the results, identify implications, and suggest future research directions.

7.1 Key findings

The survey identified widespread access issues experienced by CMC who require speech pathology support. All of the SLPs worked with children who had reduced access to tertiary speech pathology services, and 85% of respondents in 2015 also had patients with poor access to local services. Possibly in response to these access issues, tertiary SLPs have adopted telepractice at higher rates than the general profession. In 2011, 16% of respondents had adopted telepractice, and this rate grew significantly ($p < 0.05$) by 2015, when 40% of respondents had used telepractice. Most SLPs viewed telepractice positively, and were willing and interested to use it with their patients. However, many SLPs did not feel confident to use telepractice, and a number of barriers to telepractice adoption were identified. Two thirds of SLPs did not consider formal screening services to be appropriate for telepractice service delivery.

The exploratory method comparison study compared in-person speech and language screening with screening using two easily accessible telepractice methods (HBT and SBT). A total of 34 children participated, however, only eight CMC participated (27%). All of the HBT screening sessions were completed, however, two of the SBT sessions (6%) were discontinued due to an Internet outage, and eleven SBT sessions (32%) were interrupted by major technical difficulties. Poor audio and image quality were observed across both telepractice methods, although image distortions were more common during SBT screening. Children demonstrated more difficult behaviours during HBT screening ($p < 0.05$) and SBT screening ($p < 0.01$), and were more likely to request repetitions ($p < 0.05$), which has implications for standardised screening.

Observed feasibility issues related back to telepractice barriers that had been previously identified in the survey, including concerns about audio and image quality, and concerns about behaviour management. It is likely that the advantages of telepractice screening will outweigh any feasibility concerns held by parents and caregivers, particularly in the case of SBT screening, which had a high number of feasibility issues but offers the convenience of accessing services from home. Speech-language pathologists are also likely to value the SBT approach, as the majority of SLPs surveyed would prefer to provide services directly to the patient's home, rather than to a hospital or clinic.

Screening of oromotor function was valid via telepractice, and inconsistency screening was valid for all children using the HBT method, and for school-aged children using the SBT method. However, a number of speech sounds could not be validly screened during HBT and SBT, most likely due to audio and image quality concerns. The accuracy of language screening varied by type of screener and telepractice method. Scores on the *PLS-4 Screening Test* had high accuracy via SBT screening ($r = 0.65$, $p < 0.01$), but accuracy was only medium using the HBT method ($r = 0.39$, $p =$ ns). In contrast, *CELF-4 Screener* scores had high accuracy during HBT screening ($r = 0.68$, $p < 0.01$), but accuracy was only medium for the SBT condition ($r = 0.44$, $p =$ ns). For the preschool-aged children, behaviour (particularly moving out of camera view) may have affected the accuracy of scores during HBT screening. However, for school-aged children, improved accuracy during HBT screening is probably due to this system's capabilities (e.g. improved image quality, ability to point to multiple pictures simultaneously). When choosing a telepractice method for language screening, SLPs should consider the age and behaviour of the child, and choose a telepractice system that is best able to cater for screening task requirements. Speech-language pathologists should also be aware that judgement can be difficult for certain speech sounds.

Understanding telepractice from the caregiver's perspective was important. Caregivers were satisfied with all three methods, and would be willing to use telepractice again, and to recommend it to other parents. Many SLPs in the survey identified that concerns about caregiver satisfaction with telepractice services were a barrier to telepractice adoption. It was interesting to see find that caregivers are actually more satisfied with telepractice services than perceived by SLPs. Some caregivers reported that they needed to take on a behaviour management role during screening, in order to keep their child focused and compliant. This may be of concern to SLPs, as many SLPs surveyed had identified that the caregivers' ability

to act as an assistant was a potential barrier to telepractice adoption. Speech-language pathologists will need to consider the parents' ability to assist their child during screening before implementing telepractice screening services.

Overall, most caregivers (like most SLPs) preferred in-person services over telepractice services. However, caregivers acknowledged that they would be willing and keen to use telepractice if they were unable to easily access in-person screening. In contrast, school-aged children preferred HBT screening over the in-person method, possibly due to the novelty factor. School-aged children were satisfied with both HBT and SBT screening methods, and reported adequate audio and video quality during telepractice screening.

7.2 Future research

This research contributes important information to tertiary SLPs regarding the prevalence of access issues among CMC patients, and highlights the need to consider alternative service delivery models for these children. However, future work should aim to explore service accessibility from the perspective of CMC and their families, as clinicians may not give a true representation of the issues that affect families.

This survey has documented high rates of telepractice adoption among tertiary SLPs, and demonstrated that SLPs view telepractice positively. However, future work is required to capture any future changes to telepractice adoption, particularly as technology improves and adapted resources are released (validation of telepractice assessments is in progress). Further research is required to understand barriers that prevent SLPs from using direct telepractice service (e.g. screening), and to determine whether identified facilitators such as hands-on training and work-shadowing are effective in improving SLP's confidence to use telepractice, and their willingness to use it for direct service provision. Future studies should investigate whether a relationship exists between telepractice adoption and the demographics of tertiary SLPs (e.g. age, years of experience) or patient characteristics (e.g. diagnosis type, age group). For future research, a larger, well-designed survey with more rigorous sampling will minimise biases that existed in the current study, and produce results that are able to be generalised more easily.

The exploratory method comparison study in my thesis has provided preliminary support for the feasibility, validity, and acceptability of paediatric speech and language screening using HBT and SBT methods. However, further work is required to confirm the efficacy of these approaches, with thought given to methods and strategies that may improve the feasibility and validity of telepractice screening, particularly for screening of speech sounds and language (i.e. a web-based videoconferencing system with in-built screen-sharing capabilities may circumvent difficulties associated with screen-sharing software in the present study). A larger sample of CMC is required in order to establish efficacy for this population. The sample should also endeavour to include participants from both metropolitan and rural/remote areas, and to recruit participants with a range of speech and language severity levels. To improve study design, future studies should include a number of speech pathology assessors, which will also enable measurement of provider satisfaction. Once efficacy is established, large-scale randomised controlled trials (RCT) can be conducted to prove the effectiveness of the two telepractice approaches (i.e. real-world application).

7.3 Concluding statement

My thesis aimed to investigate the role of telepractice for remote speech and language screening of CMC. To achieve this aim, I surveyed tertiary SLPs and documented widespread patient access issues, thus confirming that alternative service delivery models such as telepractice are required for this group of children. This survey also established that tertiary SLPs are willing and interested to implement telepractice service with their patients, and already use telepractice at higher rates than the general speech pathology population. Having established a clinical need and a willing population of clinicians, I went on to conduct an exploratory method comparison study to compare screening via two readily-accessible telepractice methods (HBT using a custom-built point-to-point videoconferencing system, and SBT using consumer-grade equipment and free videoconferencing software) with in-person screening. This work has formally established early support for the feasibility and acceptability of these telepractice approaches for a general paediatric population, and has confirmed validity of oromotor, inconsistency and language screening via telepractice for some age groups. Detection of some speech sounds was not valid via telepractice. Unfortunately, due to recruitment difficulties, numbers of CMC were small and these findings cannot be generalised to this population.

This thesis contributes new evidence to expand the evidence-base for general paediatric speech and language screening/assessment via telepractice. Findings from this study may assist in the planning and implantation of telepractice screening services, both within Australia and internationally, for SLPs and other allied health professionals.

In conclusion, telepractice services may improve service access for CMC patients, and SLPs who work with CMC are willing and interested to use telepractice with this population. This thesis provides preliminary evidence for the feasibility, validity, and acceptability of speech and language screening using readily-accessible telepractice services for a general paediatric population.

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CHILDREN'S HEALTH QUEENSLAND
LADY CILENTO CHILDREN'S HOSPITAL

Queensland Government

INVITATION TO PARTICIPATE IN A RESEARCH PROJECT

Speech and Language Assessment for Children with Cancer: a Comparison of Telehealth and Face-to-face Assessment Methods.

Investigators:
Ms Olivia Taylor (Principal Investigator)
Senior Speech Pathologist, Lady Cilento Children's Hospital
MPhil Student, Centre for Online Health (University of Queensland)
Phone: 0408 802 557
Email: olivia.taylor@uq.net.au
Address: Speech Pathology Department
Lady Cilento Children's Hospital, Raymond Terrace, South Brisbane, QLD, 4101.

A/Prof Anthony Smith, Centre for Online Health (University of Queensland)
Dr Nigel Armfield, Centre for Online Health (University of Queensland)
Dr Pamela Dodrill, Boston Children's Hospital

We would like to invite you and your child to participate in a research project. This project will compare different methods of speech and language assessment for children with cancer. **We have invited children both with and without cancer to participate.**

Please read this sheet carefully and be confident that you have understood the information before you agree for your child to participate.

What is this study about?
The Lady Cilento Children's Hospital aims to provide the best possible care to children with cancer, including speech pathology services if needed. Services are provided to children all over Queensland and in other states. Children in rural and remote areas, and some children in metropolitan areas, may find it difficult to access speech pathology services when they are discharged home from hospital. This may be due to distance, staff vacancies, waiting lists, a lack of public transport, the parent's work commitments, or mobility issues (e.g. wheelchair use).

Telehealth may provide a solution to these problems, however, there is no information on whether or not telehealth is useful and effective for speech and language assessment with children who have cancer.

This study aims to compare three different methods of speech and language assessment: 1) Face-to-face assessment; 2) Queensland Health videoconferencing system; and 3) Internet-based videoconferencing, using standard computers and videoconferencing software. The validity, audio and video quality, cost, and feasibility will be compared, as well as the preferences of the child, parent, and speech pathologist.

What does this study involve?
You and your child will need to attend the Lady Cilento Children's Hospital for testing. We will assess your child's speech and language using a brief speech and language screening assessment using the three methods (face-to-face; QH videoconferencing system; internet-based videoconferencing). The order of the methods will be

randomly assigned to your child. **The assessments will be video recorded and stored in the research files.** The speech pathologist will score your child during the assessment, and will gather data from the video recordings, including; number of requests to repeat information, number of breaks in video and audio signal, and the total time to complete the assessment. At the end of each assessment, you and your child (if your child is aged 6-12 years) will rate the audio and video quality of the assessment against a checklist. When all three assessments are finished, you and your child (if your child is aged 6-12 years) will rate the methods in order of preference.

If your child is aged 3-5 years, the assessments will take approximately 1 hour to complete. If your child is aged 6-12 years, the assessment will take approximately 1.5 hours to complete.

If the screening tests show that your child may have a speech or language delay, your child's communication will be comprehensively assessed during a face-to-face appointment during another visit. This will take approximately 1-1.5 hours to complete. **This assessment will also be recorded and stored in the research files.** You will be provided with a written summary of these results following the assessment.

Are there any risks?
There are no risks involved in this project that are above and beyond the risks of everyday life. You will be present with your child at all times. All members of staff involved in this project are experienced paediatric health professionals and/or skilled health researchers, with a current Blue Card (Working with Children Check).

How will this research benefit my child?
Your child's speech and language development will be screened by an experienced paediatric speech pathologist. If required, your child will be fully assessed, and you will receive a written report.

This research will assist the Lady Cilento Children's Hospital to plan future clinical services using telehealth, which may allow your child and other children to access telehealth services at home. This is beneficial for families who have difficulty accessing speech pathology services. At a broader level, this research may result in clinical practice changes in other hospitals, with other groups of sick children, as well as for children without cancer who live in rural and remote areas.

What happens if I change my mind?
Participation in this study is voluntary, and you are free to withdraw from the study at any time. This will not affect the relationship that you and your child have with staff at the Lady Cilento Children's Hospital.

What about confidentiality?
We will follow Queensland Health's documented policies and procedures to ensure your child's confidentiality. Only the investigators will have access to identifiable information about your child, and all test forms and surveys will be marked with a code, rather than your child's name. The group results from this study are expected to be published in peer-reviewed health journals, but the identity of families involved in this study will not be revealed.

Will there be any compensation?
No, there will not be any compensation for families who participate in this study.

Who do I contact if I need further information or have any concerns?
Please contact Ms Olivia Taylor (Principal Investigator) if you have any concerns or questions.

The *Children's Health Queensland Ethics Committee* has approved this study. Should you wish to discuss the study with someone who is not directly involved - in particular regarding policies, the conduct of the study, your rights as a participant, or any complaints - please contact the coordinator of the ethics committee on 3636 9167 or by email CHQEthics@health.qld.gov.au.

CHILDREN'S HEALTH SERVICE DISTRICT
ROYAL CHILDREN'S HOSPITAL

CONSENT FORM

Assessing Speech and Language in Children with Cancer: An RCT Comparing In-Person Assessment with Assessment via Telehealth.

Investigators:
Ms Olivia Taylor, Speech Pathologist, Royal Children's Hospital (Principal Investigator)
Dr Pamela Dodrill, Specialist Speech Pathologist, Royal Children's Hospital
Dr Andrew Hallahan, Paediatric Oncologist, Royal Children's Hospital
Dr Anthony Smith, Centre for Online Health
Dr Nigel Armfield, Centre for Online Health

I, _____ (please print your name), hereby consent for my child _____ (please print your child's name) to take part in the research project titled: *Assessing Speech and Language in Children with Cancer: A RCT Comparing In-Person Assessment with Assessment via Telehealth.*

I acknowledge that I have read the information sheet provided. The nature of the project and the effects it may have on my child have been explained to my satisfaction by the investigators.

I freely consent to my child's participation in the project.

I understand and agree to the release of my child's assessment data for the purpose of statistical analysis. I understand and agree to the recording of my child's assessment, and storage of the recording in the research files.

I give permission for the above investigators to have access to my child's medical records.

I am aware that the results of any tests involving my child will not be published so as to reveal their identity. The privacy of my child will be maintained at all times, and no information regarding my child's medical history will be divulged.

I understand that I am free to withdraw my child from the project at any stage, and that this will not affect in any way, the ongoing or future management of my child.

Signed: _____ Date: _____
(parent/carer)

Name of parent/care (please print) _____

Address of non-parental carer: _____

Legal authority of non-parental carer _____

Witness: _____ Date: _____

If you have any questions or concerns about his study, and would like to discuss it with someone who is not directly involved, in particular regarding policies, the conduct of this study, your rights as a participant, or any complaints, please contact the coordinator of the RCH Ethics Committee on 3636 9167.

APPENDIX A Method comparison study: caregiver and child satisfaction surveys

CHILDREN'S HEALTH SERVICE DISTRICT
ROYAL CHILDREN'S HOSPITAL

CAREGIVER SURVEY: IN-PERSON ASSESSMENT

Participant Code: _____ **Date:** _____ **Order Presented:** ☐ 1st ☐ 2nd ☐ 3rd

Assessing Speech and Language in Children with Cancer: An RCT Comparing In-Person Assessment with Assessment via Telehealth.

This survey aims to gather information on your satisfaction with the in-person assessment. Please read each sentence and indicate how strongly you agree by putting an **X** in the box.

	Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
I am happy with the service my child received during the assessment.					
The speech pathologist was able to adequately assess my child.					
I would allow my child to participate in a face-to-face assessment again in the future.					
I would recommend face-to-face assessment to other parents.					
I was nervous or apprehensive before my child was assessed.					
I felt comfortable during the assessment.					
My child felt comfortable during the assessment.					
The speech pathologist was able to develop a good relationship / rapport with my child during the assessment.					
The speech pathologist was easily able to manage my child's behaviour during the assessment.					
I was concerned about confidentiality during the assessment.					

Please write any additional comments in the space below:

_____

_____

_____

_____

Version Number: 2 Date: 01.06.2011 HREC Number: HREC/11/QRCH/26

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CHILDREN'S HEALTH SERVICE DISTRICT
ROYAL CHILDREN'S HOSPITAL

CAREGIVER SURVEY: REAL-TIME VIDEOCONFERENCING ASSESSMENT
Participant Code: _____ **Date:** _____ **Order Presented:** ☐ 1st ☐ 2nd ☐ 3rd

Assessing Speech and Language in Children with Cancer: An RCT Comparing In-Person Assessment with Assessment via Telehealth.

This survey aims to gather information on your satisfaction with the assessment via real-time videoconferencing. Please read each sentence and indicate how strongly you agree by putting an **X** in the box.

	Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
I am happy with the service my child received during the assessment.					
The speech pathologist was able to adequately assess my child.					
I would allow my child to participate in assessment using real-time videoconferencing again in the future.					
I would recommend assessment using real-time videoconferencing to other parents.					
I was nervous or apprehensive before my child was assessed.					
I felt comfortable during the assessment.					
My child felt comfortable during the assessment.					
The speech pathologist developed a good relationship/rapport with my child during the assessment.					
The speech pathologist was easily able to manage my child's behaviour during the assessment.					
I was concerned about confidentiality during the assessment.					
My child has previously received services using real-time videoconferencing (please circle).	YES			NO	

Please write any additional comments on the back of this page:

Please write any additional comments below:

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CHILDREN'S HEALTH SERVICE DISTRICT
ROYAL CHILDREN'S HOSPITAL

CAREGIVER SURVEY: INTERNET-BASED VIDEOCONFERENCING ASSESSMENT
Participant Code: _____ **Date:** _____ **Order Presented:** ☐ 1st ☐ 2nd ☐ 3rd

Assessing Speech and Language in Children with Cancer: An RCT Comparing In-Person Assessment with Assessment via Telehealth.

This survey aims to gather information on your satisfaction with the assessment via internet-based videoconferencing. Please read each sentence and indicate how strongly you agree by putting an **X** in the box.

	Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
I am happy with the service my child received during the assessment.					
The speech pathologist was able to adequately assess my child.					
I would allow my child to participate in assessment using internet-based videoconferencing again in the future.					
I would recommend assessment using an internet-based videoconferencing to other parents.					
I was nervous or apprehensive before my child was assessed.					
I felt comfortable during the assessment.					
My child felt comfortable during the assessment.					
The speech pathologist developed a good relationship/rapport with my child during the assessment.					
The speech pathologist was easily able to manage my child's behaviour during the assessment.					
I was concerned about confidentiality during the assessment.					
My child has previously received services over the internet (please circle).	YES			NO	

Please write any additional comments on the back of this page:

Please write any additional comments below:

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CHILDREN'S HEALTH SERVICE DISTRICT
ROYAL CHILDREN'S HOSPITAL

CAREGIVER SURVEY: COMPARISON OF ALL ASSESSMENTS

Participant Code: _____ **Date:** _____

Assessing Speech and Language in Children with Cancer: An RCT Comparing In-Person Assessment with Assessment via Telehealth.

Please number the different methods of assessment in order of your preference, with 1 = the best.	☐ In-person ☐ Real-time Videoconferencing ☐ Internet-Based Videoconferencing
Please number the different methods of assessment in order of visual quality, with 1 = the best.	☐ In-person ☐ Real-time Videoconferencing ☐ Internet-Based Videoconferencing
Please number the different methods of assessment in order of audio quality, with 1 = the best.	☐ In-person ☐ Real-time Videoconferencing ☐ Internet-Based Videoconferencing

Which are the most important factors for you when deciding which method of assessment should be used with your child (in-person, real-time videoconferencing, or internet-based videoconferencing)? Please number the following options in order of the MOST important to the LEAST important, with 1 = MOST IMPORTANT, and 9 = LEAST IMPORTANT.

☐ How **easily** and **effectively** the speech pathologist can assess my child.

☐ How **quickly** the speech pathologist can assess my child.

☐ How easily the speech pathologist can **build rapport / a relationship** with my child.

☐ How easily the speech pathologist can manage my child's **behaviour** during assessment.

☐ How far I have to **travel** so that my child can see a speech pathologist.

☐ My knowledge of **computers**.

☐ **Confidentiality** and security.

☐ Infection control – avoiding contact with other people in the hospital who may **pass on infection to my child.**

☐ Infection control – avoiding contact with other people in the hospital who may **catch an infection from my child.**

Please write any additional comments below:

_____
_____
_____
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CHILDREN'S HEALTH SERVICE DISTRICT
ROYAL CHILDREN'S HOSPITAL

PARTICIPANT SURVEY: IN-PERSON ASSESSMENT

Participant Code: _____ Date: _____

Assessing Speech and Language in Children with Cancer: An RCT Comparing In-Person Assessment with Assessment via Telehealth.

Ask the child these questions and encourage them to point to "Good" "OK" "Bad" on the picture board. Record the child's responses below.

How easy was it to hear the speech pathologist?	☐ Good ☐ OK ☐ Bad
How easy was it to see the speech pathologist?	☐ Good ☐ OK ☐ Bad
How easy was it to see the pictures?	☐ Good ☐ OK ☐ Bad

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CHILDREN'S HEALTH SERVICE DISTRICT
ROYAL CHILDREN'S HOSPITAL

PARTICIPANT SURVEY: REAL-TIME VIDEOCONFERENCING ASSESSMENT

Participant Code: _____ **Date:** _____

Assessing Speech and Language in Children with Cancer: An RCT Comparing In-Person Assessment with Assessment via Telehealth.

Ask the child these questions and encourage them to point to "Good" "OK" "Bad" on the picture board. Record the child's responses below.

How easy was it to hear the speech pathologist?	☐ Good ☐ OK ☐ Bad
How easy was it to see the speech pathologist?	☐ Good ☐ OK ☐ Bad
How easy was it to see the pictures?	☐ Good ☐ OK ☐ Bad

Queensland Government

CHILDREN'S HEALTH SERVICE DISTRICT
ROYAL CHILDREN'S HOSPITAL

PARTICIPANT SURVEY: INTERNET-BASED VIDEOCONFERENCING

Participant Code: _____ **Date:** _____

Assessing Speech and Language in Children with Cancer: An RCT Comparing In-Person Assessment with Assessment via Telehealth.

Ask the child these questions and encourage them to point to "Good" "OK" "Bad" on the picture board. Record the child's responses below.

How easy was it to hear the speech pathologist?	☐ Good ☐ OK ☐ Bad
How easy was it to see the speech pathologist?	☐ Good ☐ OK ☐ Bad
How easy was it to see the pictures?	☐ Good ☐ OK ☐ Bad

Queensland Government

CHILDREN'S HEALTH SERVICE DISTRICT
ROYAL CHILDREN'S HOSPITAL

PARTICIPANT SURVEY: COMPARISON OF ALL ASSESSMENTS

Participant Code: _____ **Date:** _____

Assessing Speech and Language in Children with Cancer: An RCT Comparing In-Person Assessment with Assessment via Telehealth.

Ask the child these questions and encourage them to point to the pictures on the picture board. Record the child's responses below.

Which one did you like the best? _____ _____ _____ _____ _____	☐ In-person ☐ Real-time Videoconferencing ☐ Internet-Based Videoconferencing
Which one was the worst? _____ _____ _____ _____ _____	☐ In-person ☐ Real-time Videoconferencing ☐ Internet-Based Videoconferencing