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Telehealth and autism: A systematic search and review of the literature

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Abstract

Purpose: Research interest in telehealth and autism spectrum disorder (ASD) has grown. There is a need to review the literature to allow speech-language pathologists (SLPs) and other service providers to consider applicability to their settings. The aim of this review was to examine the nature and outcomes of studies examining telehealth assessment and/or intervention in ASD.
Method: A systematic search of the literature was undertaken, with 14 studies meeting inclusion criteria. The authors extracted information from each included article, including participant characteristics, technology used, measures and reported outcomes. Quality review of articles was undertaken.
Result: The 284 participants with ASD across the 14 included studies ranged in age from 19 months to adulthood. The quality of the studies varied. A range of services were provided via telehealth, including diagnostic assessments, early intervention and language therapy. Results suggested that services delivered via telehealth were equivalent to services delivered face to face, and superior to comparison groups without telehealth sessions.
Conclusion: The findings suggest there may be a range of benefits in using telehealth with individuals with ASD, their families, and teachers. Further research, however, is required particularly regarding the use of telehealth directly with children with ASD for assessment and intervention.

Keywords: *autism spectrum disorder*; *telehealth*; *speech-language pathology*

Introduction

Telehealth is a broad-term describing health care services that utilise information communication technology to deliver services. In the speech-language pathology context, telehealth has been defined as the "the application of telecommunications technology to deliver professional services at a distance by linking clinician to client, or clinician to clinician for assessment, intervention, and/or consultation" (American Speech and Hearing Association, n.d., p. 1). These approaches have evolved from the early use of audio and video tapes and telephone discussions (e.g. Harrison, Wilson, & Onslow, 1999), to the current use of both sophisticated real time communication technology over the internet, with data and image sharing using equipment ranging from custom built videoconferencing suites, as well as low cost internet based communication software (e.g. Skype) with headsets, webcams, speakers, hand-held cameras, microphones and internet connectivity (Keck & Doarn, 2014). Telehealth in speech-language pathology is becoming an established practice in certain areas, with research indicating successful use in treating fluency disorders (Harrison et al., 1999; Lewis, Packman, Onslow, Simpson, & Jones, 2008; O'Brian, Smith, & Onslow, 2014; Wilson, Onslow, & Lincoln, 2004), dysphagia (Sharma, Ward, Burns, Theodoros, & Russell, 2013; Ward, Burns, Theodoros, & Russell, 2013), adult speech and language disorders (Constantinescu et al., 2010; McGrath, Dowds, & Goldstein, 2008) and speech sound disorders in childhood (Grogan-Johnson et al., 2013). Telehealth has also been used successfully in formal language assessments in children (Sutherland et al., 2017; Waite, Theodoros, Russell, & Cahill, 2010). Based on these successes, clinicians and researchers are beginning to explore the potential for telehealth as a tool for assessment and intervention across a range of practice areas, including working with individuals with autism spectrum disorder (ASD).

Telehealth applications in autism spectrum disorder

Autism spectrum disorder is a neurodevelopmental disability characterised by differences in social communication and social interactions, as well as restricted, repetitive patterns of behaviour, interests or activities (American Psychiatric Association, 2013). It is a lifelong condition, meaning that individuals and their families are likely to require a range of interventions over a long period of time. A number of evidence-based programmes exist, including Early Intensive Behavioural Intervention (Prior, Roberts, Rodgers, Williams, & Sutherland, 2011) and the Early Start Denver Model (Dawson et al., 2010), but access to these programmes, and/or training clinicians or parents to administer these programmes in the community is challenging. For families who live remotely from services, and those who are limited by transport and other logistical difficulties, accessing appropriate services in a timely way can be difficult and telehealth may be a useful primary or adjunct intervention mode. Despite the success of telehealth in other areas, the literature regarding telehealth use with students with diverse learning needs, such as ASD to deliver assessment and intervention is limited.

Prior to the current review, Boisvert, Lang, Andrianopoulos, and Boscardin (2010) completed the most recent systematic review of research related to autism and telehealth, which yielded only eight studies that met their inclusion criteria: the study involved at least one person with ASD, the use of telehealth between an expert clinician and a remote site and at least one dependent measure involving the individual with ASD and the results of an assessment or evaluation of changes in behaviour. There were 46 participants involved across the eight studies (range $n = 1–29$) with an age range of 2–11 years. The services provided included behaviour analysis, teacher, therapist or parent training in particular techniques or interventions, psychiatric consultations and ongoing consultations regarding individual education plans. The overall results of the review were positive, in terms of the successful implementation of the telehealth services, reduced challenging behaviours, improved social-communication, and participant satisfaction across the various studies. However, it was noted that a minority of studies employed an experimental design and some studies reported significant technical difficulties. Furthermore, none of the included studies involved direct telehealth services to the individual with ASD.

Research interest in telehealth as an adjunct or equivalent practice to face to face services has grown since the last systematic review, as evidenced by the growth in publications. For instance, a search using the PsycINFO database using the search terms "telehealth OR telepractice" revealed 387 articles published between 2000 and 2010, with 619 articles in the five years to 2016. As a result, there is a need to review the literature regarding the use of telehealth to allow individual speech-language pathologists (SLPs) and service providers more broadly to consider applicability to their settings. Accordingly, the aim of this review is to document the research into the use of telehealth for ASD since the previous (2010) systematic review, with regards to (a) the type of service delivered, (b) the recipients of the telehealth service and (c) the outcomes of the telehealth services provided.

Method

The *Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)* statement was used to guide the systematic review process (see Figure 1); the protocol for this review was not published a priori. A systematic search of the literature was undertaken using the databases Medline, PsycINFO, ERIC, CINAHL and PUBMED for articles published up to December 2016. These databases are in keeping with the databases searched in the previous review by Boisvert et al. (2010). Titles and abstracts were searched using key words to describe telehealth and ASD (("telehealth" OR "telemedicine" OR "telepractice" OR "telecare") AND "Autis* (allowing searches for Autism, Autistic, Autisms etc.)" OR "Asperger" OR "PDD-NOS" (Pervasive Developmental Disorder – Not Otherwise Specified)). The search was limited to English language. In keeping with the previous systematic review, only articles appearing in peer reviewed journals were included. There was no limit on date of publication, however, no eligible articles were found prior to 2010 that were not included in the previous review.

A total of 155 articles that included both the telehealth and autism search terms were found across the five databases. After duplicates were removed, 86 remained. Titles and abstracts were screened by the first author based on predetermined inclusion criteria including: (a) inclusion of at least one individual with autism or parent of a person with autism; (b) implementation of a telehealth system for the purpose of assessment or intervention; (c) utilisation of a design that allows for experimental control (in the case of intervention studies) or comparison condition (in the case of diagnostic studies); (d) measurement of factors associated with telehealth implementation (such as child outcomes, feasibility, parent outcomes); and (e) published in a peer reviewed journal. Both synchronous (real time consultation) and asynchronous (capturing digital samples such as images or videos (Deshpande et al., 2009) telehealth modalities were considered. However, studies that described parent, teacher or clinician training using web-based materials but without consultation were not included as these were not considered telehealth in this context, as per
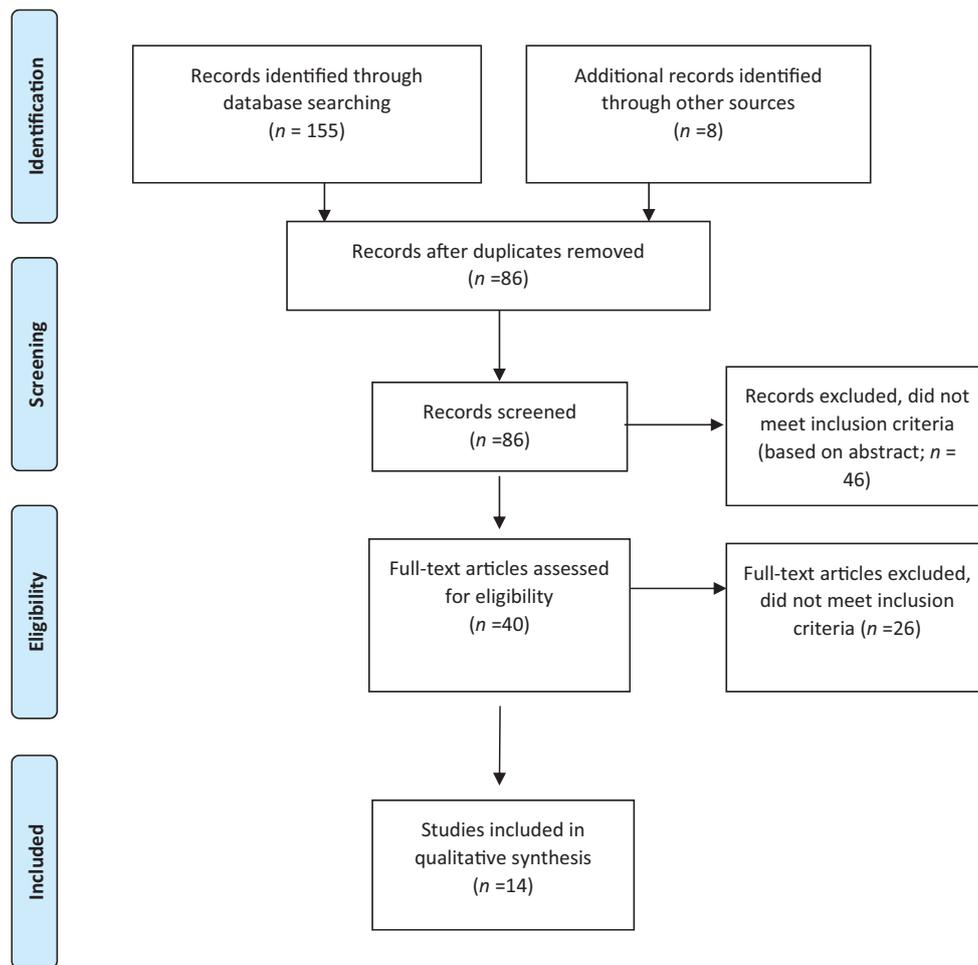
Figure 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) summary of paper screening process.

the ASHA (n.d.) definition of telehealth (e.g. Fisher et al., 2014). General reviews or discussion articles (e.g. Goldstein & Myers, 2014; Pearl et al., 2014; Reese, Braun, et al., 2015; Savin, Garry, Zuccaro, & Novins, 2006; Terry, 2009) were excluded as were articles describing other technology such as wearable sensors (Fletcher, Poh, & Eydgahi, 2010), virtual reality (Max & Burke, 1997) or technology in general (Aresti-Bartolome & Garcia-Zapirain, 2014). The eight studies included in the Boisvert et al. (2010) systematic review were not included; these been described adequately in the previous systematic review. There were no studies published before 2010 that were not included in the prior review. After screening the 86 papers based on title and abstract, 40 papers remained. These were independently read in full by two reviewers (the first and third authors) in order to determine eligibility with discussion to resolve differences. Following review, 14 papers remained that met all criteria. A hand search of the references of these 14 papers was completed with eight additional articles identified by their titles as being of potential interest; of these, four did not involve any participants with ASD (Boydell, Volpe, & Pignatiello, 2010; Cefai, Smith, & Pushak, 2010; Gros et al., 2013; Taylor

et al., 2008) and the remaining four involved online learning, eLearning or computer based training modules without an interactive synchronous or asynchronous telehealth component (Buzhardt & Heitzman-Powell, 2005; Hamad, Serna, Morrison, & Fleming, 2010; Jang et al., 2012; Wainer & Ingersoll, 2013), leaving the number of included articles at 14.

Quality review of included intervention articles was undertaken using the Scientific Merit Rating Scales (SMRSs; National Autism Center, 2015). The process involved rating the intervention research studies on five dimensions of experimental rigour (research design, participant ascertainment, generalisation, and measurement of dependent and independent variables). These ratings are then combined and an overall scientific merit score obtained. Scores of 3, 4 or 5 indicate that sufficient scientific rigour has been applied, a score of 2 indicates initial evidence about treatment effects and a score of 0–1 indicates that insufficient scientific rigour has been applied to the population of individuals with ASD. The first and third authors extracted the following information from each included article: participant characteristics (age, diagnosis, gender), the technology used, the type of

service, the study design/methodology, measures and reported outcomes.

Result

The details of the included papers are summarised in Table I. Fourteen papers, all originating from the United States, were published between 2010 and 2016, across a range of disciplines as described below.

Participant characteristics

Participants with ASD. Participants with ASD were directly and actively involved in telehealth (i.e. interacting with a clinician via a telehealth platform) in three studies: 23 adults were participants in one study that investigated remote diagnosis (Schutte et al., 2015); a child aged 11 years was engaged in language intervention (Boisvert et al., 2012), and; 17 students with a mean age of 11 years were involved with their parents in an anxiety programme (Hepburn, Blakeley-Smith, Wolff, & Reaven, 2016). A further 243 children with ASD were involved in the studies via their parents' or teachers' interaction with telehealth and child outcomes of interventions measured. Ages of the children ranged from 19 months to early adolescence.

Parents. Multiple studies investigated telehealth interventions aimed at parents with the total number of parents, across all studies, equalling 211. The age of the children ranged from 19 months to early adolescence.

Professionals. Forty-nine teachers were participants in one study (Ruble et al., 2013) as part of teacher/child dyads.

Technology

The majority of the studies utilised off-the-shelf, readily available equipment, including desk top computers, lap tops, webcams and tablet computers. One study used a specially designed platform (VISYTER; Schutte et al., 2015). Publicly available videoconferencing software such as Skype, Oovoo and Adobe Connect was used in 10 of the studies; three studies used unspecified password protected videoconferencing systems.

Service type

The studies investigated a diverse range of service types, as described below.

Diagnostic assessment. Three papers examined telehealth diagnostic services. Reese, Jamison, et al. (2013) and Reese, Braun, et al. (2015) used video conferencing (VC) between rooms in the same building to observe parents administering parts of the *Autism Diagnostic Observation Schedule – 2 (ADOS-2),* a play-based diagnostic assessment. Parents were randomly assigned to a VC condition

or an in-person (IP) condition. In both studies, parents watched a video demonstrating administration of parts of the ADOS-2, received information and were then coached through elements of the assessment by trained observers. Parents in the VC condition received coaching via clinicians using the VC system; parents in the IP condition received coaching by a clinician in the same room. Schutte et al. (2015), in contrast, used a specially designed platform (known as VISYTER) to deliver Module 4 of the ADOS-2 to 23 adults with known diagnoses of ASD.

Early intervention. Six studies examined telehealth and early intervention. Early intervention services delivered via telehealth included "Program ImPACT" (Ingersoll & Berger, 2015; Ingersoll et al., 2016; Pickard et al., 2016), "iPICS" (Meadan et al., 2016), a general communication intervention (Baharav & Reiser, 2010) and an imitation training (Wainer & Ingersoll, 2015). All the interventions were delivered via telehealth to parents. Five of the studies compared an online training only condition (non-telehealth condition) with online training plus parent telehealth sessions (telehealth condition); the sixth study (Baharav & Reiser, 2010) used a single-subject time-series (A–B) repeated measures design to compare telehealth sessions to intervention as usual (i.e. face to face sessions).

Anxiety intervention. One study (Hepburn et al., 2015) delivered an anxiety intervention ("Telehealth Facing Your Fears (FYF) Intervention") to 17 parent–child dyads via telehealth. Child participants had an average age of 11.5 years and all were diagnosed with both autism and anxiety. Outcomes were compared to a waiting list cohort ($n = 16$).

Functional behaviour assessment and functional communication training. Two studies of functional assessment of behaviour and functional communication training (FCT) were included in the review. Lindgren et al. (2016) compared the outcomes of 71 parents of children with autism and/or developmental delays who were trained to deliver functional assessment and FCT in three different conditions: (1) in home, face-to-face parent training; (2) coaching via VC at a regional centre; and (3) in-home coaching via telehealth. Suess, Wacker, Schwartz, Lustig, and Detrick (2016) examined functional analysis (FA) and communication training for three parents, comparing coached (via telehealth) and independent trials.

School age-intervention. Ruble et al. (2013) provided intervention to 49 teacher–child dyads aged 3–9 in three groups: (1) web-based education with face to face consultation; (2) web-based education with web-based consultation; and (3) a group that received web-based education only (non-telehealth). The goals were individualised and not described in detail in the article.

Table I. Results of the systematic review.

Article	Participant characteristics	Telehealth participant	Technology	Service	Design/method	Measures	Reported outcomes
Baharav and Reiser (2010)	Two children with autism 4;6 and 5;2 with their parents	Parents	Dell Latitude 2100 Netbook computer, web cam, broadband Internet connection, wireless BlueTooth headsets, Skype version 4.0.226	Communication intervention; parent training and coaching to parents of children with ASD	Proof-of-concept pilot study; single-subject time-series (A–B) repeated measures design	*Vineland Adaptive Behavior Scales, MacArthur Communicative Development Inventories (CDI)*; number and frequency of subjects' initiations and responses, clinicians' and parents' number of provided opportunities for interaction (overtures), and time spent in reciprocal social interactions	Communication gains made in the "treatment as usual" phase were maintained and extended in the telehealth treatment period. Parents reported that the sessions were valuable, both agreed that services delivered via telepractice at home are as valuable as sessions directly delivered by the clinician but were unsure whether they would rather have a session at the clinic or at home
Boisvert, Hall, Andrianopoulos, and Chaclas (2012)	Eleven-Year-old boy with autism	Child with ASD	Adobe connect, PresenceLearning, ConnectNow™, Skype for videoconferencing, webcam, microphone, speakers	Language intervention (use of transition words in narratives) in telehealth and onsite conditions	Single subject case study, changing condition (ABC), repeated measures research design	Count of transition words in narratives	Increase in the use of transition words compared with baseline, performance more consistent in telehealth condition compared with face to face condition
Hepburn, Blakeley-Smith, Wolff, and Reaven (2016)	Seventeen parent-youth dyads. Mean age 11.5 years; 14 male, non-verbal IQ range from <70 to >115). All diagnosed with autism and anxiety	Parents and children with ASD	OoVoo videoconferencing platform; commercially available web cams, computers, internet access	Feasibility and potential efficacy of a telehealth version of Face Your Fears (Reaven et al, 2011)	Cohort study, comparison of pre- and post-telehealth intervention child anxiety measures. Comparison of telehealth and waitlist group post-intervention measures	Participant monitoring form, parent and youth satisfaction ratings, treatment fidelity checklist, log of technical difficulties, *Screen for Anxiety and Related Emotional Disorders in Children* (SCARED; Birmaher et al., 1999), Parenting Sense of Competence Scale	High satisfaction ratings from parents and youth; significant technical difficulties in 5.8% of sessions, moderate technical difficulties more common. High levels of fidelity of programme implementation. Statistically significant differences between experimental and comparison group (wait list) on anxiety measure
Ingersoll and Berger (2015)	Twenty seven parents of a child with ASD age from 27 to 73 months	Parents	Skype video conferencing software, laptop, internet, webcams (all unspecified)	Self-directed online learning with or without coaching for telehealth-based parent-mediated intervention for young children with ASD	Randomised controlled trial (online learning with or without telehealth assistance)	Program (ImPACT) Knowledge Quiz, intervention fidelity, programme engagement, programme evaluation	High parent satisfaction and programme acceptability; improvement in their intervention knowledge. More accurate programme implementation and engagement in therapist assisted group. No child measures reported

(continued)

Table I. Continued

Article	Participant characteristics	Telehealth participant	Technology	Service	Design/method	Measures	Reported outcomes
Ingersoll, Wainer, Berger, Pickard, and Bonter (2016)	Twenty seven parents of a child with ASD between the ages of 19 and 73	Parents	Not described but as in Ingersoll & Berger (2015)	Self-directed online learning with or without coaching for telehealth-based parent-mediated intervention for young children with ASD	Randomised controlled trial (online learning with or without telehealth therapy assistance)	Parent Intervention Fidelity, Parent Sense of Competence Scale, Family Impact Questionnaire, Language Targets, MacArthur-Bates Communicative Development Inventory, Vineland Adaptive Behavior Scales, Second Edition	Improved fidelity, parent self-efficacy and parenting stress in both groups; therapist-assisted group made greater gains in their use of the intervention, greater increases in their positive perceptions of their child, were significantly more likely to complete the programme. Improved social communication skills in both groups; only the therapist-assisted group made improvements in social skills
Lindgren et al. (2016)	16 + 23 + 32 children (71 total across three groups) aged 21 – 84 months, delivered a service between 1996 and 2014. Group A included children with ASD and other developmental disabilities, other groups only ASD	Parents	Windows lap top, ethernet cable, Skype (for home based group), local health centre video conferencing equipment for clinic group	Parent delivered functional assessment and functional communication training	Observational data of three groups over time – in home face to face parent training, coaching via video conferencing at a regional centre, in-home telehealth coaching. All groups were part of research projects reported elsewhere	Observational measures of behaviour (i.e. occurrences of target behaviour during sessions), cost	The mean percentage reduction in problem behaviour >90% for all groups and not significantly different between the three service models. Overall costs were lowest for the home telehealth group
Meadan, Snodgrass, Meyer, Fisher, Chung, and Halle (2016)	Three mother-child dyads; ages 2, 3 and 4	Parents	iPad, secure online file sharing service, videoconference via Skype, screen-capture software (Camtasia)	i-PiCS intervention – online teaching phase then parent coaching on modelling (2 × 30 min per week), mand-model, and time delay	Multiple-baseline design across strategies within each family	Parent quality and rate of strategy use; child communication skills (defined as child initiations and responses to communication). Social validity interview	Coaching appeared to be the intervention component that has the largest impact on the combined measure of quality and rate of strategy use; however, a potential sequence effect needs to be considered. No clear impact on child communication. Good parental satisfaction
Pickard, Wainer, Bailey, and Ingersoll (2016)	Twenty eight parents of a child with ASD between the ages of 19 and 73 months completed questionnaires; 10 parents	Parents	Skype video conferencing software, laptop, internet, webcams (all unspecified)	Self-directed online learning with or without coaching for telehealth-based parent-mediated intervention for	Mixed method, random assignment to treatment groups	Survey examining (1) intervention acceptability, (2) perceived child social communication gains, (3) burden of the intervention on the family and (4) frequency	Parents in the TA group reported that coaching was essential, parents in the SD group indicated that coaching would have made learning the intervention. Parents in the TA

(continued)

Table I.   Continued

Article	Participant characteristics	Telehealth participant	Technology	Service	Design/method	Measures	Reported outcomes
	(five from the SD group and five from the TA group) involved in qualitative interview			young children with ASD		of programme use; interview examined (1) overall perception of ImPACT Online, (2) perception of the feasibility of the programme, (3) experience of support and (4) programme referral preferences	group were 50% more likely to report gains in social communication
Reese, Jamison, et al. (2013)	Eleven children with ASD diagnosis, 10 with existing diagnosis of developmental delay; ages 3–5, three girls. Ten children assigned to videoconferencing condition (IVC), 11 to in-person (InP) condition	Parents	High-definition monitors and cameras, unstated use of internet connection	Diagnostic assessments using parent administered ADOS and ADI-R questionnaire for children already identified with ASD or ID	Method comparison design (randomised to in-person (InP) or video conference (VC) assessment)	Autism Diagnostic Observation Schedule (ADOS); Autism Diagnostic Interview – Revised (ADI-R); Parent satisfaction survey	High levels (20/21) of agreement for diagnostic status. Similar levels of agreement between clinicians, significant disagreement on one item (social pointing). High satisfaction reported by parents
Reese, Jamison, Braun, Wendland, Black, Hadorn, ... Prather (2014)	Seventeen children, 2.5 and 6 years old seeking assessment for ASD	Parents	High-definition monitors and cameras, unstated use of internet connection	Diagnostic assessments using parent administered free play, ADOS and ADI-R questionnaire (algorithm items only) for children not yet assessed for ASD. DSM 5 criteria	Method comparison design (randomised to in-person (InP) or video conference (VC) assessment) with confirmatory assessment within 60 days	DSM-5 symptoms, Primary diagnosis, Parent integrity checklists	82% accuracy of in-person assessments, 86% accuracy for VC condition. Fidelity of parent administered presses described as adequate
Ruble, McGrew, Toland, Dalrymple, and Jung (2013)	Forty nine teacher–child dyads randomised into three groups (placebo, web coaching and face to face (FF) coaching); child age range 3 and 9 years, with a mean of 6 years, 86% male	Teachers	Laptop computer, webcam, headphones and video camera. Adobe connect software	Compared web-based education + face to face consultation with web based consultation. Placebo group (online training without consultation) included	Randomised control trial using intent to treat approach	Psychometrically Equivalence Tested Goal Attainment Scaling (PET-GAS)	Mean PET-GAS change score for the placebo group was significantly lower than for the face to face consultation and web consultation groups. Very large effect size for the FF group and a large effect size for the web group relative to the placebo group. No difference between the web and face to face group
Schutte et al. (2015)	Twenty-three adults with existing ASD diagnosis	Adults with ASD	VISYTER platformOff-the-shelf equipment, dual webcams, tablet, internet access	Diagnostic assessment	Within-subject crossover design study remote ADOS and face-to-face ADOS	ADOS-2 (module 4), seven-item Post-ADOS User Satisfaction Questionnaire	High participant satisfaction with the remote assessment. Good agreement between face to face and remote assessment results
Suess, Romani, Wacker, Dyson,	Three boys, 2-year 7-months, 2 years	Parents	Windows-based PC and video monitor,	Functional analysis and communication	Case series, multi-element designs	Observations of problems behaviours, fidelity of	Reduction in difficult behaviour, various levels of

(continued)

Table I. Continued

Article	Participant characteristics	Telehealth participant	Technology	Service	Design/method	Measures	Reported outcomes
Kuhle, Lee,… Waldron (2014)	11 months and 3 years, 3 months, all with PDD-NOS, 1 with intellectual disability		webcam and headset, Debut videoconferencing software, Skype™	training for parents, coached and independent trials. Coached trials conducted via telehealth	comparing coached and independent trials	implementation, *Treatment Acceptability Rating Form – revised (TARF-R)*	parent fidelity in coached and independent trials. High parent acceptability. No formal measures
Wainer and Ingersoll (2015)	Five children with ASD, age range 29 to 59 months	Parents	Home computers, webcams and internet connections, internet-based, password-protected video-conferencing programmes	Imitation training intervention – online lessons plus remote coaching	Case series	Program engagement, measured by website usage; parent knowledge of intervention (quiz); observations of parent implementation (Overall Fidelity Score); observations of child imitation; treatment acceptability (*Behavioral Intervention Rating Scale (BIRS)*)	Strong effect of the self-directed learning on parent programme knowledge. Increased fidelity of implementation for all parents following telehealth coaching sessions. Child responses to the online learning condition compared with the training sessions varied; moderate increases in imitation rate for four of the five children were observed at follow-up. Parents' rating of acceptability indicated that the programme was highly acceptable, effective, and usable

Language intervention. One study (Boisvert et al., 2012) evaluated the impact of language intervention delivered via telehealth to an 11-year-old boy on the autism spectrum. The focus of the intervention was the use of transition words in narratives, with conventional intervention compared with telehealth intervention.

Study design/method

A range of methodologies was employed across the 14 studies. Five studies utilised a single subject, changing conditions design with repeated measures (Baharav & Reiser, 2010; Boisvert et al., 2012; Meadan et al., 2016; Suess et al., 2016; Wainer & Ingersoll, 2015). Two studies employed a cohort comparison methodology comparing the telehealth intervention groups with a non-treatment group from another study (Hepburn et al., 2016) and with previous treatment groups using face to face and centre-based telehealth interventions (Lindgren et al., 2016). Four intervention studies compared intervention groups utilising a randomised control trial design (Ingersoll & Berger, 2015; Ingersoll et al., 2016; Pickard et al., 2016; Ruble et al., 2013) with two diagnosis studies using randomisation to allocate participants to assessment conditions (Reese, Braun, et al., 2015; Reese, Jamison, et al., 2013). A third diagnosis study employed a within subjects crossover design to compare telehealth and face to face assessment outcomes (Schutte et al., 2015). With respect to comparison conditions, six studies compared online learning plus telehealth sessions to online learning alone (non-telehealth) (Baharav & Reiser, 2010; Ingersoll & Berger, 2015; Ingersoll et al., 2016; Meadan et al., 2016; Pickard et al., 2016; Wainer & Ingersoll, 2015), six studies compared telehealth with face to face conditions (Boisvert et al., 2012; Lindgren et al., 2016; Reese, Braun, et al., 2015; Reese, Jamison, et al., 2013; Ruble et al., 2013; Shutte et al., 2015), and two studies compared telehealth with no intervention or intervention as usual (Hepburn et al., 2016; Ruble et al., 2013).

The quality of the studies based on the SMRS (National Autism Center, 2015) varied. One case study involving a single participant (Boisvert et al., 2012) utilised a repeated measures design with multiple probes but the small number of participants and lack of generalisation measures meant that it scored <2 (indicating insufficient scientific rigour). Three studies scored between 2.0 and 2.9 (initial evidence; Baharav & Reiser, 2010; Ingersoll & Berger, 2015; Lindgren et al., 2016) and the remainder of the studies were scored 3 or 4 (sufficient scientific rigour). The three studies regarding diagnosis (Reese, Jamison, et al., 2013; Reese et al., 2014; Schutte et al., 2015) were not suitable to be rated by the SMRS system but were considered adequate in terms of participant ascertainment, sample size, data collected and fidelity measures.

Clinical outcomes

A range of participant, parent and teacher outcomes were measured across the included studies. These have been categorised as follows for descriptive purposes.

Diagnosis. Reese, Jamison, et al. (2013) and Reese, Braun, et al. (2015) compared the outcomes of diagnostic assessment delivered face to face, with the results when delivered via telehealth and found high levels of agreement in diagnostic status between the conditions. Greater discrepancies in agreement on individual items were noted. Similarly, Shutte et al. (2015) reported high levels of agreement regarding diagnostic categories on the ADOS (i.e. Autism, Autism Spectrum Disorder or not ASD) but with variation in the reliability of individual items.

Communication. Eight studies reported on communication outcomes (Baharav & Reiser, 2010; Boisvert et al., 2012; Ingersoll et al., 2016; Meadan et al., 2016; Pickard et al., 2016; Ruble et al., 2013; Wainer & Ingersoll, 2014). Positive impacts on communication, including improved initiations and responses, as measured through formal and observation measures were reported by Baharav and Reiser (2010). Similarly, the Boisvert et al. (2012) study reported better use of transition words after telehealth therapy compared with baseline and that the students' performance was more consistent in telehealth condition compared with face to face condition. Ingersoll et al. (2016) used structured observations as well as standardised questionnaires and found that both groups (self-directed online learning and therapist assisted online learning) showed improvements, with the therapist assisted group showing significant increases in their standard scores on the social domain of the *Vineland Adaptive Behaviour Scales – 2nd edition* while children in the self-directed condition did not. Pickard et al. (2016), in their article about the same study as described by Ingersoll et al. (2016), reported that parents in the therapist assisted group were more likely to report gains in social communication than the self-directed condition parents. Ruble et al. (2013) used "Psychometrically Equivalence Tested Goal Attainment Scaling (PET-GAS)" to measure outcomes across a wide range of individual communication, social and learning goals for 49 teacher–child dyads. Results showed similar mean PET-GAS change when comparing the face to face coaching with telehealth coaching and that both groups were better than the non-coached group. The communication outcomes were less robust for the three children in the Meadan et al. (2016) with the authors suggesting there were "no clear results across dyads for children's communication behaviour in the multiple-baseline analysis" (p. 17).

Wainer and Ingersoll (2015) reported similarly variable results for rates of imitation in their study comparing baseline with self-directed (non-telehealth) and coaching conditions.

Behaviour. Lindgren et al. (2016) used FA and FCT to reduce challenging behaviour, and found that the mean percentage reduction in problem behaviour was more than 90% for the three groups (home based, centre based telehealth and home-based telehealth). Suess et al. (2016) also reported on a reduction in problem behaviours following telehealth training and coaching.

Anxiety. The anxiety study (Hepburn et al., 2015) that delivered an intervention to 17 parent–child dyads found statistically significant differences between the experimental and comparison group (wait list) on the anxiety measures using *Screen for Anxiety and Related Emotional Disorders in Children* (SCARED; Birmaher et al., 1999).

Implementation outcomes

Reduced costs. One study (Lindgren et al., 2016) looked specifically at the costs associated with home-based telehealth compared with face to face sessions and centre based telehealth, and found that overall costs were lowest for the home telehealth group.

Satisfaction and acceptability. Parent satisfaction was a reported outcome for nine of the 14 studies (Baharav & Reiser, 2010; Hepburn et al., 2016; Ingersoll & Berger, 2015; Meadan et al., 2016; Pickard et al., 2016; Reese, Braun, et al., 2015; Schutte et al., 2015; Suess et al., 2016; Wainer & Ingersoll, 2015). All studies reported high levels of programme acceptability and parent satisfaction with the telehealth component of the intervention or assessment. In addition, two studies that involved direct telehealth involvement with individuals on the spectrum (Hepburn et al., 2016; Schutte et al., 2015) reported high participant satisfaction with the methods used.

Fidelity. Measurement of fidelity of parent implementation of tasks was a focus of seven of the 14 studies (Hepburn, et al., 2016; Ingersoll & Berger, 2015; Ingersoll et al., 2016; Meadan et al., 2016; Reese, Jamison, et al., 2013; Suess et al., 2016; Wainer & Ingersoll, 2015). The fidelity of parent administration of assessment tasks in the diagnosis study (Reese, Jamison, et al., 2013) was described as "adequate", while parent fidelity in the behaviour study of Suess et al. (2016) varied across the coached and independent trials. The remaining studies reported high levels of parent fidelity for interventions provided via telehealth (Hepburn et al., 2016; Ingersoll et al., 2016), with a number reporting that the fidelity of programmes taught to parents online was improved when telehealth coaching was provided (Ingersoll & Berger, 2015; Meadan et al., 2016; Wainer & Ingersoll, 2015).

Discussion

The present review sought to examine the literature regarding telehealth and autism published since the previous systematic review (Boisvert et al., 2010) with regards to the type of service delivered, the recipients of the telehealth service, and the outcomes of the telehealth services provided. The 284 participants on the autism spectrum across the 14 included studies ranged in age from 19 months to adulthood. A range of services were provided by telehealth, including diagnostic assessments, early intervention, functional behavioural analysis and anxiety interventions. One study addressed language impairment directly. Outcomes were largely positive with the results suggesting that services delivered via telehealth were equivalent to services delivered face to face, and superior to comparison or control groups (who did not receive the intervention), or self-directed learning without telehealth sessions.

There has been a considerable increase in research interest in this area since the previous systematic review (Boisvert et al., 2010) which found only eight eligible studies, representing just 46 participants and with only a minority of the studies employing an experimental design. Accordingly, we were able to extend the findings of the previous review, not only in terms of time frame, but through examination of the outcomes of telehealth compared with non-telehealth services (including service delivery as normal, online learning only, or face-to-face interactions). To this end, a criterion for inclusion was that the study involved a comparison condition. The 14 studies that satisfied this criterion, featured a range of methodologies, including single case study design as well as more rigorous randomised control trials. It was noted that such studies were still in the minority of the 40 studies screened, with 26 studies that met the other inclusion criteria but that did not include a comparison condition. As telehealth becomes increasingly accepted and widely used, it is essential that research examining its use features designs that allow for robust examination of its equivalence, or otherwise, with practice as usual.

In considering the relevance of the findings to speech-language pathology practice, it is important to note that most included studies focussed on telehealth for young children and their parents, carers and/or teachers. In addition, the vast majority of the recipients of telehealth interventions (i.e. the person interacting with the therapist online) were parents, carers or teachers; of the 284 participants, only 23 adults and 18 older children on the autism spectrum were directly engaged in the telehealth technologies. Only one child was directly involved in telehealth without involvement in a parent dyad (Boisvert et al., 2012) and as such, outcomes related to the provision of telehealth services to individuals with ASD are difficult to generalise. This represents

a significant gap in the literature with very little yet known about the reactions and behaviours of children and adolescents on the autism spectrum to telehealth in comparison with face-to-face conditions.

A number of limitations of the included studies were noted. Small sample sizes continue to limit the generalisability of findings in some studies, with five of the studies involving five or fewer participants ($n = 1$ to $n = 5$). It is positive to see the growth in the inclusion of comparison groups and/or conditions since the last review. However, group research continues to be limited by lack of randomisation and comparison with non-matched groups in some studies (e.g. Lindgren et al., 2016). The use of changing conditions design with repeated measures (e.g. Baharav & Reiser, 2010; Boisvert et al., 2012; Meadan et al., 2016; Suess et al., 2016; Wainer & Ingersoll, 2015), while providing a comparison between two conditions, is also limited by potential sequence effects (e.g. Meadan et al., 2016). Only three studies (Ingersoll et al., 2016; Meadan et al., 2016; Wainer & Ingersoll, 2015) included measures of outcome maintenance or generalisation.

The use of telehealth to provide diagnostic assessments for autism was explored by three studies in this review. Two of these studies (Reese, Braun, et al., 2015; Reese, Jamison, et al., 2013) used parents to deliver items of the *Autism Diagnostic Observation Schedule* (ADOS; Lord et al., 2012) to their children. While the authors reported good agreement on diagnostic status when IP and telehealth observations were compared (Reese, Jamison, et al., 2013), as well as good accuracy when telehealth assessment outcomes were compared with later assessments (Reese, Braun, et al., 2015) along with adequate parent fidelity, it is unclear to what extent the impact of the parent implementation of the assessments may have had. Parents were given information about the activities prior to the assessments and then received coaching during the assessment to implement the items which is a significant departure from standard practice. As initial studies, neither trialled providing a full autism diagnostic assessment with feedback to parents and both studies were conducted via a telehealth simulation (rooms connected by closed circuit television in the same building), suggesting that the use of telehealth for diagnostic assessments should not yet be considered an established practice. In addition, the studies used percentage agreement to measure agreement between the assessment methods, rather than a more rigorous measure of agreement appropriate for method comparison studies, such as Bland–Altman analysis (Bland & Altman, 1999; Taylor, Armfield, Dodrill, & Smith, 2014).

Limitations

The current review was limited by the small number of included studies and a meta-analysis of outcomes was not completed in the current study. Despite the growth in research and apparent uptake in the use of telehealth, only 14 studies met the inclusion criteria for this review. As a result, the findings of this study need to be interpreted with caution. In addition, there was a wide range of service types assessed in the included studies, meaning that the data on any one area are limited. Similarly, a lack of consistency, common measurement tools and clear reporting of outcomes makes completing meta-analysis impossible. This review was also limited by the lack of inclusion of grey literature and unpublished data. In addition, the first phase of screening articles in this study was completed by the first author only. Although subsequent phases of the review were completed by two of the authors, reliability of data extraction was not conducted. In addition, it is possible that appropriate articles may have been missed in this process. All included studies originated from one country (United States), potentially limiting generalisation of the findings.

Future directions

The results of this review suggest that telehealth continues to be a promising area of practice for individuals on the autism spectrum. Studies of telehealth in the past six years have focussed strongly on the provision of telehealth instruction to parents, caregivers and teachers across a range of service types and utilising a number of study designs. There are, however, gaps in the research that future studies could consider. The first of these is exploration of the role of telehealth in providing direct services to people with ASD. Few studies have examined the reactions and behaviours of children and young people on the autism spectrum when provided with telehealth services, with only one single-subject study focussed on language intervention provided via telehealth directly to a child on the spectrum. Research that assists SLPs to make decisions about providing telehealth services to children on the spectrum, such as research that considers the reactions and behaviours of these children when interacting with therapists would be valuable. Future studies also need to continue to include comparison conditions to ensure that clinicians, parents and administrators can be confident that telehealth services are at least equivalent to services provided via intervention as usual. Finally, while the studies included in the current review reported high rates of participant satisfaction, future studies should continue to explore the facilitators and barriers to the use of telehealth with clinicians, parents and individuals on the autism spectrum.

Conclusion

Telehealth has been shown to have great potential in the assessment and intervention for a range of conditions relevant to SLPs. There is growing research into the types of services offered, particularly for individuals with ASD, and there is evidence that the design and methodology of the research conducted is becoming more rigorous. This review suggests there may be a range of benefits in using telehealth to provide assessment, training and direct intervention using telehealth to individuals with ASD, their families and teachers. Further research, however, is required particularly regarding the use of telehealth directly with children with ASD for speech and language interventions.

Declaration of interest

No potential conflict of interest was reported by the authors.

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