The use of technology in the management of children with phonological delay and adults with acquired dysarthria: A UK survey of current SLP practice

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Abstract

Purpose: Technology is increasingly important for the speech-language pathology profession, but little is currently known about its use by clinicians. This study aimed to determine (i) the types of technology that speech-language pathologists (SLPs) in the UK have access to and use in practice and (ii) the barriers they encounter when assessing and treating adults with acquired dysarthria and children with phonological delay.

Method: UK SLPs were invited to complete two online surveys covering device availability, the use of technology for the assessment and treatment of acquired dysarthria and phonological delay, and barriers to using technology. Results were analysed using descriptive statistics.

Result: 126 SLPs completed the surveys. Most respondents had a range of devices available in clinic, including computer and touchscreen devices. Technology was primarily used for treatment to engage clients, provide direct feedback in sessions and encourage home practice. Reported key barriers include lack of knowledge and training, and technical support issues.

Conclusion: The use of technology in UK clinical practice varies widely, and technology adoption is hampered by various barriers. Findings indicate a need for more collaborative work between SLPs, technologists and policy-makers to develop the evidence-base for technology use in the management of acquired dysarthria and phonological delay.

Keywords: technology, dysarthria, phonological delay, speech-language pathology, service delivery

Introduction

In parallel with all other aspects related to our daily lives, technology is playing an increasing part in healthcare provision. This can take various forms. In relation to the management of clients with communication difficulties, two types of technology implementation are prominent: Telehealth, also known as "telepractice", "telemedicine", and "telespeech", focuses on the remote delivery of professional health services such as assessment, treatment, and/or consultation through telecommunications technology. These include telephone, email, video-conferencing and internet phone services like Skype, linking therapists and clients remotely (American Speech-Language-Hearing Association (ASHA), 2019)[1]. On the other hand, Technology Assisted Speech-Language Therapy (TASLT) focuses on technological support for face-to-face (FTF) interaction as well as home practice to enhance the effectiveness of intervention. These include speech recording and analysis software and devices, and mobile applications in the form of infotainment and electronic games also known as mHealth (Saz et al., 2009).

There is evidence that technology is increasingly being adopted into the management of clients with communication disorders. For example, whilst earlier reports on practice in the US and Australia indicated that telehealth was predominantly used for consultation, follow-up sessions and counselling purposes across adult and paediatric populations (ASHA, 2002; Hill & Miller, 2012), a more recent survey of US SLPs with expertise in telehealth showed a shift towards the use of telehealth for assessment and treatment (ASHA, 2016a). This was the case for a variety of communication disorders, particularly expressive and receptive language disorders, fluency and articulation in children, as well as fluency, voice and motor speech disorders in adults (ASHA, 2016a).

[1] Please note: ASHA prefers the term "telepractice", whereas "telehealth" is the more common term in the UK. Given that we focus on UK clinical practice we will use the term telehealth.

In response to the growing importance of technology in healthcare, SLP professional bodies such as ASHA in the US or the Royal College of Speech and Language Therapists (RCSLT) in the UK have endorsed both telehealth and TASLT as an appropriate mode of service delivery providing that the quality of services is equivalent to those provided in person and adheres to ethical guidelines and key clinical principles to ensure effective and safe services (ASHA, 2016b, 2017).

The research and clinical communities, in turn, have endeavoured to provide the necessary evidence to demonstrate that both telehealth and TASLT can provide the required equitable service to clients with communication disorders. One pattern that emerges from the literature is that whilst there are studies investigating the use of telehealth as a service delivery model for paediatric populations (e.g. Wales, Skinner & Hayman, 2017; Grogan-Johnson, Alvares, Rowan, & Creaghead, 2010), the main research focus for this client group lies on the use of TASLT (e.g. Madeira, Mestre, & Ferreirinha, 2017; Furlong, Erickson, & Morris, 2017). On the other hand, telehealth features more prominently in research on adult populations. For example, a well-researched population for telehealth are clients with dysarthria, where studies have shown that video-conferencing tools yield comparable results to FTF assessments for measures of speech intelligibility, perceptual speech features and level of severity of dysarthria, provided adequate technology is available and appropriate assessment protocols are followed (e.g. Constantinescu et al., 2010; Hill et al., 2009). Treatment studies delivered via telehealth also show comparable increase in perceptual, acoustic and quality of life measures to FTF sessions and yield high participant satisfaction (Constantinescu et al., 2011; Howell et al., 2009; Theodoros et al., 2006; Theodoros, Hill, & Russell, 2016; Tindall et al., 2008).

In addition to demonstrating equity of service provision, studies have established potential benefits of remote management to SLPs and clients (e.g. Mashima & Doarn, 2008; Molini-Avejonas, Rondon-Melo, de La Higuera Amato, & Samelli, 2015; Theodoros, 2012). They

highlight the fact that it allows clinicians to provide better services to underserved, rural communities, reducing their time spent travelling to clients, and being able to provide specialist services at appropriate times. This can in turn assist them in managing caseloads, reduce waiting times and optimise the timing, intensity and duration of treatment regimes (Theodoros, 2012). Remote management is also perceived to be a cost-effective means of assessing and treating clients (e.g. Hill & Miller, 2012), which is important in times of limited resources and rising pressure on the healthcare system. Equally, clients will not need to travel to clinic see the SLP, thus cutting down on fatigue, travel costs and allowing access to those who perceive travel to clinic as a barrier for engaging in treatment (e.g. Hill & Miller, 2012).

Similarly, SLPs may perceive TASLT as an accessible, convenient and cost-effective way of providing treatment (e.g. Furlong et al., 2017). One frequently reported benefit in paediatric populations is increased motivation and a more active engagement in therapy as children are often drawn to colourful animations (e.g. Gačnik, Starčič, Zaletelj, & Zajc, 2018; Madeira et al., 2017). This can positively impact on session frequency and duration of intervention, as the children enjoy playing the mobile-games (Ahmed et al., 2018; Furlong et al., 2017). Other advantages include portability of the devices, allowing more effective home practice, reduced preparation time for SLPs as well as facilitation of practice through automatic scoring of performance and tracking of client progress (Furlong et al., 2017; Madeira et al., 2017). TASLT might therefore have the potential to improve therapy outcomes (e.g. Edwards & Dukhovny, 2017).

However, despite the positive reports discussed above, research has also highlighted barriers that can prevent SLPs from implementing technologies into their practice or reduce their effectiveness for both telehealth and TASLT applications. Regarding TASLT, for example, a lack of professional standardisation of mobile apps means that SLPs may have to rely on personal judgement, star rating systems and user reviews to choose the appropriate one

(Rodríguez & Cumming, 2017). Whilst efforts to develop an evidence base for TASLT resources are continuing (see e.g. Furlong, Morris, Serry, & Erickson, 2018), there is still limited evidence for the effectiveness of the mobile apps currently on the market, i.e. they have not undergone the rigorous testing expected of FTF treatment programmes before they are adopted. Availability of disorder specific mHealth tools was also an issue until recently, with more tools being now designed for specific client populations in mind (e.g. Madeira et al., 2017). Also, to be noted is that not every client may benefit from TASLT and issues such as negative reinforcement, carer's proficiency in using the technology provided, and age appropriateness will affect clinical outcomes (Furlong et al., 2018).

Issues have also been reported in relation to telehealth provision. Earlier surveys from the US and Australia identified a range of barriers to wider use (ASHA, 2002; Department of Health and Aging (DHA), 2011; Dunkley, Pattie, Wilson, & McAllister, 2010; Zabiela, Williams, & Leitão, 2007). In the US, cost, lack of professional standards and data on efficacy and cost-effectiveness were identified as major obstacles (ASHA, 2002). Also, a high number of respondents reported that they needed to know more about telehealth before considering it for their own practices. Similar barriers were identified by Australian SLPs with specific emphasis on lack of training and education, lack of evidence for its effectiveness, lack of adequate IT support and lack of assessment and treatment resources appropriate for telehealth (DHA, 2011; Hill & Miller, 2012; Zabiela et al., 2007). Dunkley et al. (2010) further identified a mismatch between SLPs' and clients' attitudes: they found clients often had better access and more positive attitudes to telehealth use than SLPs expected.

It is likely that some of the above mentioned barriers have been resolved since these surveys were conducted. More people than ever before have access to and own devices. For instance, in the UK in 2018, 78% of adults owned a smartphone, 58% of households had access to a tablet computer and 90% of people had access to the internet in their home (Office of

Communications, 2018). In addition, availability of and access to clinical resources is also increasing. At the same time, the problems reported in relation to the implementation of TASLT above indicate that new barriers are likely to have emerged during this period. In order to guide future research and practice in this area, it is therefore important to reassess SLPs' use of and attitudes towards technology in clinical practice, both in relation to telehealth and TASLT.

Aim

The aim of our study was to establish current clinical practices by UK SLPs regarding the use of telehealth and TASLT for assessing and treating clients with communication disorders. In order to capture potential variations in data due to client group, the investigation focused on two distinct populations: adults with acquired dysarthria and children with phonological delay. These were chosen because they constitute a significant part of SLPs' caseloads in the UK and cover both acquired and developmental communication disorders, therefore providing insights into use of technology with clients across the lifespan. Acquired dysarthria represents the most frequent communication disorder in adults with neurological difficulties (Duffy, 2013). With regard to phonological delay, more than half of the paediatric caseload referred each year in the UK are children with primary speech and language difficulty (Baker & McLeod, 2011). In addition, children with phonological delay of unknown origin are thought to represent the largest proportion of children with speech sound disorders (Stow & Dodd, 2005; Shriberg, 2010). The current project aimed to answer the following research questions:

-What devices do SLPs have access to for the purposes of telehealth and TASLT?

-How do SLPs currently use telehealth and TASLT in the assessment and treatment of adults with acquired dysarthria and children with phonological delay?

-What are the barriers SLPs experience regarding the implementation of telehealth and TASLT?

Method

We developed two online surveys to establish current clinical practice by UK SLPs, targeting clinicians working with adults with acquired dysarthria and children with phonological delay separately. Ethical approval was granted by the University's School Ethics Committees.

Survey respondents

We asked practising SLPs working with our two client populations to complete the surveys, including those who were not using technology in their clinics. In line with consent declaration, incomplete surveys were discarded, as were surveys where respondents declined to consent to participate. Seventy SLPs working with people with dysarthria (PwD) accessed the relevant survey, of which 46 respondents met the above criteria. Also, 158 SLPs working with children with phonological delay (CwPD) accessed their survey, of which 80 were fully completed. Therefore, we report here on 126 survey responses.

Responses were received from SLPs in England (60.6%), Scotland (25.0%), Wales (4.5%) and Northern Ireland (9.8%), with respondents working primarily full-time (63.6%) for the National Health Service (NHS; 86.4%) or in private practice (9.1%). Just over half of the work settings for SLPs working with PwD were inpatient and outpatient wards in hospitals (52.4%) followed by clients' homes (24.4%), health centres (8.1%) and community centres (4.9%). The remaining SLPs (10.2%) worked in other settings including nursery homes and rehabilitation units. SLPs working with CwPD were primarily based in schools (37.9%) and nurseries (12.6%) as well as in health centres and clinics (25.3%) and clients' home (9.3%). The remaining SLPs (14.9%) worked in hospitals, child-development centres, community centres and private clinics. About two third of respondents (65.9%) were experienced SLPs who had worked with PwD or CwPD for more than seven years, while 17.4% were relatively newly qualified with less than two years of work experience. Most respondents saw these client groups regularly in clinic, with 72% reporting seeing more than 20 cases per year for their respective client groups.

Survey questionnaires

The surveys were designed using Qualtrics®. Each questionnaire was iteratively developed in relation to question content and answer format with a group of SLP researchers and clinicians experienced in working with PwD and CwPD. Subsequently, seven SLPs with experience of working with these two client groups piloted the surveys. They provided feedback on content, readability and general format of the questionnaires, which were modified accordingly.

The PwD survey comprised 31 questions to gather information on 1) respondents' demographics, 2) the availability of devices and relevant software in clinics, 3) respondents' use of these devices for the assessment and treatment of acquired dysarthria, and 4) their perception of barriers to using technology. The survey on technology use in the management of phonological delay consisted of a total of 33 questions requesting similar information. Information was primarily gathered through multiple-choice and forced-choice questions and rating scale questions such as 5-level Likert-type scales. In some instances, free text boxes were used to allow additional information where specific answers were not included in the set of responses. An overview of the questions in each survey can be found in the supplementary appendix A. Not all respondents answered all questions as the survey tool would logically skip and guide to the next question as appropriate. Also, some questions allowed more than one answer. Each survey took about 10-15 minutes to fill in and had to be completed in one sitting.

Distribution

Both surveys were publicised through the UK SLP professional body's bulletin (RCSLT *Bulletin*), direct contact with SLP services and social media. Links to the surveys were also distributed via mailing lists and RCSLT Clinical Excellence Networks asking for the links to be sent to members. The surveys were open between November 2016 and March 2017.

Data Storage and Analysis

All survey responses were collected anonymously, and answers were stored in Qualtrics® with data subsequently being transferred to a university-based server. Descriptive statistics were used to examine the numerical data. Due to the low number of open responses in the free text boxes, only the data collected through the multiple-choice and rating scales will be reported in the following section.

Result

Availability of devices in clinics

Figure 1 shows that a variety of devices were available to SLPs in clinics, particularly tablet/iPads, computer/laptops, telephone and, to a lesser extent, smartphones. Interestingly, only about 30% of respondents in either group reported having access to a landline telephone, suggesting that even well-established devices are not always widely available for use. Whilst availability of devices was broadly comparable across surveys, SLPs working with PwD used fewer touch-screen devices than respondents working with CwPD. Seventy-two percent of dysarthria survey respondents had access to a minimum of three devices, compared to 41% of paediatric SLPs. About one in ten respondents (13% PwD, 12% CwPD) reported having access to only one device, which was either a telephone, computer or tablet.

--- *insert Figure 1 about here* ---

Use of telehealth and TASLT in assessment and treatment

Table I shows that the majority of respondents reported employing telehealth and TASLT in clinical practice, primarily for treatment and to a lesser degree for assessment. A third of SLPs working with PwD and a quarter of SLPs working with CwPD reported that they do not use these technologies for assessment or treatment at all.

--- *insert Table I about here* ---

Assessment

Focusing on users of technology for assessment, none of the respondents reported that they used telehealth to screen or assess clients. Instead, remote contact was exclusively used for administrative purposes, such as gathering information from clients and organising appointments. On the other hand, Figure 2 shows that 90% of SLPs working with PwD and 37.5% of SLPs working with CwPD reported using devices in FTF assessment, with loudness meters and voice recorders being the most frequently used tools, respectively. For PwD, devices were used to record voice and gather baseline data (34.1%), provide direct feedback to clients (31.7%), and analyse speech (26.8%). Reported benefits included ease of recording of client's performances and gaining quantitative results, the time-saving aspect of using technology, and the ability to collect data for further evaluation and diagnosis corroboration.

--- *Insert Figure 2a and 2b about here* ---

Treatment

As indicated in Table 1, there was much greater use of devices and software such as apps and computer-based programmes in treatment. Also, patterns of use differed from the assessment context. Whilst the majority of SLP technology users working with PwD applied technology to support FTF sessions (86%), it was also used to encourage people to practise at home (79%). A smaller number of respondents (28%) reported having used technology to replace FTF sessions. Results for SLPs working with CwPD showed a similar trend. SLPs reported using technology to increase client motivation (82%), to facilitate home practice (63%), and to analyse speech (48%). Respondents further indicated that the use of TASLT had improved clinic attendance (29%) and reduced the number of FTF sessions needed (18%). Specifically, for home practice desktop software (19.3%) and apps (29.6%) were used; for FTF interaction, respondents reported primarily using apps (44.7%) and voice recorders (47.4%).

Figure 2 further shows that apps were the most frequent type of technology used by both groups of respondents (PwD: 62.2%, CwPD: 55%). For PwD, apps - but also computer software

such as the LSVT Companion were used to treat loudness, articulation, pitch and tempo, with the aim of improving intelligibility and voice quality as shown in table II. For CwPD, apps and computer software were used for articulation therapy, practising minimal pairs and improving phonological awareness, as well as serving as a tool for voice recording and phonetic transcription (cf. Table II).

---*Insert Table II about here* ---

The decision to use devices and software in the treatment of PwD was mainly based on whether the client was keen to use it (33.9%), followed by the client having the technological knowledge and being motivated to practise at home (both 21.5%), as well as ownership of the necessary equipment (15.4%). In the case of CwPD, app usage was recommended to clients who were engaged with the tools in clinic (63.6%) and/or had access to them at home (27.3%).

Barriers to using technology

The main barriers to using telehealth and TASLT in the management of PwD and CwPD are shown in Figure 3. Whilst both groups reported a number of barriers, these differed according to the client group. For SLPs working with PwD, the most commonly reported issues included clients' lack of device ownership and lack of technical knowledge as well as lack of training for SLPs. Clinicians working with CwPD, on the other hand, indicated that their major barriers constituted a lack of devices in clinics, followed by a lack of awareness of suitable apps, no permission to put apps on NHS devices, and a lack of appropriate software and apps in general.

As well as diverse responses concerning the two client groups, further differences in barrier perception depended on whether respondents were current users of technology or not. For example, SLPs working with PwD *who used technology* reported clients' lack of device ownership and lack of technical knowledge as the most significant barriers, whereas *non-users* reported that their lack of training and not knowing what tools existed prevented them from adopting technology in their current practice. Similarly, *technology users working with CwPD*

cited a lack of relevant apps along with permission issues as the main constraint, whereas *non-users* reported lack of devices in clinics as the most limiting factor for adopting technology, followed by lack of knowledge of suitable apps.

---*Insert figure 3 about here* ---

Discussion

The use of telehealth and TASLT for the management of communication disorders in children and adults has grown considerably over the last decade, in line with general technological advances and a heightened interest on the part of clients and clinicians in using devices as part of SLP service provision. This project sought to determine the extent to which SLPs in the UK use telehealth and TASLT in the assessment and treatment of PwD and CwPD, and what barriers they face that might prevent technology adoption.

Availability of devices and their use

Access to devices is essential for using telehealth and TASLT, and our results suggest that most SLPs have various types of devices available in their clinics, including computers as well as touchscreen devices. At the same time, more than 10% of respondents had access to only one of these devices, which in some cases was either the telephone or the computer, highlighting potential differences between services regarding device access for therapeutic use. Despite the limited access for some SLPs, it is evident that the majority of respondents used technology - primarily in the form of apps - in their clinical practice, underlining the growing importance of TASLT for service delivery. However, it is also worth noting that in our survey the percentage of non-users is greater than that of SLPs reporting restricted access to devices, suggesting that availability of technology is not the only barrier to implementation, as discussed further below.

Assessment and treatment practices

There was a clear trend in using devices to support FTF assessment and treatment rather, than replacing or conducting assessment and treatment remotely using devices. This was unexpected

given the growing body of evidence in the literature for the effectiveness, reliability and validity of remote assessment (e.g. Constantinescu et al., 2010; Hill et al., 2009). There are various possibilities to explain the trend. For a start, the survey outcomes could reflect the fact that respondents had no need to assess clients remotely because they were able to attend clinic. Alternatively, it could highlight a lack of awareness of current evidence supporting the effectiveness of this means of service provision, or of appropriate technology to implement these management practices. Problems with technology, such as a lack of Wi-Fi connectivity, have been reported previously (e.g. Hill & Miller, 2012), and also emerged as relevant factors in our study. In addition, despite the favourable reports on the effectiveness of remote assessment, previous research has also identified that remote assessments have some limitations in examining more subtle features such as breathing or oromotor skills (Mashima & Doarn, 2008).

Our findings also indicate that two to three times as many clinicians employ devices during treatment than assessment, replicating findings from Hill and Miller's survey of Australian SLPs (2012). In addition, whilst nearly all respondents who used devices as part of FTF assessment for PwD agreed that they were beneficial in obtaining a quantitative record of the client's performance, only a third took audio recordings to gather baseline data and just over a quarter used devices to analyse speech. This ties in with observations by Miller and Bloch (2017), who found that only 5% of SLTs treating people with acquired dysarthria used technologies as part of their clinical assessments, either routinely or occasionally, but twice as many expressed an interest in using them. Miller and Bloch (2017) interpret this finding as evidence that the availability of technology may be more of an issue for some therapists than perceived limited value. However, given the abundant research into technology-supported assessment of speech disorders and the wide availability of acoustic analysis tools (e.g. McKechnie et al., 2018), device access cannot be the only reason for the limited use of

technology for client assessment. One possible explanation is that assessment tools still require a certain amount of skill for reliable use, as they are insufficiently automated to achieve reliable results for certain speech and voice parameters. There is therefore a case for developing more user-friendly tools. These could include recent speech technology developments such as software to estimate speech intelligibility, or fully or partially automated ways to transcribe and analyse speech (e.g. Ahmed et al., 2018; Campbell, Harel, Hitchcock, & McAllister Byun, 2017; Carmichael, 2015).

Regarding the use of technology for treatment, our respondents mostly used apps and, to a lesser degree, computer-based speech analysis software. The latter was predominantly used to treat PwD, working on various speech features such as prosody and articulation, which are commonly addressed by UK SLPs when treating adults with dysarthria (Miller & Bloch, 2017). SLPs working with CwPD reported mainly using apps that targeted minimal pairs practice, phonological awareness and listening skills. Interestingly, more than 50% of these respondents use non-targeted apps, e.g. apps designed for articulation disorders being used for phonological awareness training. Our survey did not explore in detail why this was the case. However, one reason might be that currently more apps are available for articulation practice than for phonological awareness training. Also, some aspects of intervention, such as the need for engaging picture material, score-keeping and reward mechanisms are similar for the two disorders, which allows clinicians to draw on the wider choice of apps to suit the client's needs.

These findings raise the question of what the purpose of technology use in SLP services should be. Replacing traditional paper-based games with more captivating activities to improve client engagement is an important aspect (Furlong et al., 2017; Madeira et al., 2017; Zajc, Istenič Starčič, Lebeničnik, & Gačnik, 2018). However, as a profession we also need to identify, test and implement ways to maximise the potential of technology for SLP services to address the key challenges services face such as access issues, long wait-list times, or suboptimal

treatment intensity due to limited resources. Use of telehealth and TASLT in SLP service provision has the potential to address these challenges, and will therefore play a key role in ameliorating - or even closing - the widening gap between supply and demand for SLP services. It is therefore encouraging to see that the SLPs in our study explored technology as an aid to achieving the regular intensive practice needed to effect change by promoting homework practice. However, SLPs need to be better supported in choosing the appropriate technology to achieve this. Whilst resources in the form of blogs or websites are currently available to the profession (e.g. ORCHA, 2019), these can be subjective and insufficiently comprehensive to allow informed decision making. The next step thus has to be the strengthening of the evidence-base related to technology use - in particular apps - to test their clinical benefit (e.g. Furlong et al., 2018) and to make this information readily accessible to SLPs.

Barriers

A range of barriers to using technologies were reported by SLPs at institutional, professional and client level, mirroring findings from previous surveys (ASHA, 2002; DHA, 2011; Hill & Miller, 2012; Zabiela et al., 2007). At first sight this may suggest that little has changed over the last decade in terms of tackling technological issues within the global SLP context. However, considering the substantial developments we have experienced over the last decade, it appears more likely that these barriers reflect new challenges that have arisen as a result of these significant advances. For instance, concerns over data security and privacy issues have emerged as a result of the significant increase in device ownership coupled with better Wi-Fi access (Office of Communications, 2018), and is therefore a relatively new barrier. Our surveys also found that SLPs who used technology and those who did not experienced different barriers. The main barriers for the latter group working with PwD concern professional development issues, whereas the former group perceived the main barriers as being at client level. Professional development issues were also highlighted as main barriers by paediatric non-users

including not knowing what apps would be suitable for the management of phonological delay. Technology users, on the other hand, identified external issues including permission issues and a lack of relevant apps as factors preventing them from using devices and software more widely. In other words, different priorities emerged for users and non-users of technology in addressing barriers, indicating that development is necessary at all levels to enable the implementation – and expansion – of technology use in clinical services.

Understanding the main barriers experienced by SLPs is necessary to push for change (Hill & Miller, 2012), with a focus on those issues that are amenable to alterations, such as implementing better training to improve clinicians' technological capabilities or adding technology use to curriculum guidelines. Barriers over which there is less control, such as Wi-Fi connectivity in rural areas and IT support in general, are without doubt more difficult to tackle. However, it might be possible to address some of the issues by continuing to build the evidence base related to the use of telehealth and TASLT to fully determine its effectiveness, to strengthen the negotiating position with IT departments to put appropriate systems in place to use these. As part of this, future research should focus on identifying rigorous and efficient systems and processes to navigate the quickly changing app landscape, searching for relevant apps and evaluating their clinical benefit. This calls for wider engagement between the profession, policy makers and technology communities.

As it stands, the use of technology in SLP provision in the UK appears to be largely determined by each individual clinician's knowledge and willingness to engage with technology, combined with determination to overcome institutional and client barriers at various stages of treatment. Joint efforts at individual, local, national as well as international levels will be required to tackle these challenges and effect the change needed to equip SLP services with the technological resources and skills that can benefit clients' communication.

Limitations

Our study is the first to examine the clinical use of technology in the management of acquired dysarthria and phonological delay by UK SLPs. Whilst we gained important insights, a number of limitations have to be acknowledged. First, in line with all voluntary surveys, the participants were self-selecting and technology users might have been more inclined to complete it, which could have affected the results on device availability and use. In addition, we only focused on two communication disorders, and response rates differed between the disorders with a considerably higher rate for the survey on phonological delay. We also had a higher response rate from SLPs in Scotland than would be expected based on numbers of registered SLPs. Therefore, despite a reasonably high n=126 UK SLPs completing the survey, we cannot guarantee that results are representative of all UK SLP services. This is also important in light of other potential differences between services such as level of funding and governance, which we have not established as part of our survey, but might have influenced the results of the current study. Also, in an effort to keep the surveys to a reasonable length and achieve a high response rate, we made limited use of open-ended questions. Focus group interviews of SLPs should be conducted to obtain a more comprehensive picture of potential barriers and how technology is used to e.g. encourage home practise or improve clinic attendance.

Conclusion

Technology has significant future potential and is set to continue to shape SLP practice over the coming years. This survey is the first of its kind to provide timely data on UK SLPs' current use and perception of technology for two major client groups. The results suggest variable engagement with technology across services, partly caused by lack of access to the technology itself, as well as a reliable clinical evidence base. The profession should therefore push for policy development and research that keeps pace with technological advances to ensure that SLP services form part of the technological future.

Declaration of interest

The authors report no conflicts of interests. The authors alone are responsible for the content and writing of the paper.

Word count main text: 5144; whole document: 6724

References

Ahmed, B., Monroe, P., Hair, A., Tan, C. T., Gutierrez-Osuna, R., & Ballard, K. J. (2018). Speech-driven mobile games for speech therapy: User experiences and feasibility. *International Journal of Speech-Language Pathology*, *20*(6), 644-658. doi:10.1080/17549507.2018.1513562

American Speech-Language-Hearing Association (2002). *Survey Report on Telepractice Use Among Audiologists and Speech-Language Pathologists*. Available from: http://www.asha.org/uploadedFiles/practice/telepractice/SurveyofTelepractice.pdf).

American Speech-Language-Hearing Association (2016a). *2016 SIG 18 telepractice survey results*. Available from www.asha.org.

American Speech-Language-Hearing Association (2016b). *Scope of practice in speech-language pathology*. Available from www.asha.org/policy.

American Speech-Language-Hearing Association. (2017). *Apps for speech-language pathology and practice*. Available from http://www.asha.org/SLP/schools/Applications-for-Speech-Language-Pathology-Practice/.

American Speech-Language-Hearing Association (2019). *Telepractice Overview*. Available from http://www.asha.org/Practice-Portal/Professional-Issues/Telepractice/.

Baker, E., & McLeod, S. (2011). Evidence-based practice for children with speech sound disorders: Part 1 narrative review. *Language, Speech, and Hearing Services in Schools*, *42*(2), 102-139. doi:10.1044/0161-1461(2010/09-0075)

Campbell, H., Harel, D., Hitchcock, E., & McAllister Byun, T. (2018). Selecting an acoustic correlate for automated measurement of American English rhotic production in children. *International Journal of Speech-Language Pathology*, *20*(6), 635-643. doi:10.1080/17549507.2017.1359334

Carmichael, J. (2015). Dysarthria diagnosis via respiration and phonation. In *International Conference and Workshop on Computing and Communication (IEMCON),* Institute of Electrical and Electronics Engineers (IEEE), 1-5. doi:10.1109/iemcon.2015.7344537

Constantinescu, G., Theodoros, D., Russell, T., Ward, E., Wilson, S., & Wootton, R. (2010). Assessing disordered speech and voice in Parkinson's disease: A telerehabilitation application. *International Journal of Language & Communication Disorders*, *45*, 630-644. doi:10.3109/13682820903470569

Constantinescu, G., Theodoros, D., Russell, T., Ward, E., Wilson, S., & Wootton, R. (2011). Treating disordered speech and voice in Parkinson's disease online: a randomized controlled non-inferiority trial. *International Journal of Language & Communication Disorders*, *46*, 1-16. doi:10.1258/135763306779380101

Department of Health and Aging (2011). The ehealth readiness of Australia's allied health sector. Available from http://www.health.gov.au/internet/publications/publishing.nsf/Content/ehealth-readiness-allied-toc.

Duffy, J. R. (2013). *Motor speech disorders: Substrates, differential diagnosis, and management*. St. Louis, Mo: Elsevier Mosby.

Dunkley, C., Pattie, L., Wilson, L., & McAllister, L. (2010). A comparison of rural speech-language pathologists' and residents' access to and attitudes towards the use of technology for speech-language pathology service delivery. *International Journal of Speech-Language Pathology*, *12*, 333-343. doi:10.3109/17549500903456607

Edwards, J. & Dukhovny, E. (2017). Technology Training in Speech-Language Pathology: A Focus on Tablets and Apps. *Perspectives of the ASHA Special Interest Groups, 2,* 33-48. doi:10.1044/persp2.sig10.33

Furlong, L., Erickson, S., & Morris, M. E. (2017). Computer-based speech therapy for childhood speech sound disorders. *Journal of Communication Disorders, 68,* 50-69. doi:10.1016/j.jcomdis.2017.06.007

Furlong, L., Morris, M., Serry, T., & Erickson, S. (2018). Mobile apps for treatment of speech disorders in children: An evidence-based analysis of quality and efficacy. *PloS one*, *13*(8), e0201513. doi:10.1371/journal.pone.0201513

Gačnik, M., Starčič, A.I., Zaletelj, J., & Zajc, M. (2018). User-centred app design for speech sound disorders interventions with tablet computers. *Universal Access in the Information Society*, *17*, 821-832. doi:10.1007/s10209-017-0545-9

Grogan-Johnson, S., Alvares, R., Rowan, L., & Creaghead, N. (2010). A pilot study comparing the effectiveness of speech language therapy provided by telemedicine with conventional on-site therapy. *Journal of Telemedicine and Telecare*, *16*, 134–139. doi:10.1258/jtt.2009.090608

Hill, A. J. & Miller, L. E. (2012). A survey of the clinical use of telehealth in speech-language pathology across Australia. *Journal of Clinical Practice in Speech-Language Pathology*, *14*, 110-117.

Hill, A. J., Theodoros, D. G., Russell, T. G., & Ward, E. C. (2009). The redesign and re-evaluation of an internet-based telerehabilitation system for the assessment of dysarthria in adults. *Telemedicine and e-Health*, *15*, 840-850. doi:10.1089/tmj.2009.0015

Howell, S., Tripoliti, E., & Pring, T. (2009). Delivering the Lee Silverman Voice Treatment (LSVT) by web camera: A feasibility study. *International Journal of Language and Communication Disorders*, *44,* 287-300. doi:10.1080/13682820802033968

Madeira, R. N., Mestre, V., & Ferreirinha, T. (2017). Phonological Disorders in Children? Design and user experience evaluation of a mobile serious game approach. *Procedia Computer Science, 113*, 416-421. doi: https://doi.org/10.1016/j.procs.2017.08.359

Mashima, P. A. & Doarn, C. R. (2008). Overview of telehealth activities in speech-language pathology. *Telemedicine and e-Health, 14*, 1101-1117. doi:10.1089/tmj.2008.0080

McKechnie, J., Ahmed, B., Gutierrez-Osuna, R., Monroe, P., McCabe, P., & Ballard, K. J. (2018). Automated speech analysis tools for children's speech production: A systematic literature review. *International journal of speech-language pathology*, 20(6), 583-598.

Miller, N. & Bloch, S. (2017). A survey of speech–language therapy provision for people with post-stroke dysarthria in the UK. *International Journal of Language and Communication Disorders, 52*, 800-815. doi:10.1111/1460-6984.12316

Molini-Avejonas, D. R., Rondon-Melo, S., de La Higuera Amato, C. A., & Samelli, A. G. (2015). A systematic review of the use of telehealth in speech, language and hearing sciences. *Journal of Telemedicine and Telecare, 21*(7), 367–376. doi:10.1177/1357633X15583215

Office of Communications (2019). *Statistics and facts on the communications industry*. Available from: https://www.ofcom.org.uk/about-ofcom/latest/media/facts.

ORCHA - Unlocking the power of Digital Health for the population (2019). [website]. Retrieved from https://www.orcha.co.uk/

Rodríguez, C. D. & Cumming, T. M. (2017). Employing mobile technology to improve language skills of young students with language-based disabilities. *Assistive Technology, 29*, 161-169. doi:10.1080/10400435.2016.1171810

Saz, O., Yin, S. C., Lleida, E., Rose, R., Vaquero, C., & Rodríguez, W. R. (2009). Tools and technologies for computer-aided speech and language therapy. *Speech Communication, 51*, 948-967. doi:10.1016/j.specom.2009.04.006

Shriberg, L. D. (2010). Childhood speech sound disorders: From post-behaviorism to the post-genomic era. In R. Paul & P. Flipsen (Eds.), *Speech sound disorders in children*, pp. 1–34.

Stow, C., & Dodd, B. (2005). A survey of bilingual children referred for investigation of communication disorders: A comparison with monolingual children referred in one area in England. *Journal of Multilingual Communication Disorders*, 3(1), 1-23. doi: 10.1080/14769670400009959

Theodoros, D. (2012). A new era in speech-language pathology practice: Innovation and diversification. *International Journal of Speech-Language Pathology*, *14*, 189-199. doi:10.3109/17549507.2011.639390

Theodoros, D. G., Constantinescu, G., Russell, T. G., Ward, E. C., Wilson, S. J., & Wootton, R. (2006). Treating the speech disorder in Parkinson's disease online. *Journal of Telemedicine and Telecare*, *12*, 88-91. doi:10.1258/135763306779380101

Theodoros, D. G., Hill, A. J., & Russell, T. G. (2016). Clinical and quality of life outcomes of speech treatment for Parkinson's disease delivered to the home via telerehabilitation: a noninferiority randomized controlled trial. *American Journal of Speech-Language Pathology*, *25*, 214-232. doi:10.1044/2015_ajslp-15-0005

Tindall, L. R., Huebner, R. A., Stemple, J. C., & Kleinert, H. L. (2008). Videophone-delivered voice therapy: A comparative analysis of outcomes to traditional delivery for adults with Parkinson's disease. *Telemedicine and e-Health*, *14*, 1070-1077. doi:10.1089/tmj.2008.0040

Wales, D., Skinner, L., & Hayman, M. (2017). The Efficacy of Telehealth-Delivered Speech and Language Intervention for Primary School-Age Children: A Systematic Review. *International Journal of Telerehabilitation*, *9*(1), 55–70. doi:10.5195/ijt.2017.6219

Zabiela, C., Williams, C., & Leitão, S. (2007). Service delivery in rural, remote and regional speech pathology. *Acquiring Knowledge in Speech, Language and Hearing*, *9*, 39–47.

Zajc, M., Istenič Starčič, A., Lebeničnik, M., & Gačnik, M. (2018). Tablet game-supported speech therapy embedded in children's popular practices. *Behaviour and Information Technology, 37,* 693-702. doi:10.1080/0144929x.2018.1474253

Table I

Technology use among survey respondents in % (PwD – People with Dysarthria; CwPD – Children with Phonological Delay; please note: figures for assessment and treatment denote percentages of technology users rather than the total number of survey respondents)

	PwD	Used for	CwPD	Used for
Non-users:	37%		25%	
Users:	63%		75%	
		Assessment: 43%		Assessment: 47%
		Treatment: 97%		Treatment: 82%

Table II

Areas treated by survey respondents using technology for PwD and CwPD in % (PwD – People with Dysarthria; CwPD – Children with Phonological Delay)

PwD		CwPD	
Loudness	85.7%	Articulation Therapy	57.6%
Intelligibility	78.6%	Minimal Pairs Practice	54.6%
Articulation	71.4%	Phonological Awareness	51.5%
Voice quality	64.3%	Development of Listening Skills	45.5%
Pitch	50.0%	Voice Recording	45.5%
Tempo	46.4%	Specific Phonetic Sound Cue	39.4%
		Phonetic Transcription	21.2%

Figure 1: Availability of devices reported by survey respondents in % (PwD – People with Dysarthria; CwPD – Children with Phonological Delay)

Figure 2a and b: Types of technology used by survey respondents during Face-To-Face assessment and treatment: a) PwD (People with Dysarthria) and b) CwPD (Children with Phonological Delay) in %

Figure 3: Barriers to using technology reported by survey respondents in % (PwD – People with Dysarthria; CwPD – Children with Phonological Delay; users – respondents who use technology; non-users – respondents who do not use technology)