

# A systematic review of the use of telehealth in speech, language and hearing sciences

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## Abstract

**Introduction:** We conducted a systematic literature review to investigate the domain of speech-language and hearing sciences (SLHS) in telehealth.

**Methods:** The databases used for the literature search were Web of Knowledge, Pubmed, Scopus, Embase and Scielo. The inclusion criteria consisted of papers published up to August 2014. Papers without peer-review evaluation, and those without abstracts or available full texts were excluded.

**Results:** A total of 103 papers were selected. The selected studies have focused primarily on hearing (32.1%), followed by speech (19.4%), language (16.5%), voice (8.7%), swallowing (5.8%), multiple areas (13.6%) and others (3.9%). The majority of the studies focused on assessment (36.9%) or intervention (36.9%). The use of telehealth in SLHS has been increasing in many countries, especially in the last 5 years. The country with the largest number of published studies was the United States of America (32.03%), followed by Australia (29.12%). The remaining studies were distributed in lower numbers among other countries.

**Discussion:** The advancement of information and communication technologies provides more favourable conditions for providing distance care in several areas. Most of studies concluded that the telehealth procedure had advantages over the non-telehealth alternative approach (85.5%); however, 13.6% reported that it was unclear whether the telehealth procedure had advantages. Some barriers still need to be overcome, such as technology, training, regulation, acceptance and recognition of the benefits of this practice by the public and professionals. The need for speech-language pathologists and audiologists to adapt to this new health care modality is evident.

## Keywords

Telehealth, telehealth, telerehabilitation, telemedicine, tele-education

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## Introduction

Advances in telehealth have resulted in a substantial increase in the use of technological resources for remote screening, assessment, intervention and health education in speech, language, and hearing disorders (SLHD). There is growing support from professional organizations for the use of this service delivery model because telehealth provides increased access to health care services, facilitates greater continuity of care, and reduces costs while preserving or enhancing patient outcomes.<sup>1</sup>

Both the American Academy of Audiology<sup>2</sup> and the American Speech-Language-Hearing Association<sup>3</sup> have developed position statements supporting the use of telehealth when the services are provided by a qualified provider, primarily developed for patients with limited access to health care, validated for efficacy and cost-effectiveness, and equivalent to those achieved via face-to-face (FTF) measures.<sup>4</sup>

Previous literature reviews reported that although the use of telecommunication technologies has been growing, as has the number of studies about telehealth, it is still necessary to expand its application to SLHD services and further evaluate its use. Many of the studies are not systematic reviews; they include preliminary studies or studies with limited validity and reliability and low levels of evidence.<sup>5,6</sup> Furthermore, systematic reviews regarding the use of telehealth in all speech-language and hearing

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sciences specialities in the same study are not available in the current literature.

As telehealth becomes a standard means of conducting diagnostic and treatment services in SLHD, it is essential to assure that research supports its use. The aim of this paper is to provide a systematic literature review that investigates telehealth applications within the domain of speech-language and hearing sciences.

## Methods

We conducted a systematic review following the guidelines outlined by the Cochrane Handbook.<sup>7</sup>

### Selection criteria

The selected keywords in telehealth were Teleaudiology, Teleaudiometry, Telehealth, E-health, Telemedicine and Teleducation. The keywords related to speech, language and hearing sciences were Speech-language and hearing sciences, Language, Hearing, Voice and Speech. The databases used for the literature search were Web of Knowledge, Pubmed, Scopus, Embase and Scielo. The inclusion criteria consisted of papers in English or Portuguese that were published before August 2014 and were related to any sort of telehealth applications involving speech, language and hearing sciences. Papers in other languages and those without peer-review evaluations, abstracts or complete texts were excluded.

### Abstract review

Two independent reviewers selected relevant papers based on information obtained from the titles and the abstracts according to the inclusion criteria mentioned above. If the two reviewers disagreed, they conducted a discussion to seek consensus. If the disagreement persisted, a third reviewer was consulted. If necessary, the full publication was consulted. Duplicate publications and literature reviews were excluded.

### Review of the complete papers

Four reviewers formed two pairs, and each pair independently examined the data. If the two pairs' opinions differed, a discussion was conducted to reach a consensus. Some studies were excluded during this stage because they failed to fulfil the inclusion criteria upon detailed evaluation. Data related to the following factors were obtained: (1) the study's country of origin, year of publication and journal; (2) the research specialty area (hearing, language, speech, voice, multiple areas – more than one area simultaneously – and other); (3) methodological characteristics (screening, assessment, intervention, education, and other); (4) population characteristics (sample size, gender, and diseases/conditions); (5) telehealth modes (synchronous/asynchronous/hybrid) and means of telecommunication (internet/telephone/satellite/other); (6)

whether a speech-language pathologist (SLP) or audiologist participated in data collection; (7) conclusions regarding the use of telehealth (positive: the telehealth procedure had advantages over the non-telehealth alternative approach; negative: the non-telehealth alternative approach had advantages over the telehealth procedure; inconclusive: it was unclear whether the telehealth procedure had advantages/further work is probably needed); (8) the object of the study (a comparison of telehealth and FTF measures; software or telehealth process development; telediagnosis and/or telemonitoring and/or teleintervention: the use of software or processes; evaluation of/opinions on the use of telehealth; database issues: composition/improvement of databases for telehealth; teleconsulting; teleducation; other); (9) main findings: improved quality of care (i.e. equivalent care across telehealth and FTF; the validity and reliability of assessment and diagnosis; user and clinician satisfaction), improved access to care (i.e. decreased travel, decreased delays in obtaining the required quality care or in gaining access to a specialist), cost-effectiveness (i.e. reduced costs for the patient and the health service), management changes (i.e. changing the mind-sets of the people involved and effectively managing human and organizational process), policy issues (i.e. the implementation of national policies that include telehealth); and (10) barriers to telehealth.

## Results

### Descriptive information

A total of 103 papers were selected according to the previously established criteria (Figure 1).

### Country of origin, year of publication and journal

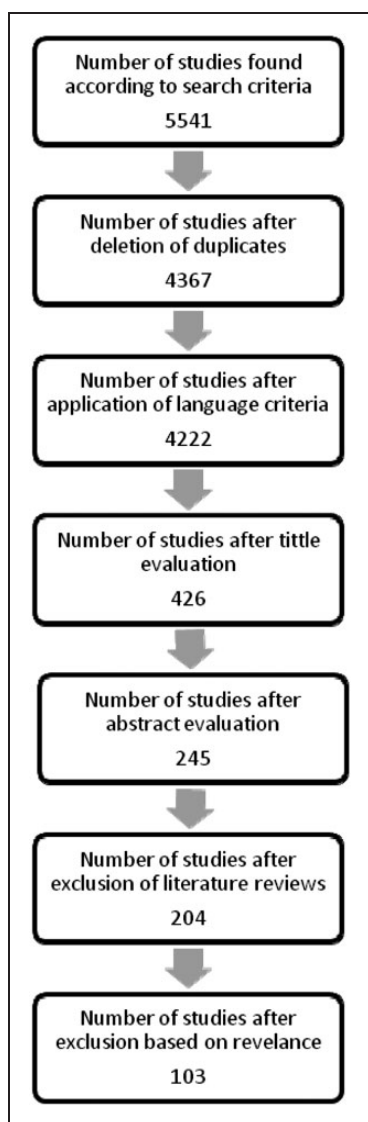
The countries with the largest number of published studies were the United States of America (32.03%) and Australia (29.12%). The remaining studies were distributed in lower numbers among other countries (Figure 2).

Most of the studies were published between 2008 and 2014 (73.7%), with the highest concentration published in 2010 (19.4%; Figure 3).

Most of the selected papers were published in journals that are not specific to telehealth (59.2%). The papers that were published in specific telehealth journals ( $n = 42$ ) were distributed as follows: 52.4% in the Journal of Telemedicine and Telecare, 42.8% in Telemedicine Journal and eHealth, 2.4% in the Journal of Medical Internet Research and 2.4% in the International Journal of Telemedicine and Applications.

### Research specialization

Most of the studies focused on hearing (32.1%), followed by speech (19.4%), language (16.5%), voice (8.7%), swallowing (5.8%), multiple areas (hearing and/or language and/or speech and/or voice: 13.6%) and others (3.9%).



**Figure 1.** Search and selection process.

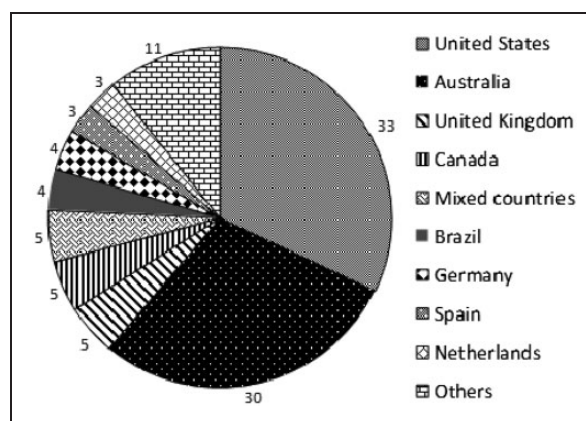
These data will be further discussed in each specific session.

### Methodological characteristics

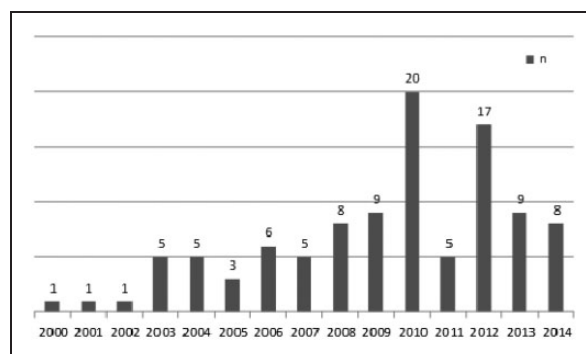
The majority of the studies focused on assessment (36.9%) or intervention (36.9%). The other studies focused on screening (8.7%), education (1%), various methodologies (including screening, assessment, intervention, monitoring and/or education: 11.6%) and others (4.9%).

### Population characteristics (sample size, gender, diseases/conditions)

Of the papers that involved human participants, the number of subjects ranged from 1 to 3830 (mean 104.69, SD = 441.1). Four of the studies (3.8%)<sup>8-11</sup> did not involve subjects because they concerned the development of telehealth proposals that were not being applied to people at the time. Most of the studies used both genders (75.7%),



**Figure 2.** Countries involved in the telehealth studies ( $n = 103$ ). If two countries were involved, the study was categorized as mixed. If a country had only one or two studies, it was categorized as "Others".



**Figure 3.** Year of publication.

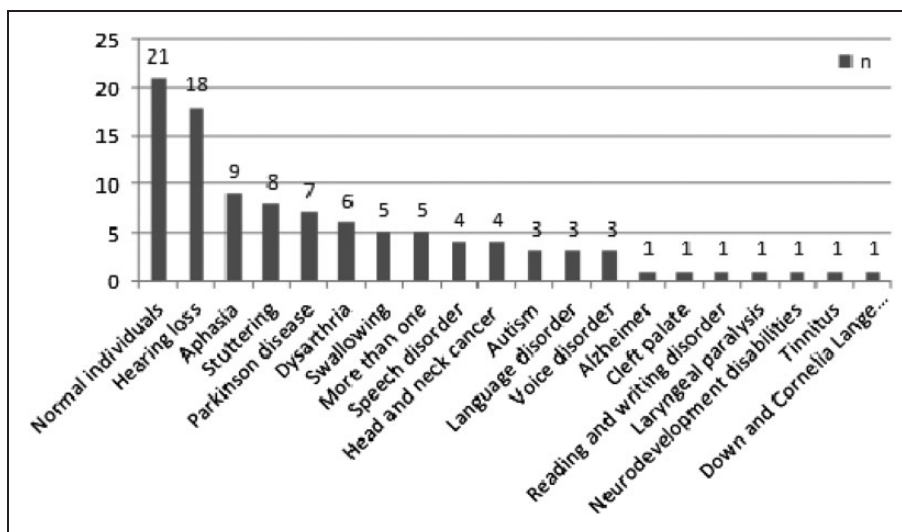
but 3.8% investigated only men. The remaining studies (16.5%) did not mention the gender of the participants.

Regarding age, the subjects were categorized as follows: children (0–12 years old), adolescents (12–17 years old), adults (18–59 years old) and the elderly (60 years and older). Thus, 54.4% of the studies focused on adults and the elderly, 26.2% focused on children and adolescents, and 5.8% focused on all age groups simultaneously; other studies (9.7%) did not mention the ages of the participants.

Regarding diseases/conditions, most of the studies focused on individuals without known disorders (20.3%), followed by those with hearing loss (17.5%), aphasia (8.7%) and stuttering (7.7%; Figure 4). These data will be further discussed in each specific area.

### Modes of telehealth and means of telecommunication

Most of the studies employed a synchronous mode (real-time interaction;<sup>4</sup> 54.3%), followed by hybrid (a process that mixed synchronous and asynchronous modes; 26.2%) and non-synchronous modes (offline or asynchronous, store-and-forward process;<sup>4</sup> 17.5%); for two of the studies, this classification did not apply.<sup>8,12</sup>



**Figure 4.** Population characteristics (diseases/conditions).

Regarding the means of communication, we found that the vast majority used the internet alone (74.8%) or combined with an additional internet-based device (14.6%), followed by a phone only (7.9%). Other telecommunications media, such as digital lines and satellite transmissions, appeared in only one study each (0.9%); one study did not describe the communication media used (0.9%), and one did not use any medium (questionnaire to assess the availability of using telehealth) (0.9%).<sup>12</sup>

#### *SLP and audiologist participation in data collection*

For most of the studies, SLPs or audiologists participated in the data collection (82.5%); 13.6% did not mention whether SLPs or audiologists were involved, and only 3.9% did not include these professionals.

#### *Conclusions regarding the use of telehealth*

Most of the studies concluded that the telehealth offered advantages over the non-telehealth procedures (85.5%), and 13.6% reported that it was unclear whether the telehealth procedure offered advantages. Only 0.9% of the selected studies concluded that the non-telehealth alternative approach offered advantages over the telehealth approach.

#### *Studies according to topic*

A summary of the study results according to topic is presented below. Complete results (including specific and detailed results by topic) according to SLHD topics are presented in the Appendix.

**Hearing.** In total, 33 papers<sup>11,13-44</sup> on hearing were selected. Most of them (63.6%) were published after 2010. Nineteen studies (57.6%) included subjects without known disorders, and one of the papers also studied

individuals with hearing loss; eight (24.2%) studied individuals with cochlear implants, five (15.2%) studied hearing aid users, and one (3%) investigated individuals with tinnitus. The main goal of the studies was to identify the presence of hearing loss. The main findings of most of the studies (93.9%) indicated a benefit of telehealth with regard to improved access to care. The cost-effectiveness was reported by 21.2% of the papers, while changes in management and policy issues were cited by only one study.

#### *Language*

Seventeen papers<sup>8,45-60</sup> on language were selected. From 2001 to 2014, there was no year with a predominant number of published papers. Among the study participants, aphasia was the most common disorder (41.2%), followed by autism spectrum disorders (17.6%). The main purposes of the studies were to evaluate satisfaction with the use of telehealth (64.7%) and to assess the use of software or remote diagnosis (64.7%); the next most common aim was the comparison between data obtained via FTF and via telehealth (58.8%).

The vast majority of the papers reported ease of access as the greatest gain from the use of telehealth. Virtual health care allows users who have no SLPs in their area or who are bedridden and have limited mobility to benefit from speech-language therapy. The participating patients and/or their parents reported that they perceived remote therapy to be as valuable as that delivered directly by a clinician.

**Speech.** Twenty papers<sup>10,61-79</sup> on speech were selected, and 55% of these were published in the last 5 years. Regarding the pathologies studied, 40% of the papers concerned stuttering, and 30% concerned dysarthria. In most of the studies, the methodological proposal focused on intervention (75%); the main objective was the comparison of



remote and FTF interactions (75%), followed by the evaluation of the satisfaction with telehealth (45%) and teleconsulting (45%). Five of the studies presented all of these purposes together.

All of the studies suggest that telehealth delivery was as efficient as FTF delivery, but was more successful and more cost-effective. The feasibility of telehealth applications in speech assessment and treatment has been documented. Overall, the patients and their families were satisfied with this mode of treatment.

**Voice.** Nine papers<sup>9,80-87</sup> on voice were selected. One (11.1%) was published more than 5 years ago. The population studied included patients with dysphonia related to Parkinson's disease (44.4%), poor vocal quality with several aetiologies (44.4%), and laryngeal paralysis (11.2%).

Most of the studies (66.6%) presented improved access to care and speech therapy professionals and the possibility of performing follow-up telemonitoring as the main findings. The studies also mentioned cost-effectiveness as a positive result; telehealth reduced costs by decreasing the need for patients to travel to access health services, decreasing the space needed to store voice samples, and permitting the internet-based transmission of samples for analysis.

**Swallowing.** Six papers<sup>88-93</sup> on swallowing were selected; all were published in the last 5 years. The studied population included patients with dysphagia; one paper (16.6%) involved subjects who were actors simulating swallowing disorders.

All studies compared the use of telehealth with FTF practice. Most of them mentioned improved quality of care for individuals with swallowing disorders. Furthermore, the studies presented as their main finding improved access to care and professionals. The studies emphasized the need for early diagnosis and intervention in cases of dysphagia, considering the associated morbidity and mortality risks.

Multiple areas (hearing and/or language and/or speech and/or voice).

Fourteen of the selected studies were classified as belonging to more than one category because they presented procedures in multiple SLHD areas.<sup>94-107</sup> Five studies (35.7%) focused on speech and language; three (21.42%) focused on hearing, speech and language; another three (21.42%) focused on swallowing and voice; two (14.28%) focused on speech and voice; and one (7.14%) focused on orofacial myology and swallowing. Most of the studies (57.14%) assessed the user's satisfaction with telehealth and found that the majority of the users felt comfortable with it.

Regarding the comparison of telehealth and FTF practice, the results suggested that online assessment is a potentially viable, feasible and reliable service. The studies mainly mentioned the improvement of access to care.

**Others.** Four studies examined disorders that were classified as "other" (4.2%) given their low frequency in our

systematic review of telehealth applications in SLHD. All of these studies were published in the last 5 years.

**Orofacial Myology.** Two studies focused on orofacial myology: one involved subjects,<sup>108</sup> and the other addressed the quality, scope and readability of websites containing information about speech therapy and orofacial functions.<sup>11</sup> In the first study,<sup>108</sup> the overall results supported the validity and reliability of internet-based screening in the studied population. In the second study,<sup>11</sup> the results showed that on average, websites that deal with orofacial functions presented standard reading clarity.

**Reading and writing disorders.** One study addressed the remote assessment of reading and writing disorders.<sup>109</sup> The overall positive results of the study support the validity and reliability of remote assessment for these disorders.

**SLPs' opinions regarding communication via telehealth.** One study discussed professional opinion regarding the use of strategies to facilitate communication via telehealth.<sup>109</sup> The residents had better and positive access to the technologies for speech-language pathology service delivery than expected for the SLPs.

### **Benefits and barriers**

The results indicated that telehealth presented advantages and barriers. All of those topics are presented separately below.

**Improved access to care.** Improved access to care was the main benefit mentioned in the studied papers (80.6%). The use of telehealth can reduce patients' driving time, make health care more accessible for patients who live in communities with few specialists, and can promote patient-centred care. Increased use of telehealth also allows providers to reach more patients. In both rural and urban areas, telehealth can be used for screening and for providing routine health care services, thus reserving limited FTF appointment times for those who need to be seen in person.

**Cost-effectiveness.** Only 12.6% of the 103 studies mentioned cost-effectiveness. The full social benefits of these initiatives are therefore unknown, making it difficult for decision-makers to compare different programmes and make informed decisions about which are worth implementing from a social perspective. Telehealth reduces the time required for health care, missed work, costly transports and unnecessary home visits. In addition, home monitoring programmes can reduce expensive hospital visits.

**Satisfaction.** The results revealed that telehealth improved the quality of care, resulting in a good level of satisfaction from the users. Parents felt comfortable or as comfortable

as they did with FTF situations when discussing matters with the therapist online, and they were satisfied or as satisfied as FTF with their level and their child's level of interaction/rapport with the therapist. For adults, remote treatment has been described as convenient; they considered that this new approach would make life easier, stressing the ease of access to quality health care. Telehealth was also considered similar to the FTF approach in most cases. The therapists determined that telehealth applications as safe as FTF for the recipient, are comparable with a FTF session and are easy to use.

**Barriers to the implementation of telehealth.** The main barriers cited were the need of more data to improve the software used; the acceptance for a new proposal for health care; internet speed; and other technological limitations. It is important to point out that 25.24% of the studies did not mention barriers to the implementation of telehealth.

## Discussion

The results of this systematic review indicated that the number of studies about telehealth applications in SLHD has increased, especially in the last 5 years.

The countries with the largest number of published studies were the United States of America and Australia. These two countries have widely dispersed populations, and service delivery via telehealth is important. The remaining studies were distributed in lower numbers among different countries.

Concerning age, most of the studies involved adults and the elderly. The small number of studies with children, especially younger children, may be due to the fact that children need a mediator to help them interact with the speech therapist at a distance and to operate the equipment. The long-distance telehealth interaction may be most suitable for children who are older than 6 years of age. Ages and education levels are also important and need to be considered.

Telehealth is essential in situations where the availability of a qualified professional is limited. This statement is relevant to care and treatment related to hearing considering the high prevalence of hearing loss and a shortage of professionals in this area. Thus, there is a need to develop teleaudiology services aimed at increasing access to hearing health care. This need is reflected by the large number of studies that aim to develop, enhance, validate or compare telehealth tools with FTF measures to improve the possibilities for patients with a hearing loss diagnosis. These studies suggested that many questions about the suitability of software programs and the cost-effectiveness of telehealth still need to be solved.

Providing language therapy to persons with language disorders is an intensive and dynamic process. However, because of cuts in health care spending, patients may not receive the necessary amount of language therapy to achieve significant gains in language abilities. In this context, the role of parents or caregivers as agents of

intervention becomes increasingly obvious, and telehealth enables professionals to train them using remote access via the internet.

The present study confirms that valid and reliable assessment of speech disorders can be achieved via telehealth and that it could be a good tool for providing access to care and long-term care. Telehealth may be useful for delivering therapy in areas that do not have adequate speech-language therapy services. It is an effective and well-appreciated service that can contribute to the quality of care in remote areas. The improvement of technology and the evaluation of assessment protocols can make patients more familiar with this mode of treatment.

The main needs that had motivated voice professionals to study the feasibility and applicability of telehealth resources in their practice are mostly related to: improving access to services related to assessing and treating voice disorders; the storage and transport of voice samples to be analysed for diagnosis; and to monitor patients' progress. The main benefits of the related studies were the possibility of quickly conducting distant vocal screening and assessment for a larger number of individuals, improving access to care and reducing the costs.

Despite some changes in the vocal signal wave after long-distance transmission, the remote assessment proposal was considered reliable and viable, even though our results highlighted the importance of conducting further studies.

The main professional needs that motivated the study of the feasibility and applicability of telehealth resources in swallowing disorders were related to improving access to services and promoting higher-quality ratings to guide diagnosis. These needs reflect the shortage of skilled professionals in the field in many regions of the world and the need for a second opinion by experts on diagnosis and treatment.

The overall results of the present systematic review indicated that telehealth activities demonstrated mainly advantages over the alternative non-telehealth approaches. Regarding the advantages, the studies predominantly showed improvements in access to care, followed by cost-effectiveness and satisfaction. In addition, some barriers to the implementation of telehealth were mentioned. Many people have inadequate or no access to a primary care provider, and access to specialty care is limited. People on a low income and those living in rural and medically underserved areas face additional economic and geographic barriers to care. Telehealth can improve access to health services, mainly for those low-income individuals, and can promote patient-centred care because it enables individuals to take more control over their own health and becomes an intrinsic part of the individual care pathway. Telehealth also allows information about such patients' health conditions to be monitored regularly so that issues can be flagged before they become 'care critical'.

Considering that cost-effectiveness analysis is a more inclusive economic evaluation method in that both costs

and programme outcomes are investigated, the vast majority of the economic evaluations of telehealth focus on cost estimates alone. Consequently, the full range of economic benefits of telehealth programmes is rarely considered and quantified. The costs associated with the new technologies raised serious questions about the sustainability of telehealth and who should bear the costs of a telehealth service.

Regarding satisfaction, the studies showed that telehealth provides great potential for supplementing traditional delivery of services and channels of communication in ways that extend therapists' ability to meet their patients' needs. The majority of the patients reported that they felt well supported in spite of not having a therapist physically present. Telehealth was also considered similar to the FTF approach in most cases, and it can facilitate access to quality health care.

Although telehealth was generally presented as an advantageous modality for health care in SLHD, the reviewed studies mentioned some barriers to its implementation. The need for more data to improve the software packages used for telehealth is linked with limitations related to developing more accurate digital measures and audio and video technologies to support remote access. It also involves costs and the need for technical support for therapists and users. Furthermore, it can be difficult to access patients' prior health conditions or medical data, resulting in a lack of important information for remote assessments and diagnosis.

Although the opinion of patients, parents and therapists regarding the use of telehealth has been in general positive and motivating, the acceptance of telehealth as an alternative to personal contact was also identified as a barrier to its implementation in some studies. Telehealth activities also require basic individual computer competence and familiarity with internet applications, as well as some cognitive and audiovisual skills. In addition, sometimes there are some difficulties with the positioning of participants in front of the web-camera; these difficulties make it difficult to gain an adequate view of the patient's face, an important requirement for distinguishing among similar-sounding phonemes in speech and language assessments, for instance, or for examining orofacial structures and functions.

Internet speed and other technological limitations were also mentioned as barriers. Some places are still limited by the lack of available high-speed internet, and problems such as difficulties in transmitting audio and video information and the risk of not successfully completing the session are faced. The challenge is to ensure that the functionality of the system is fully achieved at these low bandwidths. Other technological limitations involved the need to increase the frame rate when acquiring patients' images; this adjustment is important for guaranteeing the quality of images needed mainly for remote assessment and diagnosis in SLHD.

In conclusion, most of the studies reviewed positively evaluated the use of telehealth compared with the FTF

modality and examined cost minimization when considering the aspects related to access and quality of care. However, the studies also provide evidence of the need for additional investigations that would enable the generalization of results.

The need for SLPs and audiologists to adapt to this new modality of health care is evident. Professionals should become familiar with the available technologies for conducting clinical and diagnostic procedures and for educational and professional training activities.

Furthermore, future studies, particularly randomized controlled trials, should be conducted to provide more evidence for establishing best practices in SLHD telehealth, considering procedures related to remote screening, assessment and intervention. The development of standards and guidelines is essential for promoting the effective implementation of telehealth in SLHD. Moreover, cost-effectiveness analyses are needed to justify telehealth applications and reimbursement.

### Declaration of Conflicting Interests

The authors declare that there is no conflict of interest.

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## Appendix. Complete results according to SLHD topic

### Hearing

Thirty-three (32.1%) papers on hearing were selected. Most of them (63.6%) were published after 2010. Of the 33 papers, 19 (57.6%) had subjects without known disorders; one also studied individuals with hearing loss; eight (24.2%) studied individuals with cochlear implant; five (15.2%) studied hearing aid users; and one (3%) investigated individuals with tinnitus.

The main goal of 78.9% of the 19 papers was to identify the presence of hearing loss. To achieve this goal, seven studies (36.8%) used audiometry,<sup>14–20</sup> and four (21.05%) used a combination of audiometry and other procedures: otoacoustic emissions<sup>21</sup> or immittance/otoscopy.<sup>22–24</sup> Most of these<sup>14–21,23</sup> found substantial agreement between remote and FTF procedures and demonstrated the feasibility of telehealth for hearing screening or assessment. In two other studies,<sup>22,24</sup> the results of assessments were uploaded to a database, and remote specialists reviewed the online assessments. The authors concluded that it was feasible to integrate a mobile telehealth screening service into existing community-based services.

The other four (21.05%) studies assessed the hearing of individuals using different tests: auditory brainstem response (ABR),<sup>25</sup> otoacoustic emissions,<sup>26</sup> the speech-in-noise test<sup>27</sup> and the hearing-in-noise test.<sup>28</sup> Those studies suggested that the use of these telehealth tools is feasible for assessing hearing status online and that they obtain valid data. The results showed that interjudge and intrasubject reliability at local and remote sites were high.

In addition to those 15 papers, four papers included individuals without known disorders, but had different main objectives: two used audiometry to compare telehealth and FTF measures<sup>13,29</sup> and/or used telehealth

**Table 1.** Papers reviewed – Hearing.

Authors	Year	Studied population	Study object	Methodological characteristics	Main findings	Barriers to telehealth
Givens and Elangovan <sup>14</sup>	2003	no known disorder	comparison + development + application	assessment	improved access to care	other
Givens et al. <sup>16</sup>	2003	no known disorder	comparison + development + application	assessment	improved access to care	more data
Delb et al. <sup>26</sup>	2004	no known disorder	application + database	other – screening and follow-up	improved access to care	not cited
Eikelboom and Atlas <sup>12</sup>	2005	no known disorder	satisfaction	other – questionnaire (availability/ motivation for the use of telehealth)	cost-effectiveness	acceptance
Ribera <sup>28</sup>	2005	no known disorder	comparison + application	assessment	improved access to care	more data
Laplante-Levesque et al. <sup>42</sup>	2006	hearing loss (hearing aid users)	application	other – intervention and education	improved quality of care/improved access to care	more data
Krumm et al. <sup>21</sup>	2007	no known disorder	comparison + application	assessment	improved access to care	more data
Choi et al. <sup>15</sup>	2007	no known disorder	comparison + development + application	assessment	improved access to care	environment/difficulty
Lancaster et al. <sup>23</sup>	2008	no known disorder	comparison + application	screening	improved access to care	acceptance
Yao et al. <sup>29</sup>	2009	no known disorder	comparison + development	assessment	improved access to care/cost-effectiveness	acceptance/other
Ramos et al. <sup>36</sup>	2009	cochlear implant	comparison + application	intervention	improved access to care/improved quality of care/cost-effectiveness	more data
Seren <sup>20</sup>	2009	no known disorder	comparison + development + application	screening	improved access to care/improved quality of care/cost-effectiveness	more data
Wesarg et al. <sup>32</sup>	2010	cochlear implant	comparison + application	intervention	improved access to care/cost-effectiveness	speed/technological limitations
Wasowski et al. <sup>33</sup>	2010	cochlear implant	application + satisfaction	intervention	improved access to care/change management	not cited
McEivien et al. <sup>34</sup>	2010	cochlear implant	comparison + application	intervention	improved access to care	speed
Elliott et al. <sup>22</sup>	2010	no known disorder	application + teleconsulting	screening	improved access to care	more data

(continued)

Table 1. Continued

Authors	Year	Studied population	Study object	Methodological characteristics	Main findings	Barriers to telehealth
Yao et al. <sup>19</sup>	2010	no known disorder	comparison + development + application	assessment	improved access to care/cost-effectiveness	not cited
Swanepoel et al. <sup>13</sup>	2010	no known disorder/hearing loss	comparison + satisfaction	assessment	improved access to care	environment/more data
Swanepoel et al. <sup>17</sup>	2010	no known disorder	comparison + application	assessment	improved access to care	more data/lack of evaluation
Lundberg et al. <sup>41</sup>	2011	hearing loss (hearing aid users)	teleeducation	education	improved access to care/improved quality of care	more data
Smith et al. <sup>24</sup>	2012	no known disorder (indigenous)	application + teleconsulting	screening	improved access to care	not cited
Penteado et al. <sup>39</sup>	2012	hearing loss (hearing aid users)	application	Intervention—hearing aid fitting	policy issues/improved access to care	more data/difficulty
Henry et al. <sup>44</sup>	2012	Tinnitus	application + teleeducation	other – intervention/education	improved access to care	more data
Campos and Ferrari <sup>40</sup>	2012	hearing loss (hearing aid users)	comparison + application	intervention	improved access to care	cost/time/more data
Goehring et al. <sup>35</sup>	2012	cochlear implant	application	assessment	improved access to care	more data
Hughes et al. <sup>31</sup>	2012	cochlear implant	comparison + application	assessment	improved access to care	environment
Ramkumar et al. <sup>25</sup>	2013	no known disorder	comparison + application	assessment	improved access to care	speed
Molander et al. <sup>27</sup>	2013	no known disorder	development + application	screening	improved access to care/cost-effectiveness	not cited
Masal.ski and Kręcicki <sup>18</sup>	2013	no known disorder	comparison + development + application	screening	improved access to care	more data
Kuzovkov et al. <sup>37</sup>	2014	cochlear implant	application + satisfaction	other – intervention, satisfaction	improved access to care/improved quality of care	technological limitations
Eikelboom et al. <sup>38</sup>	2014	cochlear implant	comparison + application	intervention	improved access to care	technological limitations
Bastos and Ferrari <sup>43</sup>	2014	hearing loss (hearing aid users)	satisfaction	other – questionnaire and education	improved quality of care	more data

(continued)



Table 1. Continued

Authors	Year	Studied population	Study object	Methodological characteristics	Main findings	Barriers to telehealth
Singh et al. <sup>30</sup>	2014	no known disorder (professionals)	satisfaction	other – questionnaire (availability/motivation for the use of telehealth)	improved access to care/improved quality of care	acceptance/skills
<p>Definitions:</p> <p>Study object– comparison – telehealth versus face-to-face measures comparison;  – development – software or telehealth process development;  – application – remote diagnostics and / or telemonitoring and / or teleintervention – software or process application;  – satisfaction – assessment / satisfaction on the use of telehealth;  – database – composition / improvement of databases for telehealth;  – teleconsulting;  – teleeducation;  – other.</p> <p>Barriers to telehealth– speed – internet speed;  – cost / time – higher cost / longer time compared with face-to-face;  – environment – physical structure of the environment (acoustic isolation, lighting);  – technological limitations – hardware / technological limitations (camera, zoom, microphone, headphone, etc.);  – acceptance – difficulty of acceptance of telehealth as an alternative to personal contact (lack of physical contact, reduction of visual cues, difficulty of training of professionals involved, etc.);  – skills – interference of individual skills–use of computer / internet / telehealth (auditory skills, visual skills, reading skills, dementia, impaired concentration, cognition, etc.);  – more data – need to improve the software or the programme (telehealth) –limitations or needs more data, as well as the need to study the cost-benefit relation;  – difficulty – difficulty related to internet access / difficulty of access to the computer (either by competence or cost);  – lack of evaluation – lack of evaluation of this modality of care (telehealth);  – other – other (including: professional license for telehealth / difficulty for the remuneration of telehealth services / lack of access to medical data of the patient / comparison of different technologies);  – not cited.</p>						

**Table 2.** Papers reviewed – Language.

Authors	Year	Studied population	Study object	Methodological characteristics	Main findings	Barriers to telehealth
McCullough <sup>50</sup>	2001	Down syndrome and Cornelia Lange syndrome	application + satisfaction + teleducation	intervention	improved quality of care	cost/time
Brennan et al. <sup>46</sup>	2004	Aphasia	comparison + application	assessment	improved access to care	not cited
Johnson <sup>51</sup>	2004	deafness	application + satisfaction	assessment	improved access to care	not cited
Bongár <sup>8</sup>	2006	aphasia	development	intervention	improved access to care	not cited
Vestal et al. <sup>52</sup>	2006	Alzheimer	comparison + satisfaction + teleconsulting	assessment	improved access to care	not cited
Beveridge <sup>53</sup>	2006	aphasia	comparison + satisfaction + teleconsulting	intervention	improved access to care	not cited
Palsbo <sup>54</sup>	2007	aphasia	comparison + satisfaction + teleconsulting	assessment	improved access to care	not cited
Hill et al. <sup>45</sup>	2009	aphasia	comparison + application + satisfaction	assessment	improved quality of care	not cited
Waite et al. <sup>49</sup>	2010	language disorder	comparison + satisfaction + teleconsulting	assessment	improved access to care	not cited
Baharav and Reiser <sup>55</sup>	2010	autism	comparison + application + satisfaction + teleducation	intervention	improved quality of care	technological limitations
Turkstra et al. <sup>56</sup>	2012	language disorder	comparison + satisfaction + teleconsulting	intervention	improved access to care	skills
Vismara et al. <sup>57</sup>	2012	autism	development + application	intervention	improved access to care/ cost-effectiveness	not cited
Vismara et al. <sup>48</sup>	2013	autism	application + satisfaction + teleducation	intervention	improved quality of care	cost/time/skills
Hailey et al. <sup>58</sup>	2013	aphasia	development + application + satisfaction	assessment	improved access to care	not cited
Pearl et al. <sup>59</sup>	2014	neuro developmental disabilities	application + teleconsulting	other – assessment and intervention	improved quality of care	not cited
Constantinescu et al. <sup>60</sup>	2014	deafness	application + comparison	intervention	improved quality of care/ improved access to care	more data
Agostini et al. <sup>47</sup>	2014	aphasia	application + comparison	intervention	improved quality of care/ improved access to care	more data

Definitions as for Table 1.

**Table 3.** Papers reviewed – Speech.

Authors	Year	Studied population	Study object	Methodological characteristics	Main findings	Barriers to telehealth
Kully <sup>61</sup>	2000	stuttering	comparison + teleconsulting	intervention	improved access to care/ improved quality of care	not cited
Sicotte et al. <sup>67</sup>	2003	stuttering	comparison + satisfaction + teleconsulting comparison	intervention	improved quality of care	not cited
Theodoros et al. <sup>68</sup>	2003	dysarthria	comparison	assessment	improved access to care	technological limitations/ acceptance
Wilson et al. <sup>69</sup>	2004	stuttering	application + satisfaction	intervention	improved access to care	cost/time/acceptance
Hill et al. <sup>70</sup>	2006	dysarthria	comparison	assessment	improved access to care	speed
Waite et al. <sup>71</sup>	2006	Speech disorder	comparison	intervention	improved access to care	acceptance
Lewis et al. <sup>72</sup>	2008	stuttering	application	intervention	improved access to care	speed
Ziegler and Zierdt <sup>64</sup>	2008	dysarthria	application	assessment	improved access to care/ improved quality of care	not cited
O'Brian et al. <sup>62</sup>	2008	stuttering	comparison	intervention	improved access to care	acceptance/skills
Hill et al. <sup>65</sup>	2009	dysarthria	comparison + application + satisfaction	assessment	improved quality of care/ improved access to care	technological limitations
Koushik et al. <sup>73</sup>	2009	stuttering	comparison + satisfaction + teleconsulting	intervention	improved quality of care	other
Carey et al. <sup>63</sup>	2010	stuttering	comparison + satisfaction	intervention	improved access to care	cost/time
Grogan-Johnson et al. <sup>74</sup>	2010	Speech disorder	comparison	intervention	improved access to care	acceptance
Beijer et al. <sup>75</sup>	2010	dysarthria	comparison + development + application + database + teleconsulting	intervention	improved quality of care	not cited
Beijer et al. <sup>76</sup>	2010	dysarthria	comparison + satisfaction + teleconsulting	intervention	improved access to care	more data
Constantinescu et al. <sup>77</sup>	2010	Parkinson's disease	comparison + satisfaction + teleconsulting	intervention	improved quality of care	not cited
Whitehead et al. <sup>66</sup>	2012	cleft palate	development + application + satisfaction + teleconsulting	intervention	improved access to care/ improved quality of care	speed
Packman and Onslow <sup>10</sup>	2012	stuttering	comparison + satisfaction + teleconsulting	intervention	improved access to care	cost/ time
Grogan-Johnson et al. <sup>78</sup>	2013	speech disorder	comparison	intervention	improved access to care	acceptance
Martín-Ruiz et al. <sup>79</sup>	2013	language disorder	development + teleconsulting	screening	improved quality of care	more data

Definitions as for Table 1.

process/software development<sup>29</sup> to investigate the validity of audiometry via telehealth. One of the studies also evaluated patient satisfaction with the use of telehealth<sup>13</sup> and found that most subjects indicated a preference for automated teleaudiometry. Another study<sup>12</sup> found that the most common reasons behind a willingness to use telehealth were reducing the wait time for an appointment and cost. Regarding professionals' motivation to use telehealth,<sup>30</sup> one study reported that telehealth is likely to have a minimal effect on hearing health care but a positive effect on access to healthcare.

Eight studies with cochlear implant users (24.2%) aimed to develop and validate telehealth strategies for the remote programming or fitting of cochlear implants, to compare telehealth and FTF measures or to assess satisfaction with the use of telehealth. Overall, the authors verified the validity, feasibility and efficiency of telehealth for the remote programming/fitting of cochlear implants.<sup>31–38</sup>

Similarly, four papers (12.1%) verified the feasibility of telehealth for programming, adapting and verifying hearing aids<sup>39,40</sup> and for the guidance/counselling of hearing aid users.<sup>41–43</sup> Those studies demonstrated that these remote tools can provide important and effective alternatives when FTF services are not available.

A single study (3.0%) developed a programme for the progressive self-management of tinnitus via telephone. The authors concluded that self-reported functional limitations were reduced as a result of the intervention and that telehealth can increase the scope of specialized services.<sup>44</sup>

The main findings of most of the studies (93.9%) indicated that telehealth offered benefits with regard to improved access to care. Increased access to care is one of the primary objectives of telehealth, along with improved quality of care, which was described by 21.2% of the studies.<sup>20,30,36,37,41–43</sup> Cost-effectiveness was reported by 21.2% of the papers,<sup>12,19,20,27,29,32,36</sup> while changes in management<sup>33</sup> and policy issues<sup>39</sup> were cited by only one study each.

The main barriers cited were the need to improve software/programmes, the need to study cost-effectiveness, the acceptance of telehealth as an alternative to personal contact, internet speed, the physical structure difficulties presented by the environment, technological limitations, difficulty accessing the internet or a computer, and other factors.

### Language

The distribution of papers in the area of language followed a homogeneous distribution pattern during the study period. From 2001 to 2014, no single year had a larger number of published papers.

Regarding the study populations, people with aphasia formed the largest group (41.2%) followed by those with autism spectrum disorders (17.6%). These findings are mainly related to the fact that people with aphasia have

**Table 4.** Papers reviewed – Voice.

Authors	Year	Studied population	Study object	Methodological characteristics	Main findings	Barriers to telehealth
Mashima et al. <sup>80</sup>	2003	voice disorders	comparison + application	intervention	improved access to care	Speed/difficulty environment/more data
Wormald et al. <sup>81</sup>	2008	voice disorders	comparison + application	other – screening, assessment	improved access to care/ change management	not cited
Sáenz-Lechón et al. <sup>83</sup>	2008	voice disorders	development + database	assessment	cost-effectiveness	Skills
Tindall et al. <sup>82</sup>	2008	Parkinson's disease	comparison + application	intervention	improved access to care	not cited
Little et al. <sup>85</sup>	2009	Parkinson's disease	development + application	assessment	improved access to care/ improved quality of care	not cited
Zhu et al. <sup>84</sup>	2010	laryngeal paralysis	development + database	assessment	cost-effectiveness	more data
Xue and Lower <sup>9</sup>	2010	no known disorder	application	assessment	improved access to care	not cited
Tsanas et al. <sup>86</sup>	2010	Parkinson's disease	development + application	other – assessment, monitoring	cost-effectiveness	Skills
Tsanas et al. <sup>87</sup>	2011	Parkinson's disease	application	other – assessment, monitoring	improved access to care/ change management	not cited

Definitions as for Table 1.



**Table 5.** Papers reviewed – Swallowing.

Authors	Year	Studied population	Study object	Methodological characteristics	Main findings	Barriers to telehealth
Sharma et al. <sup>88</sup>	2011	no known disorder (actors simulating swallowing)	comparison	assessment	improved access to care	speed
Malandraki et al. <sup>89</sup>	2011	swallowing	comparison	assessment	improved access to care	Speed/other
Ward et al. <sup>90</sup>	2012	swallowing	comparison + satisfaction + teleconsulting	assessment	improved quality of care	skills
Ward et al. <sup>91</sup>	2012	swallowing	comparison + application	assessment	improved quality of care/improved access to care	more data
Malandraki et al. <sup>93</sup>	2013	swallowing	comparison + teleconsulting	assessment	improved quality of care	not cited
Ward et al. <sup>92</sup>	2014	swallowing	comparison + application	assessment	improved quality of care	skills

Definitions as for Table 1.

physical limitations that make coming to a therapy site extremely difficult or impossible.<sup>45–47</sup> Thus, the possibility of distance care is of great interest to this population.

The majority of the papers presented at least three purposes (58.8%), while one (7.1%) reported having only one purpose.<sup>8</sup> The studies' purposes varied widely, but the predominant aims were to evaluate satisfaction with the use of telehealth (64.7%) and assess the use of software or provide remote diagnosis (64.7%), and to compare the data obtained via FTF interactions and telehealth (58.8%).

The participants reported high overall satisfaction, comfort levels, and audio and visual quality in the tele-rehabilitation environment. The SLPs reported some difficulties assessing participants with severe language and cognition disorders and young children via the telerehabilitation system.

Eight studies conducted remote language assessments and compared the results with data obtained from FTF interactions.<sup>45,46,49,51,52,54,58,59</sup> All of the authors suggested that remote assessment is feasible and valid. Furthermore, very good agreement was found in the comparisons of remote and FTF assessments. High intra- and inter-rater reliability for the online assessments/interventions with adults and children supports the feasibility of telehealth in that role.

Ten papers presented data about the development of software for remote language therapy.<sup>8,47,48,50,53,55–57,59,60</sup> The results suggest that the gains made in traditional therapy can be maintained and even improved via telehealth. Patients reported increased knowledge and confidence in developing their language skills at home as a result of teletherapy. Teletherapy was shown to be an effective and reliable addition to a new era of language therapy provision.

Regarding the main findings, the vast majority of the papers (70.6%) reported ease of access as the principal

benefit of telehealth. Quality of care also appeared as one of the main findings (41.2%), with the virtual support available to parents mentioned as a major advantage.<sup>48</sup>

Regarding barriers to telehealth, most of the studies did not cite their limitations (64.7%). The barriers that were noted were the user skills (mental or physical) necessary for using the equipment (11.7%); the cost and the greater amount of time demanded from the therapist (11.7%); the need to improve the software or the telehealth programme in terms of the cost-benefit relationship and the limitations of the hardware (camera position, zoom and microphone range).

## Speech

Publications in the area of speech occurred irregularly during the 15 years studied. Among all of the studies that were included in this review, the oldest publication was in the area of speech.<sup>61</sup> The greatest concentration of papers about telehealth and speech occurred between 2008 and 2013 (70%), and 55% of the speech-related papers were published in the last 5 years. Regarding the pathologies studied, 40% of the speech studies concerned stuttering and 30% concerned dysarthria.

In most of the studies, the methodological aim was intervention (75%). The predominant main objective was the comparison of remote and FTF interactions (75%), followed by the evaluation of satisfaction with telehealth (45%) and teleconsulting (45%). Five of the studies addressed all these purposes together.

All of the studies reported positive results from using telehealth applications. Five papers<sup>61,62,65,67,77</sup> evaluated the effectiveness of conducting speech therapy via telehealth. The results were obtained through pre- and post-remote intervention assessments, questionnaires about user satisfaction and remote monitoring.<sup>61,62,77</sup>

Table 6. Papers reviewed – multiple areas.

Authors	Year	Studied population	Study object	Methodological characteristics	Main findings	Barriers to telehealth
Amir and Shabtal <sup>103</sup>	2002	other-language, speech, hearing, swallowing, developmental, information about SLP and teleconsulting	teleconsulting + other	other – screening, education	improved access to care	acceptance
Glykas and Chytas <sup>104</sup>	2004	speech disorders and learning disabilities	satisfaction	other – assessment, intervention procedures, education	improved quality of care/ improved access to care	not cited
Glykas and Chytas <sup>105</sup>	2005	speech and language disorders	satisfaction	other – screening, assessment, intervention procedures and education	improved access to care/ cost-effectiveness/change management	not cited
Giorgino et al. <sup>94</sup>	2007	aphasia – speech and language disorders	development + application	intervention	improved access to care	lack of evaluation
Ward et al. <sup>99</sup>	2007	head and neck cancer/Laryngectomy - swallowing and/or communication impairment	comparison + satisfaction + development	assessment	improved access to care	technological limitations
Parmanto et al. <sup>95</sup>	2008	speech and language disorders	development + satisfaction	intervention	improved access to care/ improved quality of care	more data
Howell et al. <sup>96</sup>	2009	Parkinson's disease - speech and voice disorders	comparison	intervention	improved access to care	speed/environment/skills/difficulty
Ward et al. <sup>100</sup>	2009	head and neck cancer/laryngectomy – swallowing and/or communication impairment	comparison + satisfaction	assessment	improved access to care	speed/technological limitations
Constantinescu et al. <sup>101</sup>	2010	Parkinson's disease – speech and language disorders	comparison	assessment	improve access to care	speed/technological limitations
Ciccia et al. <sup>102</sup>	2011	hearing loss and speech and language disorders	comparison + satisfaction + teleconsulting application	screening	improve access to care	more data/lack of evaluation
Cnossen et al. <sup>106</sup>	2012	head and neck cancer – Swallowing and/or communication impairment	application	other – monitoring	improve quality of care	not cited
Burns et al. <sup>97</sup>	2012	head and neck cancer – swallowing and/or communication impairment	application + satisfaction	intervention	improve access to care/cost-effectiveness	lack of evaluation
Constantinescu <sup>98</sup>	2012	hearing loss and speech and language disorders	satisfaction	intervention	improve access to care	not cited
Goldberg et al. <sup>107</sup>	2012	aphasia – speech and language disorders	application	other – assessment and intervention	improve access to care/ improve quality of care	more data

Definitions as for Table 1.

**Table 7.** Papers reviewed – others.

Authors	Year	Studied population	Study object	Methodological characteristic	Main findings	Barriers to telehealth
Waite et al. <sup>49</sup>	2010	reading and writing disorder	comparison	assessment	improved access to care	speed / more data
Dunkley et al. <sup>109</sup>	2010	no known disorder (facilitation of communication)	satisfaction	other – questionnaires and interviews	improved access to care	acceptance
Waite et al. <sup>108</sup>	2012	speech disorder (orofacial motricity)	comparison	assessment	improved access to care	technological limitations / more data
Corrêa et al. <sup>11</sup>	2013	web sites about orofacial functions	satisfaction + teleeducation	other – evaluation of website content	improved access to care	other

Definitions as for Table 1.

Three papers<sup>68,69,71</sup> analysed the effectiveness of speech assessment via telehealth; all of the items accessed via telehealth were considered viable and reliable by users and professionals. Three other studies<sup>64,76,79</sup> addressed the effectiveness of technologies for remote speech disorder assessment and telemonitoring. The professionals considered the technological tools efficient, reliable and valid for remote assessment.

Eight studies compared the use of telehealth applications with FTF practice: four<sup>63,66,70,78</sup> performed this comparison the feasibility of FTF and remote interactions for speech assessment and diagnosis. The authors concluded that the remote assessment was as effective as the FTF assessment. Four other studies<sup>10,72,74,75</sup> compared FTF and remote interactions to determine the feasibility of telehealth for speech therapy; and the user evaluations were positive for all of the cited proposals.

All of the studies reported user satisfaction with the results of the remote procedures. Sixteen studies<sup>10,61–65,67–72,73,75,78,79</sup> reported therapist satisfaction with the results of assessments administered before and after the remote and FTF interventions. Finally, four other studies<sup>74–77</sup> included data regarding user evaluation and satisfaction with the use of telehealth resources related to treatment. In two of these papers,<sup>66,74</sup> the satisfaction survey showed that families were satisfied with speech assessments performed using telehealth.

Telehealth has great potential to promote access to quality services in regions where there are no professionals or specialized services.<sup>62,63</sup> All of the papers considered these two issues in their results: improved access to care (55%) and improved quality of care (25%). Four studies considered both of these aspects together.<sup>61,64–66</sup>

The main barriers identified in the selected studies were the acceptance of telehealth (30%), internet speed and the cost of implementation (15% each).

## Voice

Among the nine selected studies that examined the use of telehealth in relation to voice, only one (11.1%) was published more than 5 years ago.<sup>80</sup> The population studied

included patients with dysphonia as a result of Parkinson's disease (44.4%), poor vocal quality with several aetiologies (44.4%), and laryngeal paralysis (11.2%).

Three of the studies (33.3%) compared telehealth and FTF interactions associated with assessment and telemonitoring.<sup>80–82</sup> Regarding assessment, the authors argued that remote voice systems have the potential for screening patients at-risk for voice disorders and for monitoring voice therapy patients. Positive changes on all outcomes measures were observed for both groups after they completed the rehabilitation protocol.

Two studies (22.22%) proposed the development of software for voice assessment and for storing voice samples in a database.<sup>83,84</sup> The voice sample compression system has potentially useful applications for telehealth: it reduced storage space and allowed the transmission of voice samples over narrow-band communication channels without significant loss of information that is important for detecting voice pathologies.<sup>83</sup> The feasibility of using transmission and compression protocols to develop remote voice signal data collection and assessment systems was also validated.<sup>84</sup>

Three studies (33.3%) focused on the development of software for telemonitoring and diagnosis of voice disorders in people with Parkinson's disease.<sup>85–87</sup> The results support the cost-effectiveness and viability of objective and accurate remote assessment, diagnosis and telemonitoring.

Regarding methodological characteristics, only one study (11.1%) used telehealth resources for intervention.<sup>80</sup> It compared the application of FTF voice therapy with real-time remote therapy using a videoconferencing computer system. No significant differences were found between groups for the following outcomes: perception of voice quality, acoustic changes, patient satisfaction and laryngeal changes.

The remaining studies concerned the use of telehealth for voice screening and assessment, including the development and implementation of software for this purpose. The results showed that remote voice assessment was considered reliable and viable.

Most of the studies (66.6%) presented as the main finding the improvement on the access to care and to speech therapy professionals and the possibility of performing follow-up telemonitoring. The studies also mentioned cost-effectiveness as a positive result of using telehealth for voice assessment and telemonitoring, referring to lower costs by decreasing the need for patients to travel to access health services,<sup>82</sup> decreasing the space needed for storing voice samples,<sup>83</sup> and the possibility of transmission of samples for analysis by the internet.

As barriers to the implementation of telehealth in voice, the studies mentioned: internet speed; limitations of the physical structure of the environment; difficulty related to internet access or access to the computer; the need for improvement of the software developed/implemented for use in clinical practice; and the interference of individual skills in the use of telehealth.

## Swallowing

All (100%) of the selected studies on the use of telehealth in the area of swallowing were published in the last 5 years. The population studied included patients with dysphagia (swallowing problems), and one paper (16.6%) involved actors simulating swallowing disorders.<sup>88</sup>

All of the selected studies compared the use of telehealth with FTF practice. The results of two studies revealed a high level of agreement between therapists in FTF and remote assessment across the determined swallowing assessment parameters. In addition, the results support the feasibility and clinical utility of remote systems for assessing oropharyngeal swallowing.<sup>88,89</sup>

One study included swallowing assessment and user satisfaction data regarding the use of telehealth resources for assessment activities and telemonitoring.<sup>90</sup> Although the therapists involved in the study indicated that the telehealth environment may not have been the most efficient means of assessing the particular participants in the study, all of the remote swallowing assessments were completed successfully. The results indicated that for telehealth systems to be more widely incorporated into routine clinical care, they need to have the flexibility and design capabilities to adjust for patients with swallowing disorders and varying levels of function and physical/psychological comorbidities.

Two studies (22.2%) involved the use of resources of telehealth for diagnosis and telemonitoring.<sup>91,92</sup> The first study provided evidence that using a telehealth system with specific modifications (depending on the patient's needs) and an assistant at the patient end allows clinical accuracy comparable with that of an FTF clinical assessment of dysphagia in patients with normal or mild cognitive impairment. The results of the second study revealed that clinical decisions made remotely were comparable with those made in the FTF environment, regardless of the dysphagia severity.

Finally, two of the selected studies (33.3%) also reported the use of telehealth resources for teleconsulting

between specialists in the area of swallowing disorders.<sup>90,93</sup> The results showed that asynchronous teleconsultation can improve the quality of care for patients with dysphagia. The agreement between therapists was moderate to high for most diagnostic indicators of swallowing disorders (the presence of aspiration, silent aspiration and pharyngeal residue).

As main barriers to the implementation of telehealth in the area of swallowing, the studies cited internet speed, individual computer skills, the need for improvement of the software that was developed/implemented, and the difficulty accessing patient health history data ("other").

## Multiple areas (hearing and/or language and/or speech and/or voice)

Among the selected studies, 14 (13.6%) were presented procedures in multiple areas of SLHD. It is important to stress that it is common for SLPs and audiologists to treat patients with disorders that affect functions that are classified within multiple areas of speech-language and hearing sciences at the same time. For this reason it is not correct to separate the research findings when we are facing comorbidities.

Five studies (35.7%) focused on speech and language; three (21.42%) focused on hearing, speech and language; three (21.42%) focused on swallowing and voice; two (14.28%) focused on speech and voice; and one (7.14%) focused on orofacial myology and swallowing.

Most of the studies assessed user satisfaction with telehealth (57.14%). The majority of the users felt comfortable with telehealth or as comfortable as with FTF services.<sup>95,97-99</sup> Therapists were satisfied with telehealth.<sup>98,102</sup> Regarding the functionality of the systems, the users reported that they proved extremely helpful when they contained a multitude of useful information that could be easily accessed.<sup>102,104</sup>

Five studies (35.71%) compared the use of telehealth and FTF practice. The results suggested that online assessment is a potentially viable service delivery method.<sup>99,101</sup> The feasibility, viability and reliability of speech therapy delivered online<sup>96,100,101</sup> and of low-cost videoconferencing for the screening of speech, language and hearing development were reported.<sup>102</sup> The studies mainly mentioned improved access to care.

Three studies (21.42%) discussed the results of the development of software for use in telehealth activities. The authors commented that information technologies are a promising solution for providing long-term rehabilitation at lower cost. The technology can also be used for counselling, treatment and training, and it offered improved access to care.<sup>94,95,99</sup>

Two studies (14.28%) addressed teleconsulting and telemonitoring. The results showed that telemonitoring swallowing and speech problems in an outpatient clinic was feasible.<sup>106</sup> For people with aphasia, videoconference was a viable method for remote intervention when supported by FTF intervention.<sup>107</sup>



One study (7.14%) was categorized as “other” because its aim was to evaluate the results of teleconsulting to inform individuals with speech, language and hearing disorders and to identify possible disorders. Both services analysed appeared to be equally effective.<sup>103</sup>

The studies cited the following barriers to the implementation of telehealth: the internet speed, the physical structure of the environment, hardware limitations, the difficulty accepting telehealth as an alternative to personal contact, individual computer skills, the need to improve the telehealth software that is developed/implemented, the difficulty accessing the necessary technology, and the lack of studies that assess telehealth use.

## Others

Four of the selected studies on the use of telehealth in SLHD were classified as “other” (4.2%) because they addressed issues that appeared with a low frequency in our systematic review. All of the studies in this category (100%) were published in the last 5 years.

## Orofacial myology

Two studies focused on orofacial myology; one involved subjects,<sup>108</sup> and the other addressed the quality, scope and readability of websites containing information about speech therapy and orofacial functions.<sup>11</sup>

In the first study,<sup>108</sup> the authors examined the validity and reliability of an internet-based screening of speech intelligibility and oral-motor function in children with speech disorders. Intra- and inter-rater reliability

measures were similar for the online and FTF assessments. The overall results support the validity and reliability of the internet-based screening in the studied population. In the second study,<sup>11</sup> the results showed that on average, websites that address orofacial function presented standard reading clarity.

## Reading and writing disorders

One study addressed reading and writing disorders.<sup>49</sup> The authors proposed an internet-based videoconferencing system for the assessment of children’s literacy using a battery of standardized assessments. The overall positive results of the study support the validity and reliability of assessing children’s literacy skills via telehealth. The authors indicated that future studies should focus on improving the internet speed and software to prevent the occurrence of echo during voice recordings and breaks in the audio record.

## SLPs’ opinion regarding communication via telehealth

One study discussed professional opinions regarding the use of strategies to facilitate communication via telehealth.<sup>109</sup> The results revealed a mismatch between rural SLPs’ and residents’ access to and attitudes towards the use of technology for speech-language pathology service delivery. The residents had better access to and more positive attitudes towards the technologies for speech-language pathology service delivery than the SLPs expected them to. The results highlighted the need for better communication between professionals and rural residents when planning future service delivery.