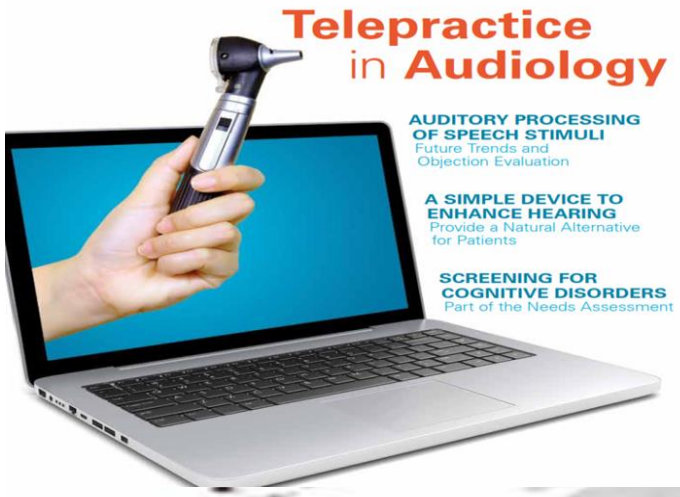
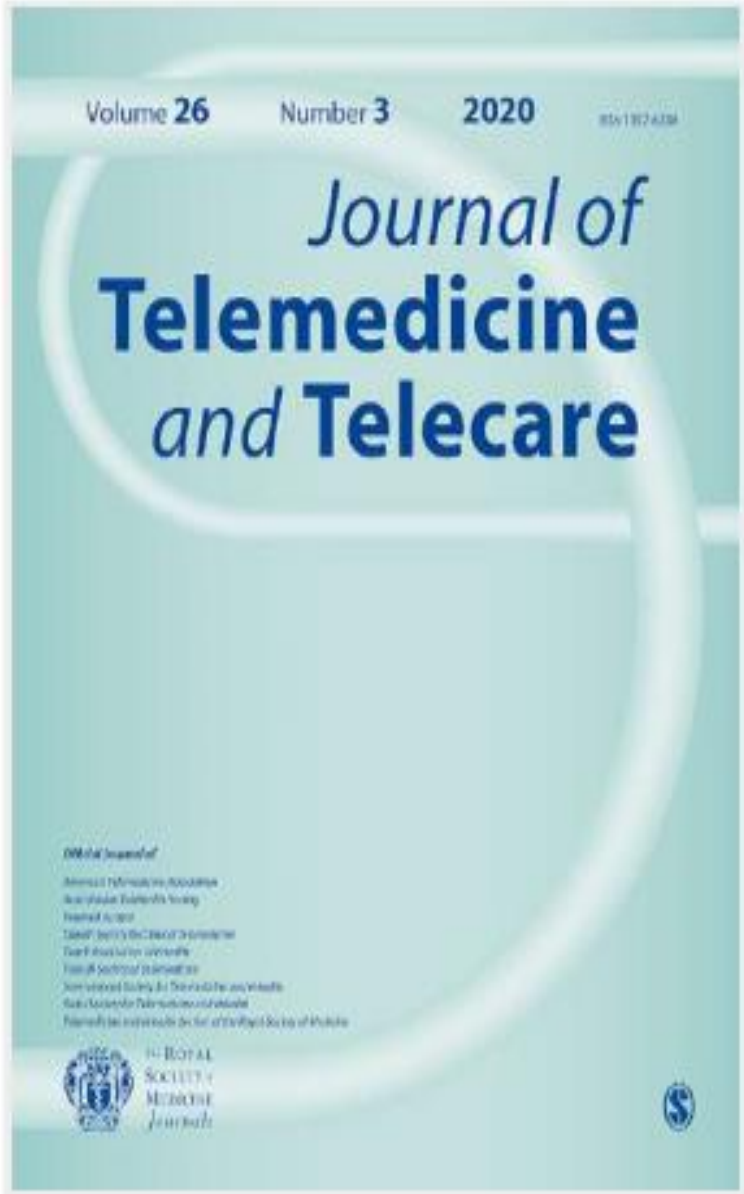


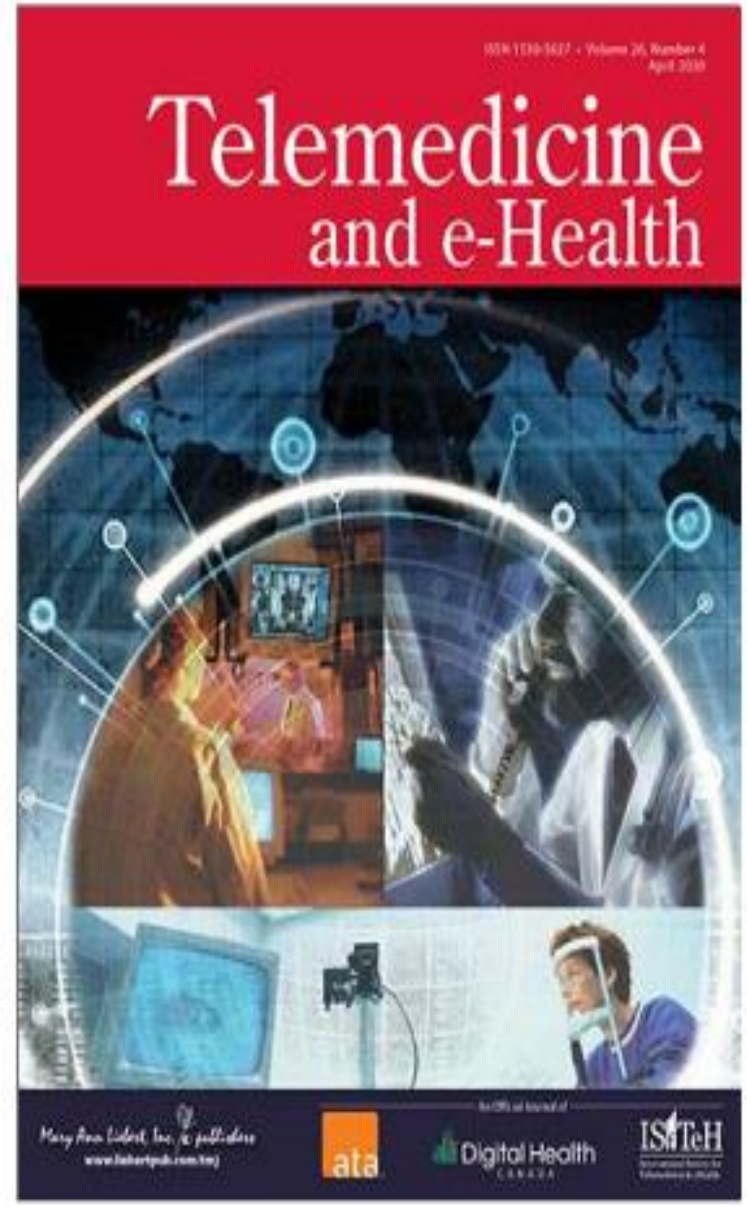

# Diagnostic Tele-Audiology

**Behieh Kohansal**

**Arak University of Medical Sciences**

# Tele-Health … Peer Reviewed Professional Journals

# A New Rationale … Telehealth in the Covid-19 Era


# Validation Research

## A Systematic Review of Telehealth Applications in Audiology

De Wet Swanepoel, Ph.D.,[1,2] and James W. Hall, III, Ph.D.[2,3]

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[3]Department of Communicative Disorders, University of Florida, Gainesville, Florida.

### Abstract

*Hearing loss is a pervasive global healthcare concern with an estimated 10% of the global population affected to a mild or greater degree. In the absence of appropriate diagnosis and intervention it can become a lifelong disability with serious consequences on the quality of life and societal integration and participation of the affected persons. Unfortunately, there is a major dearth of hearing healthcare services globally, which highlights the possible role of telehealth in penetrating the underserved communities. This study systematically reviews peer-reviewed publications on audiology-related telehealth services and patient/clinician perceptions regarding their use. Several databases were sourced (Medline, SCOPUS, and CINAHL) using different search strategies for optimal coverage. Though the number of studies in this field are limited available reports span audiological services such as screening, diagnosis, and intervention. Several screening applications for populations consisting of infants, children, and adults have demonstrated the feasibility and reliability of telehealth using both synchronous and asynchronous models. The diagnostic procedures reported, including audiometry, video-otoscopy, oto-acoustic emissions, and auditory brainstem response, confirm clinically equivalent results for remote telehealth-enabled tests and conventional face-to-face versions. Intervention studies, including hearing aid verification, counseling, and Internet-based treatment for tinnitus, demonstrate reliability and effectiveness of telehealth applications compared to conventional methods. The limited information on patient perceptions reveal mixed findings and require more specific investigations, especially post facto surveys of patient experiences. Tele-audiology holds significant promise in extending services to the underserved communities but require considerable empirical research to inform future implementation.*

### Introduction

The field of audiology encompasses prevention, assessment, and rehabilitation of hearing, auditory function, balance, and other related systems.[1,2] With an estimated 642 million people in the world affected to a mild or greater degree, and 176 million to a moderate and greater degree, hearing loss is clearly a significant global healthcare concern[1] with pervasive and far-reaching consequences. If not identified and treated early, children with hearing loss may suffer lifelong disability due to developmental delays in language, literacy, academic achievement, and social well-being.[3,4] Hearing loss in adults tends to isolate and stigmatize them, leading to poor social participation and severely restricting vocational opportunities, as evidenced by significantly higher under- and unemployment.[5] Hearing loss is therefore reported as one of the most significant contributors to the global burden of disease.[7]

Audiological diagnosis and intervention for children and adults with hearing loss offer the possibility of excellent outcomes as opposed to the negative consequences of undetected and undiagnosed hearing loss without intervention services.[8,9] The problem in providing the necessary services, however, is the shortage of audiological professionals and services in the majority of regions in the world.[10,11] Even in developed countries like the United States and Australia, rural and remote communities may not be able to access the necessary hearing healthcare services. Telehealth applications in audiology may offer some solutions to the mismatch in the apparent need for services and the limited capacity to deliver services.[12] Using information and communication technology in healthcare, as implied in telehealth,

DOI: 10.1089/tmj.2009.0171

# Terminology and Concepts

- Teleaudiology is the audiology application of telehealth
- Two general categories of teleaudiology
  - Asynchronous (store-and-forward)
  - Synchronous (real time or live)
- Teleconsultation regarding challenging patients
- Tele-education
  - Students in audiology training programs anywhere
  - Technicians
  - Audiologists
    - ✓Advanced training
    - ✓Continuing education

# ACTIVITY

Explore GooglePlay or your App store.

Type “hearing” or “hearing loss” and see what you find

Would any of these be useful to refer patients to complement your audiology services?

## Remote computing model for audiometric testing

Local consumer test site

— Webcam
— Computer
— Audiometer

Facilitator Consumer

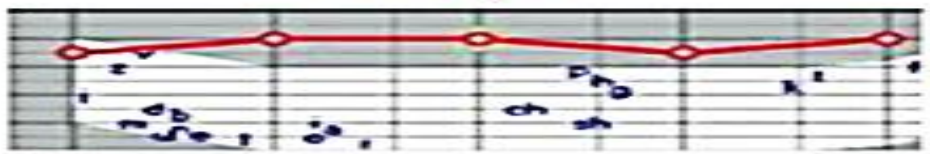
Internet/Satellite connection with remote computing software

Remote site (Regional Medical Center)

Clinician

## An asynchronous (store and forward) system

Facilitator obtains audiogram

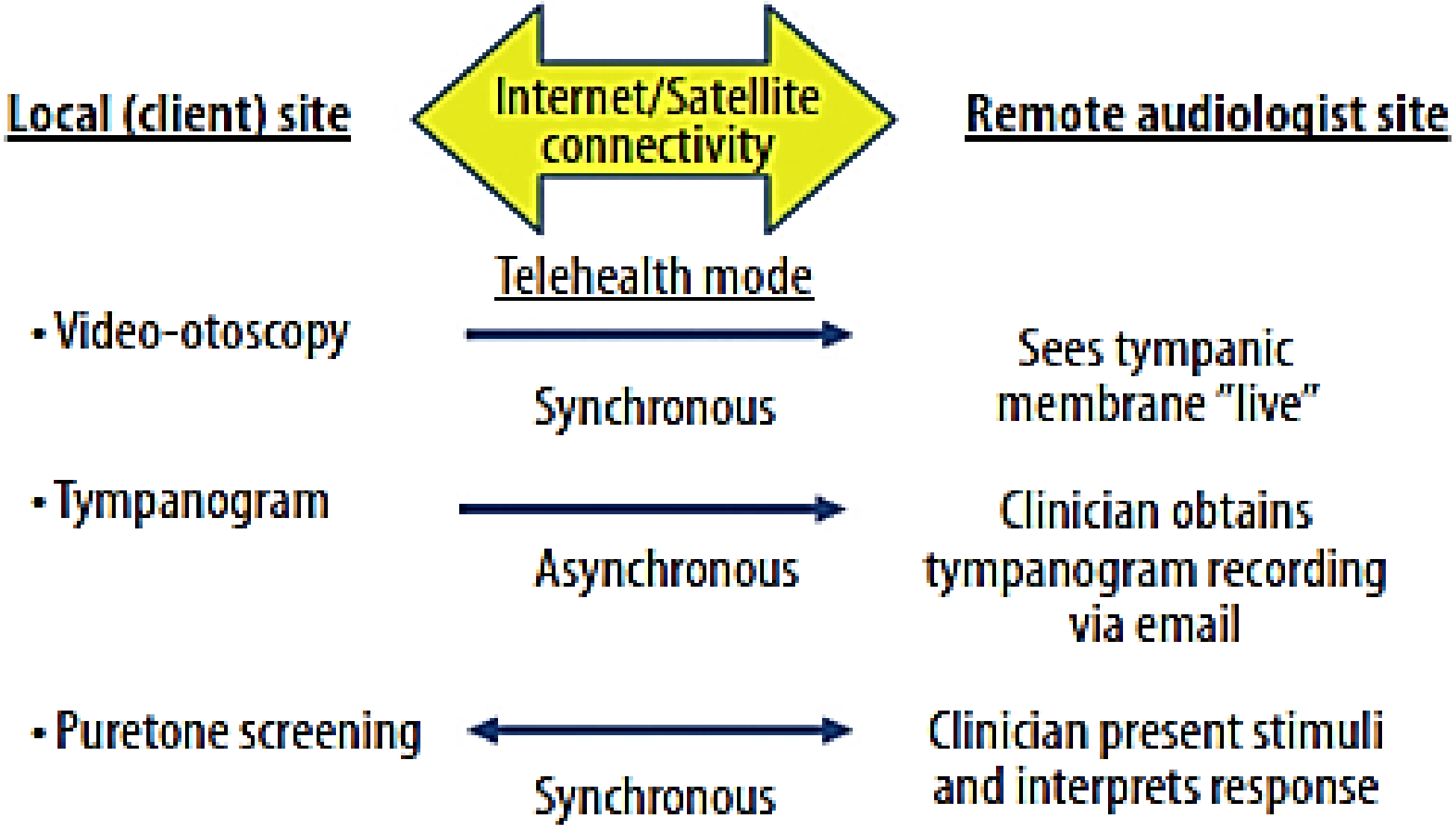


Audiogram scanned in laptop

Email audiogram sent from client site

Clinicians at regional medical center receiving email of audiogram for interpretation

# A hybrid system for school screening

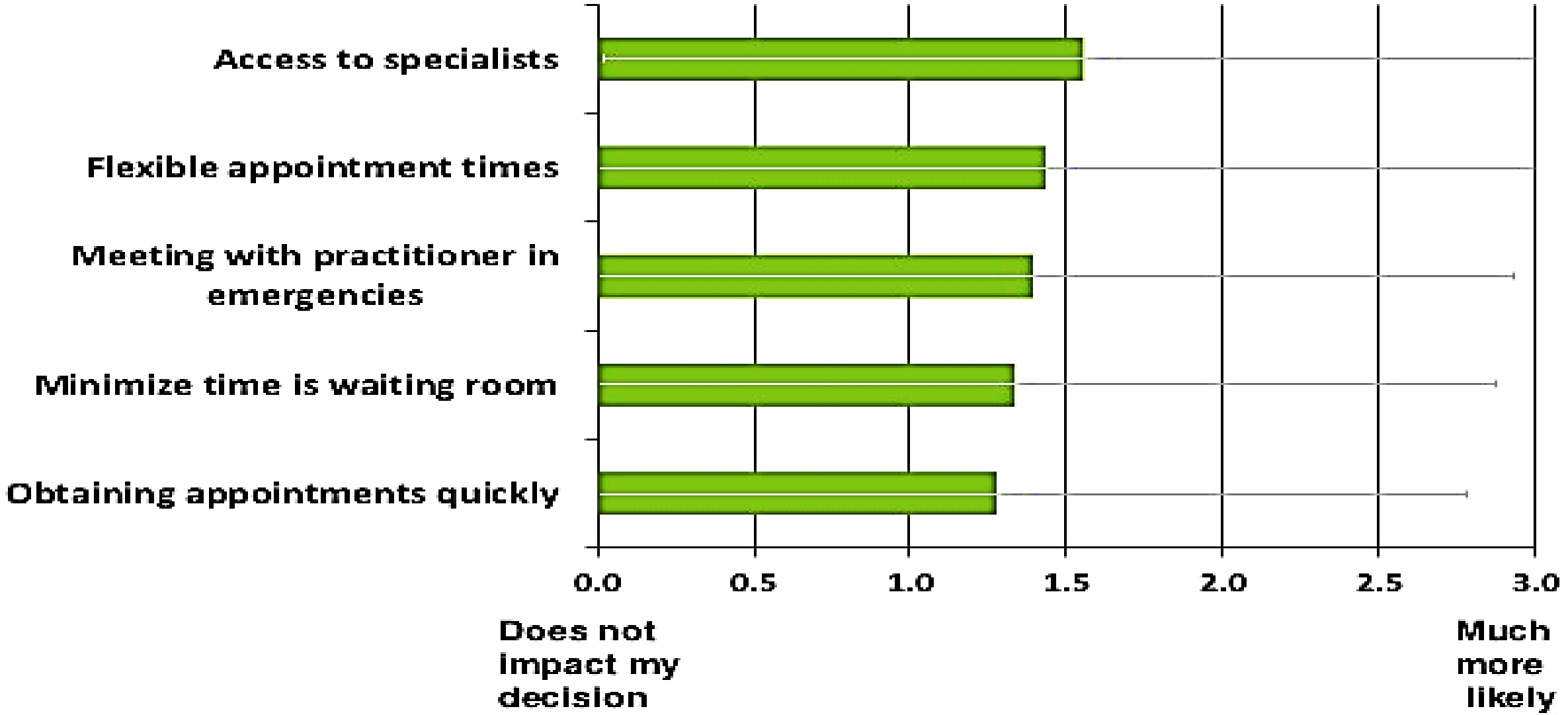


# Key Practice Considerations

# Evaluation of a Telepractice Model
## (Modified table from Rushbrooke and Houston, 2016)

| Cost/Benefit | Client | Clinician/Organization |
|---|---|---|
| **Potential Costs** | Equipment and technology needs (e.g., computer, internet) – home based | Equipment and technology needs (e.g., computer internet, agency IT) |
| | | Room hire – if to other site |
| | | Training time |
| | | Lack of reimbursement (private fee) |
| **Potential Benefits** | Access to service | No outreach travel costs |
| | Reduced travel time | Utilization of existing resources |
| | Reduced costs for travel | Integration of existing technology |
| | Reduced impact on work/education/family | Quicker delivery of troubleshooting |
| | Reduced stress | Facilitate generalization of skills into the home environment |
| | Quicker access to troubleshooting | Flexibility of service provision |
| | Generalization of skills learnt in local environment | Ease of Scheduling |
| | | Professional development |

# Factors MOST LIKELY to motivate a teleaudiology appointment



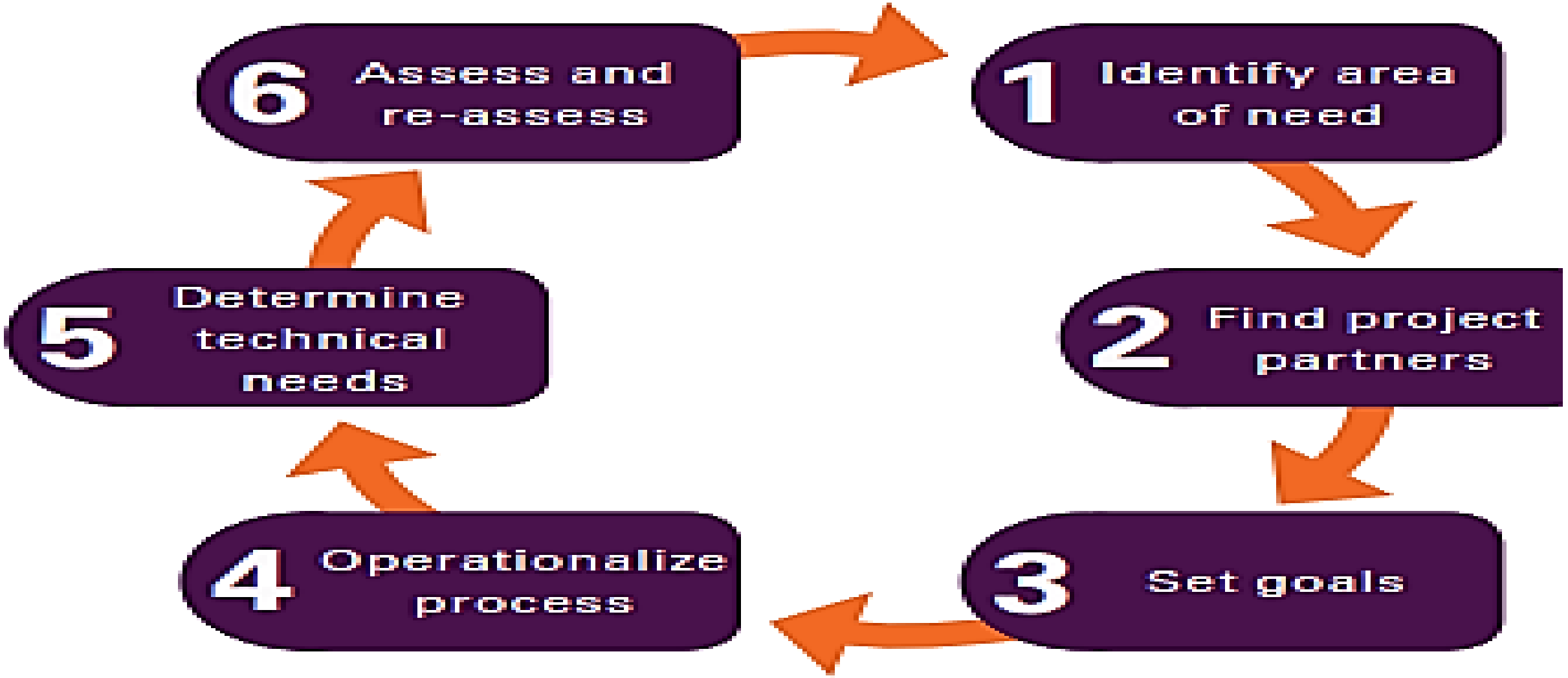



**FIGURE 1.** Six recommended steps in developing and implementing an audiology telepractice.

# Selected References – Remote Diagnostic Audiometry

**Swanepoel et al., 2010:** Automated audiometry is a reliable, accurate, and time-efficient hearing assessment for normal and hearing –impaired adults. Potential to reach underserviced areas.

**Eikelboom et al., 2013:** Validation of air- and bone-conduction assessment with automated system (AMTAS).

**Stuart, 2016:** NCHAM report: Infant diagnostic evaluations in rural settings to development of a coordinated system for the delivery of audiological evaluations for infants.

# Equipment Needs Where Patient and Facilitator are Located

- Sound Treated or Quiet Room: Ambient noise level must not exceed acceptable levels.
- High Speed Internet: Minimum requirement for high speed internet is Ping (<50ms), Download (>/= 20Mbps), Upload (>/= 3Mbps).
- USB Hub: Provides more USB connection capability for ancillary USB items, such as multiple hearing aid programming systems to be installed for use at one time.
- Electrical Surge Protector Power Strip(s): Provides more electric outlets for the multiple electronic equipment pieces and protects against electrical surges.
- Audio-Video Conferencing Platform: A HIPAA-compliant integrated video communications service using a cloud computing platform for video and audio conferencing.
- Video Conference Webcam(s): USB plug-and-play camera and speakerphone with remote control for volume and zoom features while displaying a high-definition image on the presenter's monitor.
- Additional Booth Microphone: Pending audiometer being used.
- Facilitator Headset: To communicate directly with remote provider.
- Dual Display Monitors: Preferably 22 – 24". One for displaying provider's image and one for conducting the testing. Display/screen mount bracket type depends on office layout.
- Dedicated Desktop Computer: Ideal 8.0 GB memory with i5 Core processor.
- Windows 10 Operating System: Compatible with all PC-Based equipment software requirements.
- Possible Talk-Forward Converter: Interface to allow Talk Back functionality during hearing tests under headphones.
- Keyboard and Mouse: Wireless preferred.
- PC-Based Testing Equipment as Needed: Audiometer, video otoscope, immittance bridge, REM/LSM, HIT box, etc.
- Display at Clinic Discretion: Custom-designed cabinet, table-top, and booth.

# Equipment Needs Where Remote Provider is Located

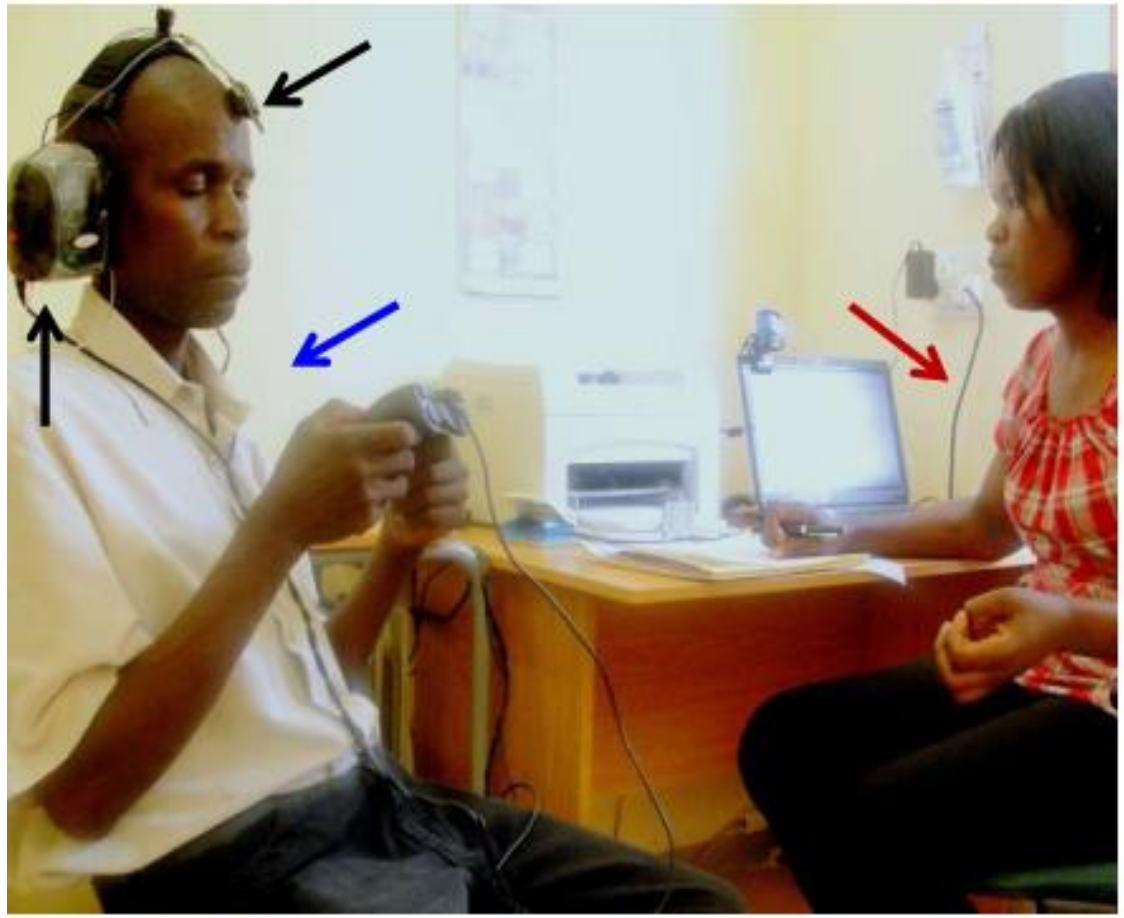
- Quiet, Well-Lit Room: Ambient noise level not to exceed acceptable levels. Natural light is best, however, can use desk lamps and overhead lights.
- Professional Background: Non-cluttered, diplomas on the wall behind provider, no distracting pictures, etc.
- Professional Appearance: White lab-coat preferred, bright shirt underneath, no distracting jewelry, etc.
- High Speed Internet: Minimum requirement for high speed internet is Ping @ <50ms, Download @ >/= 20Mbps, Upload @ >/= 3Mbps.
- Audio-Video Conferencing Platform (same as Presenting Site): A HIPAA-secure integrated video communications service using a cloud computing platform for video and audio conferencing required for conducting synchronous telehealth services.
- Additional Monitor: Preferably 22 – 24”. Allows for better visibility of audiometer controls. Display/screen mount bracket type depends on office layout.
- Laptop: Ideal 8.0 GB memory with i5 Core processor. Must have high-quality webcam.
- System Requirements: Windows 10 operating system.
- Teleconferencing Equipment: USB headset with boom mic.
- Optional Equipment: Wireless mouse and spotlight.

**In comparison to hearing screenings, full diagnostic audiometric testing is more complex. Therefore, the feasibility of remote audiometric testing for diagnostic purposes may vary from that of screenings.**

# *Technologies and Strategies … Asynchronous Teleaudiology*

- Also known as store-and-forward teleaudiology
- Probably the most commonly used technique currently
- Any type of test information, e.g.,
  - Audiogram
  - Tympanograms
  - OAE printout
  - ABR recordings
  - Video-otoscopy images
- May include findings from automated testing
- Transmitted via
  - ✓Email
  - ✓Fax
  - ✓Direct storage (e.g, DropBox; Google share drive)

# Asynchronous Teleaudiology



KUDUwave automated audiometer in rural public clinic in South Africa

- **Automated audiometer**
  - Air conduction pure tones
  - Bone conduction pure tones
- **Trained facilitator**
  - Instructs patient
  - Places earphones
  - Operates equipment
  - Contacts audiologist with questions or concerns
- **Data storage for "store-and-forward" asynchronous teleaudiology**
  - Local laptop
  - Share file software
  - Cloud storage

# *Technologies and Strategies … Synchronous Teleaudiology*

- Also known as real time or live teleaudiology
- Synchronous tele-audiology: Model 1
  - High quality interactive video (e.g., dedicated set up or laptop web camera)
  - Audiologist views and oversees facilitator provision of services
  - Audiologist intervenes to assure quality of services
  - Audiologist analyzes findings following data collection
- Synchronous tele-audiology: Model 2
  - Audiologist remotely controls typical clinical test equipment using
    - ✓Internet connection
    - ✓Application sharing software
  - Technician test skills and training are not important

# Example of Synchronous Technology Set Up
## ( Krumm M & Syms MJ. Teleaudiology. Otolaryngol Clinics North America, 44, 2011)

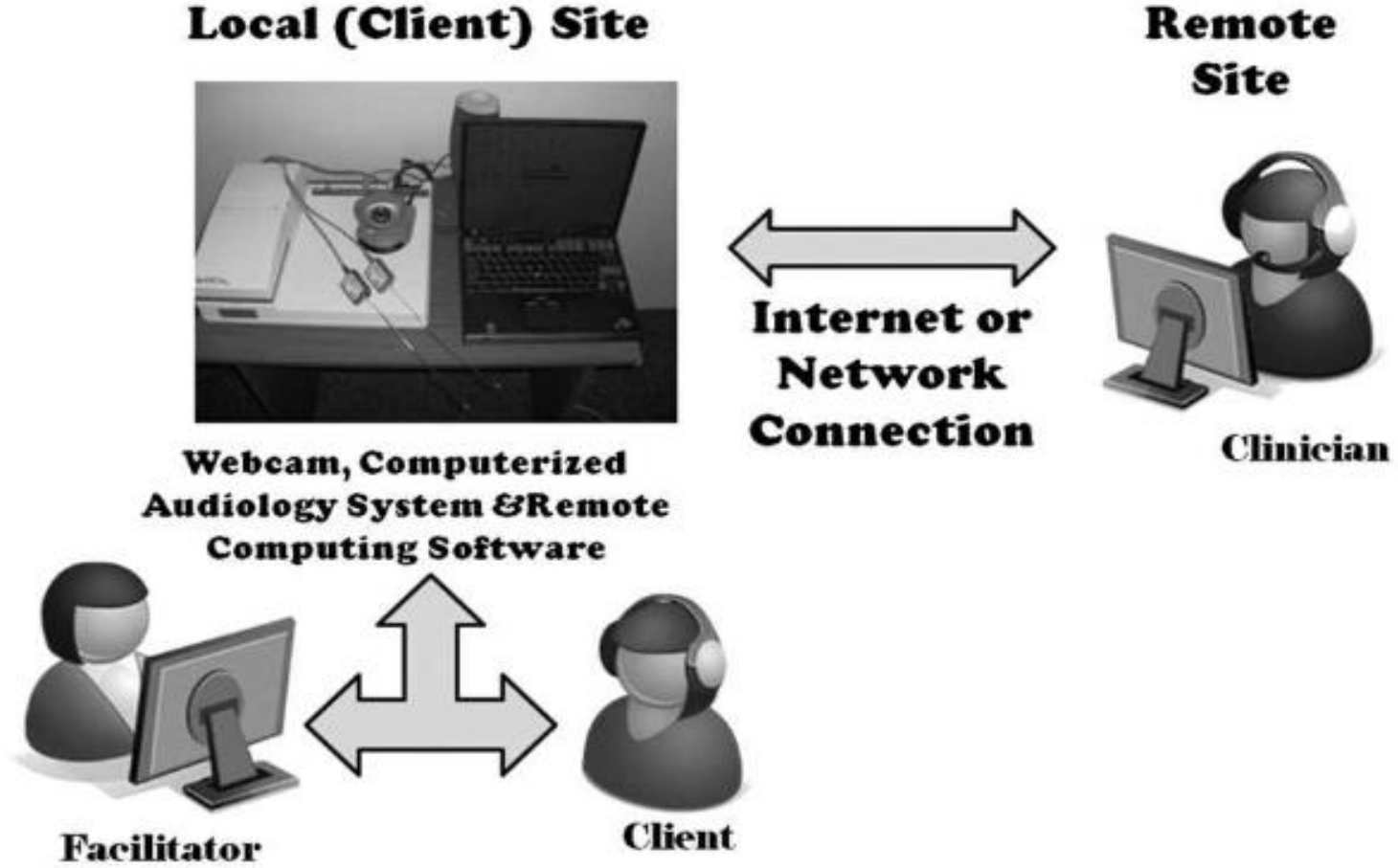



**Fig. 1.** A synchronous hearing test system.

# *Synchronous Teleaudiology Equipment Requirements*

- **Equipment for synchronous audiologist remote-controlled tele-audiology diagnostic evaluation**
  - **Audiology test equipment at patient venue**
  - **Two laptops**
  - **Two video conferencing units**
  - **Audiologist controls panning and zooming with camera**
  - **Two internet connections**
  - **Desktop sharing software**
  - **Constant real-time images**
  - **Adjustable audio**

- Store-and-forward teleaudiology may involve audiologist analysis and reporting on data collected by a facilitator for this (these) clinical service (s)

  A. Pure tone audiometry
  B. OAEs
  C. Aural immittance measurements
  D. All of the above

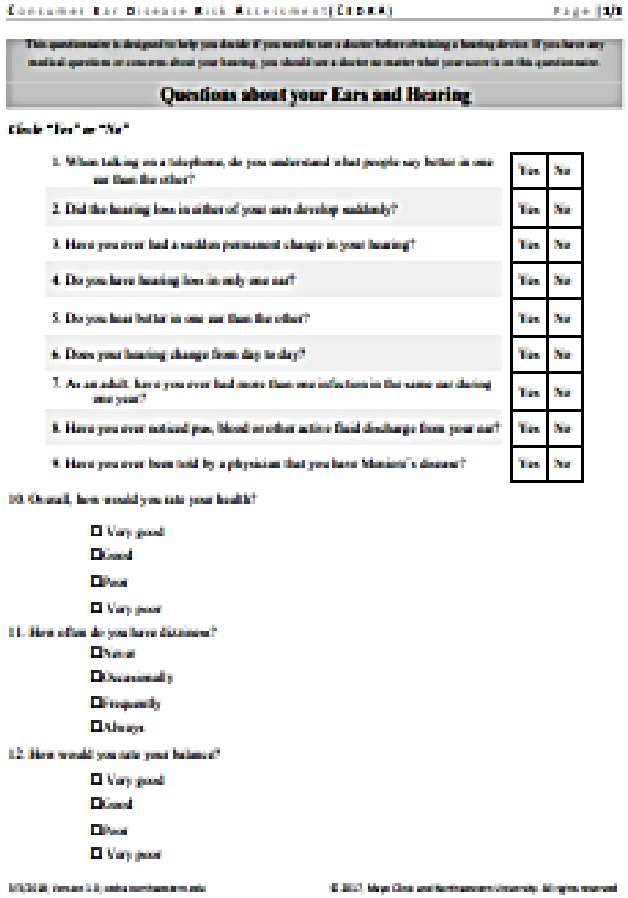
- **Research published in peer reviewed journals confirms validation of all of the following audiology services EXCEPT**

  **A. Diagnostic hearing assessment**
  **B. Vestibular assessment**
  **C. Cochlear implant programming**
  **D. Cerumen management**

# Patient history

## CEDRA – Consumer Ear Disease Risk Assessment

### *History and Ruling Out Pathology and Diseases … CEDRA*



Consumer Ear Disease Risk Assessment (CEDRA) Page | 1/3

This questionnaire is designed to help you decide if you need to see a doctor before obtaining a hearing device. If you have any medical questions or concerns about your hearing, you should see a doctor no matter what your score is on this questionnaire.

**Questions about your Ears and Hearing**

**Circle "Yes" or "No"**

| | | |
|---|---|---|
| 1. When talking on a telephone, do you understand what people say better in one ear than the other? | Yes | No |
| 2. Did the hearing loss in either of your ears develop suddenly? | Yes | No |
| 3. Have you ever had a sudden permanent change in your hearing? | Yes | No |
| 4. Do you have hearing loss in only one ear? | Yes | No |
| 5. Do you hear better in one ear than the other? | Yes | No |
| 6. Does your hearing change from day to day? | Yes | No |
| 7. As an adult, have you ever had more than one infection in the same ear during one year? | Yes | No |
| 8. Have you ever noticed pus, blood or other active fluid discharge from your ear? | Yes | No |
| 9. Have you ever been told by a physician that you have Meniere's disease? | Yes | No |

10. Overall, how would you rate your health?

- ☐ Very good
- ☐ Good
- ☐ Poor
- ☐ Very poor

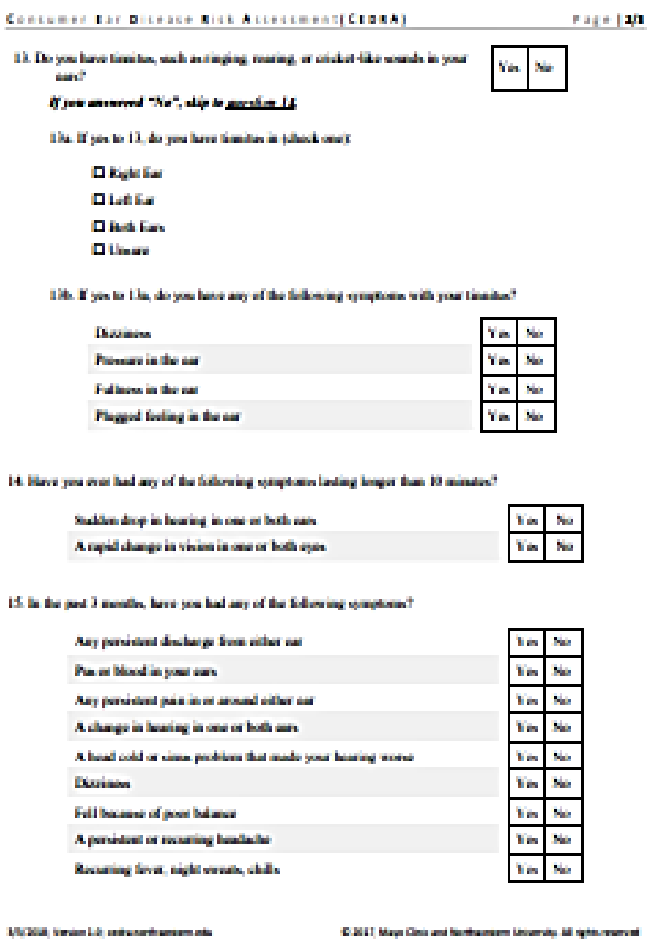
11. How often do you have dizziness?

- ☐ Never
- ☐ Occasionally
- ☐ Frequently
- ☐ Always

12. How would you rate your balance?

- ☐ Very good
- ☐ Good
- ☐ Poor
- ☐ Very poor





Consumer Ear Disease Risk Assessment (CEDRA) Page | 2/3

13. Do you have tinnitus, such as ringing, roaring, or cricket-like sounds in your ears?

| Yes | No |
|---|---|

*If you answered "No", skip to question 14.*

13a. If yes to 13, do you have tinnitus in (check one):

- ☐ Right Ear
- ☐ Left Ear
- ☐ Both Ears
- ☐ Unsure

13b. If yes to 13a, do you have any of the following symptoms with your tinnitus?

| | | |
|---|---|---|
| Dizziness | Yes | No |
| Pressure in the ear | Yes | No |
| Fullness in the ear | Yes | No |
| Plugged feeling in the ear | Yes | No |

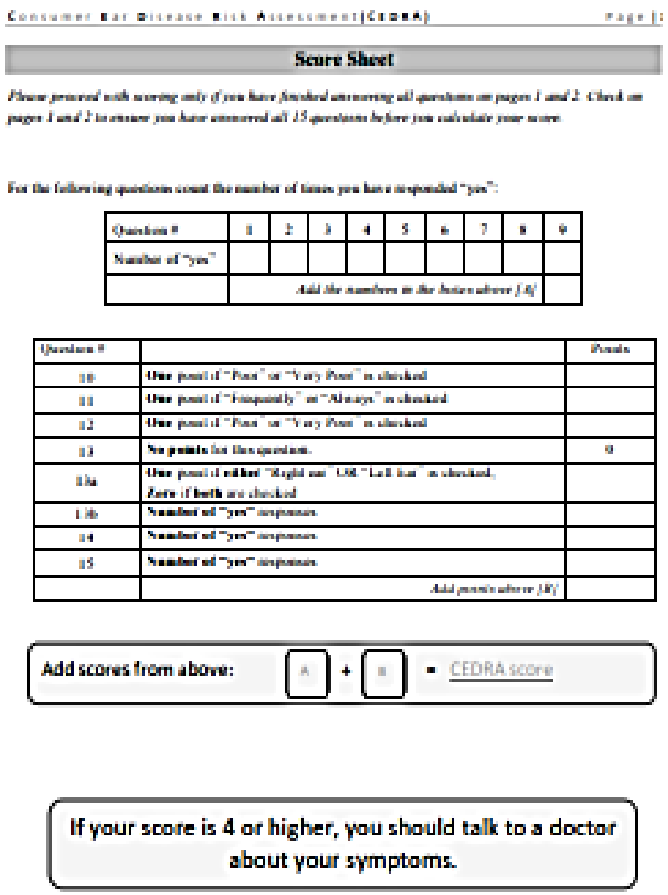
14. Have you ever had any of the following symptoms lasting longer than 10 minutes?

| | | |
|---|---|---|
| Sudden drop in hearing in one or both ears | Yes | No |
| A rapid change in vision in one or both eyes | Yes | No |

15. In the past 3 months, have you had any of the following symptoms?

| | | |
|---|---|---|
| Any persistent discharge from either ear | Yes | No |
| Pus or blood in your ears | Yes | No |
| Any persistent pain in or around either ear | Yes | No |
| A change in hearing in one or both ears | Yes | No |
| A head cold or sinus problems that made your hearing worse | Yes | No |
| Dizziness | Yes | No |
| Fell because of poor balance | Yes | No |
| A persistent or recurring headache | Yes | No |
| Recurring fever, night sweats, chills | Yes | No |





Consumer Ear Disease Risk Assessment (CEDRA) Page | 3

**Score Sheet**

*Please proceed with scoring only if you have finished answering all questions on pages 1 and 2. Check on pages 1 and 2 to ensure you have answered all 15 questions before you calculate your score.*

For the following questions count the number of times you have responded "yes":

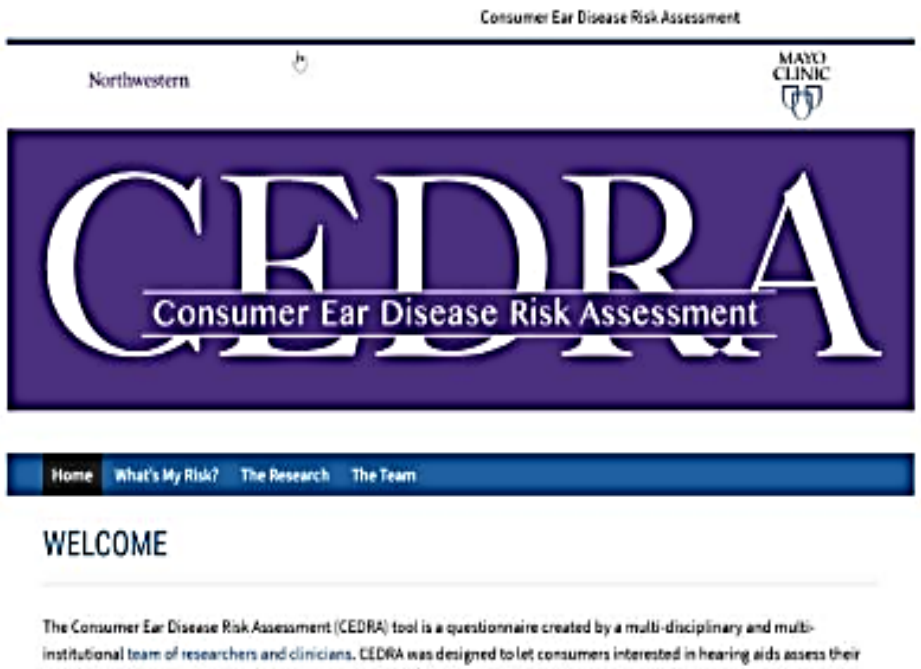
| Question # | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| Number of "yes" | | | | | | | | | |
| | *Add the numbers in the boxes above (A)* | | | | | | | | |

| Question # | | Points |
|---|---|---|
| 10 | **One** point if "Poor" or "Very Poor" is checked | |
| 11 | **One** point if "Frequently" or "Always" is checked | |
| 12 | **One** point if "Poor" or "Very Poor" is checked | |
| 13 | **No points** for this question. | 0 |
| 13a | **One** point if **either** "Right ear" OR "Left Ear" is checked. **Zero** if **both** are checked | |
| 13b | **Number of "yes"** responses. | |
| 14 | **Number of "yes"** responses. | |
| 15 | **Number of "yes"** responses. | |
| | *Add points above (B)* | |

Add scores from above: [ A ] + [ B ] = CEDRA score

If your score is 4 or higher, you should talk to a doctor about your symptoms.

https://cedra.northwestern.edu





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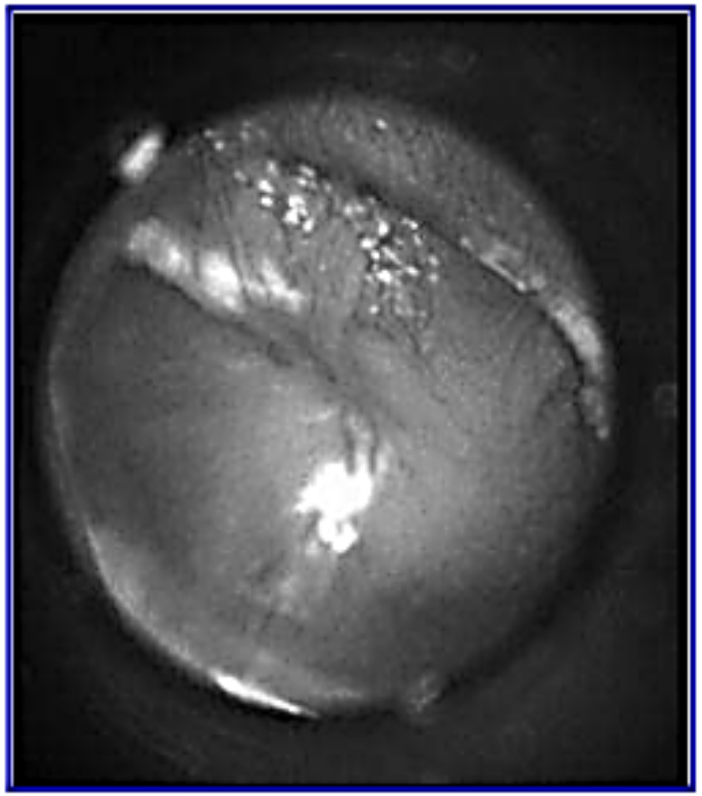
- Kleindienst, S. J., Zapala, D. A., Nielsen, D. W., Griffith, J. W., Rishiq, D., Lundy, L., & Dhar, S. (2017). Development and Initial Validation of a Consumer Questionnaire to Predict the Presence of Ear Disease. *JAMA Otolaryngology–Head & Neck Surgery*. https://doi.org/10.1001/jamaoto.2017.1175

# otoscopy

# Remote Otoscopy (www.nlm.nih.gov = >25 publications)

**Biagio L, Swanepoel D, Adeyemo A, Hall JW III & Vinck B (2013). Asynchronous video-otoscopy with a telehealth facilitator. Telemedicine & e-Health, 19, 3-6**



Video Otoscopy
(Acute Otitis Media)

**Table 2. Otologic Diagnoses Made Using Face-to-Face Otoscopy and Asynchronous Otoscopy Using Video-Otoscopic Images Acquired by an Otolaryngologist and a Clinic Facilitator ($n$=120 Ears)**

| | OTOSCOPY (%) | OTOLARYNGOLOGIST IMAGES (%) | FACILITATOR IMAGES (%) |
|---|---|---|---|
| Normal | 76.2 | 72.5 | 62.5 |
| Wax in canal | 12.3 | 10.8 | 15.0 |
| Chronic suppurative otitis media | 5.7 | 5.0 | 4.2 |
| Otitis media with effusion | 3.3 | 4.2 | 5.8 |
| Exostosis | 0.8 | 1.7 | 0.8 |
| Foreign body in canal | 0.8 | 0.8 | 0.8 |
| Otomycosis | 0.8 | 0.8 | 0.8 |
| Image not reliable to make diagnosis | NA | 4.2 | 10.0 |

NA, not applicable.

# Remote Otoscopy

Biagio et al (2014). Video-otoscopy recordings for diagnosis of childhood ear disease using telehealth at primary care level. J Telemed Telecare

# Assessment pure tone audiometry

# Remote Synchronous Hearing Assessment by An Audiologist

*Photo taken at the Featured Session on Tele-Audiology at AudiologyNOW! 2009 shows Hall at a computer performing pure-tone audiometry on a woman in rural South Africa, who can be seen on the screen, along with the test results. At the podium is Dirk Koekemoer, MD, a South African physician and self-described "social entrepreneur."*

**Tester in Dallas Texas, USA**
**Patient in rural South Africa**
**2009 AAA Convention**

**Equipment:**
**KUDUwave Automated Audiometer**

# Online Patient Guided Hearing Assessment with Apps

- uHear
- AudCal
- Mimi
- hearX



Review

## Validated Smartphone-Based Apps for Ear and Hearing Assessments: A Review

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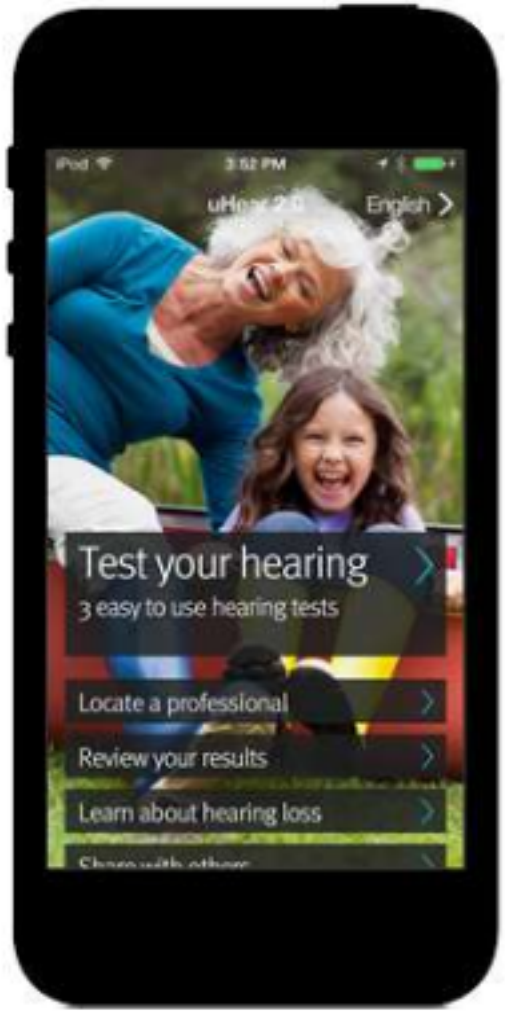

# Automated Audiometry

Figure 1. KUDUwave 5000 audiometer (GeoAxon, South Africa) Type 2 clinical audiometer. Hardware encapsulated in the earcups with USB power from notebook and USB response button. Insert earphones covered by circumaural earcups for additional passive attenuation and microphones on the outside of each earcup for active monitoring of environmental noise levels during testing.

Figure 3. Patient being tested with the KUDUwave audiometer at a pilot hearing telehealth clinic in South Africa. He is holding a response button connected to the audiometer. The notebook computer uploads all test information to a secure server using a 3G cellular Internet connection for asynchronous interpretation.

# Speech audiometry

## Speech Audiometry

INTERNATIONAL JOURNAL OF AUDIOLOGY
2018, VOL. 57, NO. 8, 561–569
https://doi.org/10.1080/14992027.2018.1463465

ORIGINAL ARTICLE

### Modernising speech audiometry: using a smartphone application to test word recognition

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**ABSTRACT**

**Objective:** This study aimed to develop and assess a method to measure word recognition abilities using a smartphone application (App) connected to an audiometer.

**Design:** Word lists were recorded in South African English and Afrikaans. Analyses were conducted to determine the effect of hardware used for presentation (computer, compact-disc player, or smartphone) on the frequency content of recordings. An Android App was developed to enable presentation of recorded materials via a smartphone connected to the auxiliary input of the audiometer. Experiments were performed to test feasibility and validity of the developed App and recordings.

**Study sample:** Participants were 100 young adults (18–30 years) with pure tone thresholds ≤15 dB across the frequency spectrum (250–8000 Hz).

**Results:** Hardware used for presentation had no significant effect on the frequency content of recordings. Listening experiments indicated good inter-list reliability for recordings in both languages, with no significant differences between scores on different lists at each of the tested intensities. Performance-intensity functions had slopes of 4.05%/dB for English and 4.75%/dB for Afrikaans lists at the 50% point.

**Conclusions:** The developed smartphone App constitutes a feasible and valid method for measuring word recognition scores, and can support standardisation and accessibility of recorded speech audiometry.

**ARTICLE HISTORY**
Received 17 November 2017
Revised 10 January 2018
Accepted 2 April 2018

**KEYWORDS**
Speech perception; tele-audiology; mobile health; word recognition; speech audiometry

**Abbreviations:** ANOVA: analysis of variance; App: application; CD: compact disc; CID: Central Institute for the Deaf; CV: consonant-vowel; CVC: consonant-vowel-consonant; dB HL: decibel hearing level; FFT: fast fourier transform; FVEWA: Foneties Verteenwoordigende Eenlettergrepige Woordlyste in Afrikaans; ISI: interstimulus intervals; mHealth: mobile health; MLV: monitored live voice; NH: normal-hearing; PI function: performance-intensity function; PTA: pure tone average; RMSE: root-mean-square-error; SRT: speech reception threshold; VU-metre: volume units metre



# Speech Audiometry

Taylor & Francis
Taylor & Francis Group

International Journal of Audiology 2016; 55: 405–411

International Journal of Audiology

Original Article

## Development and validation of a smartphone-based digits-in-noise hearing test in South African English

Jenni-Marí Potgieter[1], De Wet Swanepoel[1,2,3,4], Hermanus Carel Myburgh[5], Thomas Christopher Hopper[5] & Cas Smits[6]

*[1]Department of Speech-Language Pathology and Audiology, University of Pretoria, South Africa, [2]Callier Center for Communication Disorders, University of Texas, Dallas, USA, [3]Ear Sciences Centre, School of Surgery, University of Western Australia, Nedlands, Australia, [4]Ear Science Institute Australia, Subiaco, Australia, [5]Department of Electrical, Electronic and Computer Engineering, University of Pretoria, South Africa, and [6]Department of Otolaryngology – Head and Neck Surgery, Section Ear & Hearing and EMGO Institute for Health and Care Research, VU University Medical Center, Amsterdam, The Netherlands*

- Recent research published in peer reviewed journals has validated teleaudiology for hearing assessment including pure tone audiometry and speech audiometry with which one of the following devices

A. Flip phone
B. Smartphone
C. Otoscope
D. Tuning fork

# Otoacoustic emissions

## ( Krumm M & Syms MJ. Teleaudiology. Otolaryngol Clinics North America, 44, 2011)

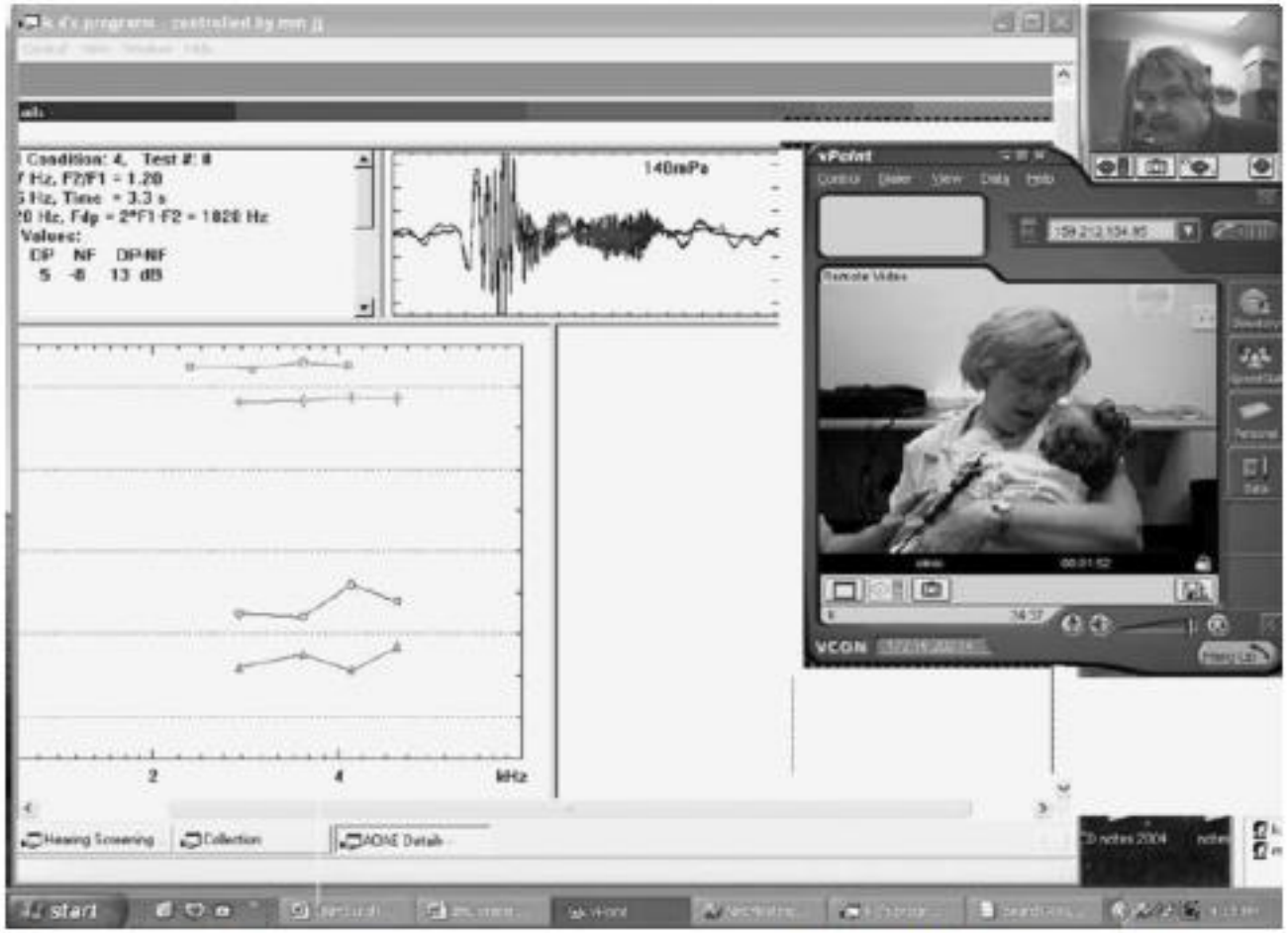
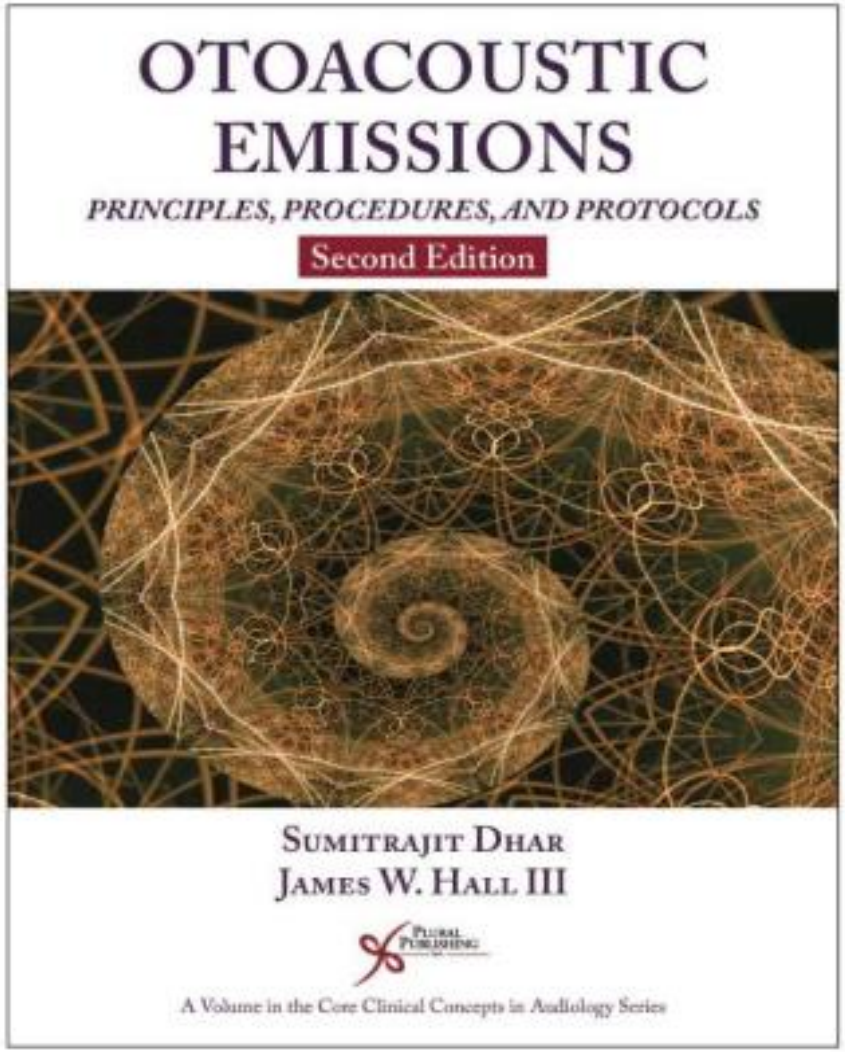



**Fig. 5.** Screen capture of a remote computing session in which DPOAEs are being measured in a young child.



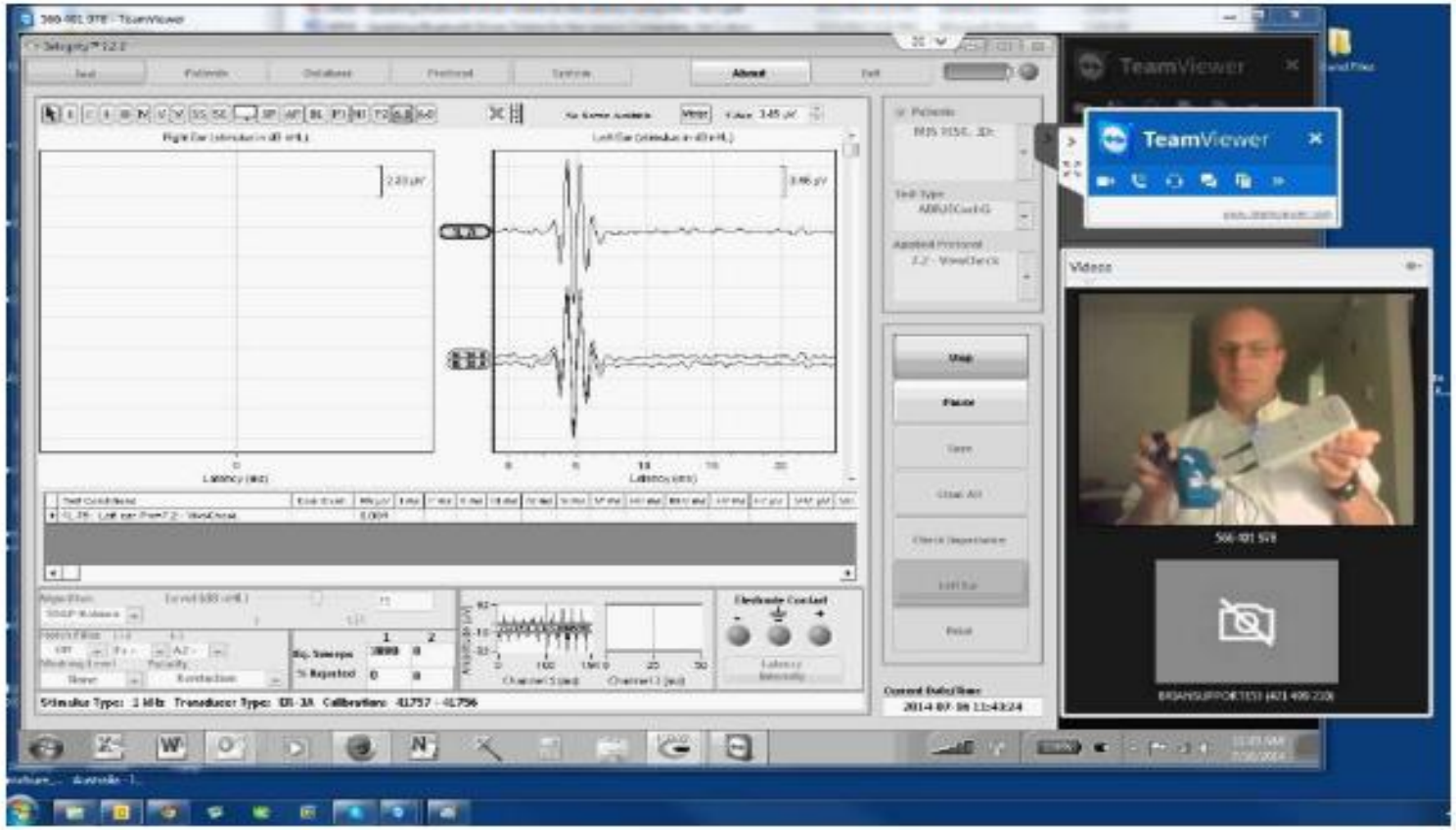
# Immittance measurements

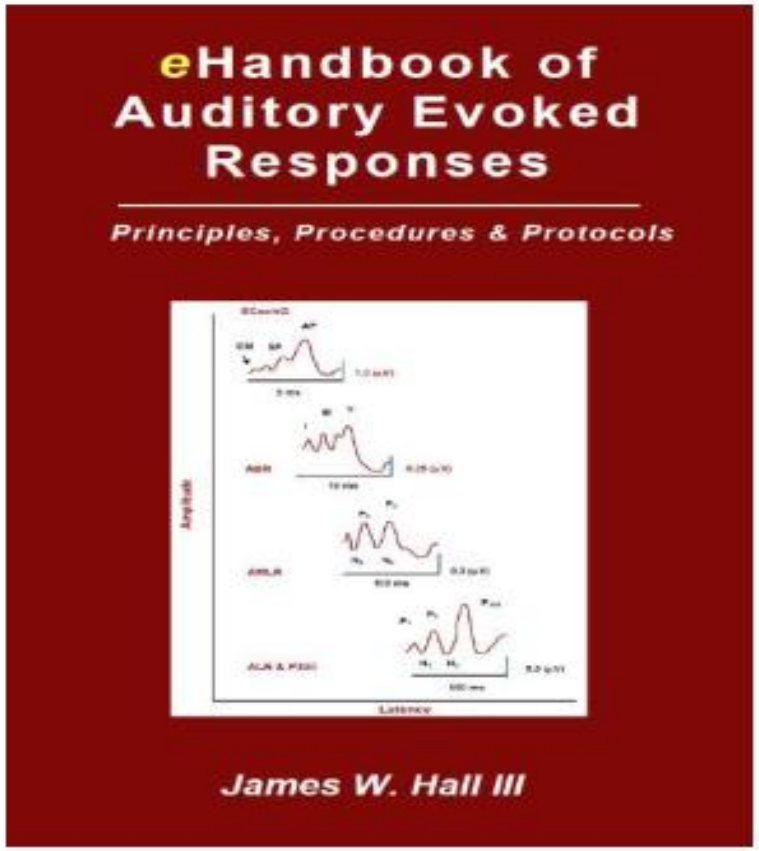
# ABR

## Auditory Brainstem Response

### Auditory Brainstem Response (ABR): Store-and-Forward or Real Time

http://www.amazon.com/dp/B0145G2FFM



# Tele-ABR

- very strict procedures concerning stimulation and acquisition parameters
- introducing objective methods of hearing assessment and advanced methodology in telerehabilitation in to 3 clinics abroad – in Ukraine, Belarus and Kyrgyzstan newly added to the National Network of Audiology.
- Before starting the examinations local technicians completed comprehensive training courses.
- They were instructed on :
- the correct patient preparation for testing, abrasions of the skin, electrode sticking, clip attaching, and launching of the appropriate software. Support documentation was prepared. After the test, the results are collected and sent to a specialist in Poland to determine the result.
- This technology assists clinicians by making it easier for them to consult with other more experienced audiologists.

# Validation of Remote identification (DPOAE) and Confirmation (ABR) of Infant Hearing Loss

***Ramkumar V, Hall JW III, Nagarajan R, Shankarnarayan VC & Kumaravelu S (2013). Tele-ABR using a satellite connection in a mobile van for newborn hearing testing. Journal of Telemedicine and Telecare, 19, 233-237***

- A colleague asks you to review and to provide an opinion on a challenging ABR. She sends ABR waveforms to you as email attachments. Following close analysis you send her an email with your opinion. This is an example of

A. Teleconsultation

B. Asynchronous (store-and-forward) teleaudiology

C. Synchronous (real time) teleaudiology

D. Remote monitoring

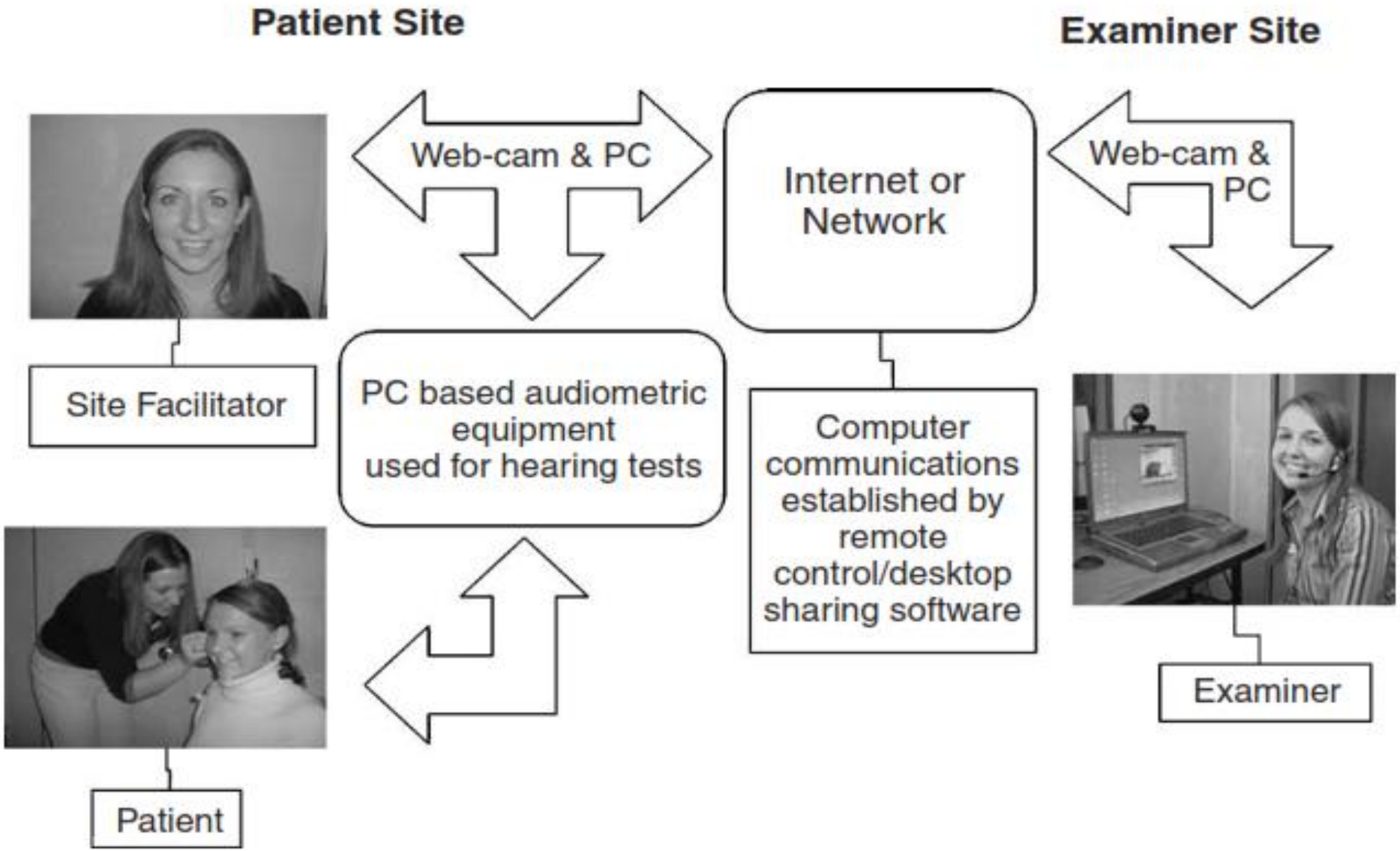



**Figure 2** Configuration of the real-time audiology telemedicine system

**Figure 1** The computerized audiometry equipment at the patient's site included the audiometer unit (positioned under the laptop computer) and an auxiliary monitor. The audiometer headphones and a client handheld switch are

**Figure 3** The equipment at the patient's site. The practitioner is displayed on the left-hand screen. The facilitator can view the audiometry results on the right-hand screen

**Fig. 3.** Equipment required at the patient site. For remote computing purposes, a computer, Web camera or dedicated camera, computerized audiometric equipment (an audiometer is pictured), video-otoscopy, immittance (not shown), and a LAN connection would permit basic teleaudiology services.

**Fig. 2.** The clinician equipment configuration for an audiologist administering telehealth services. Note only a computer (with remote computing software) and a video system (either

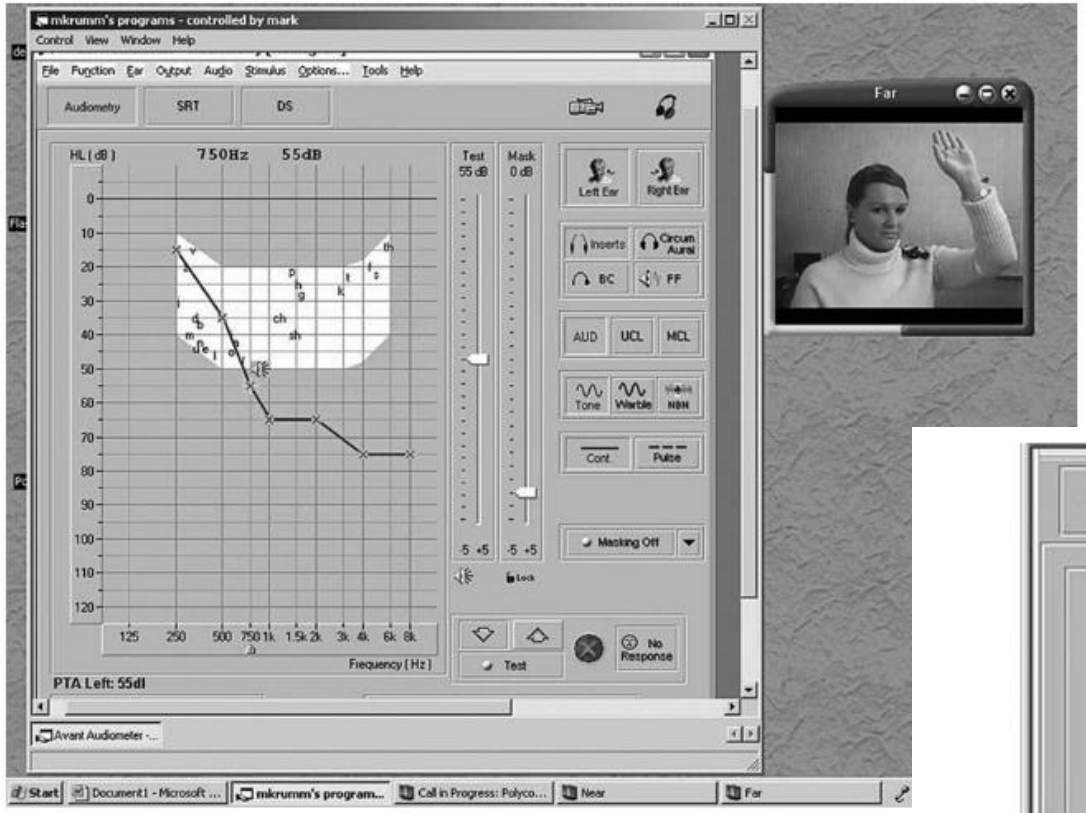
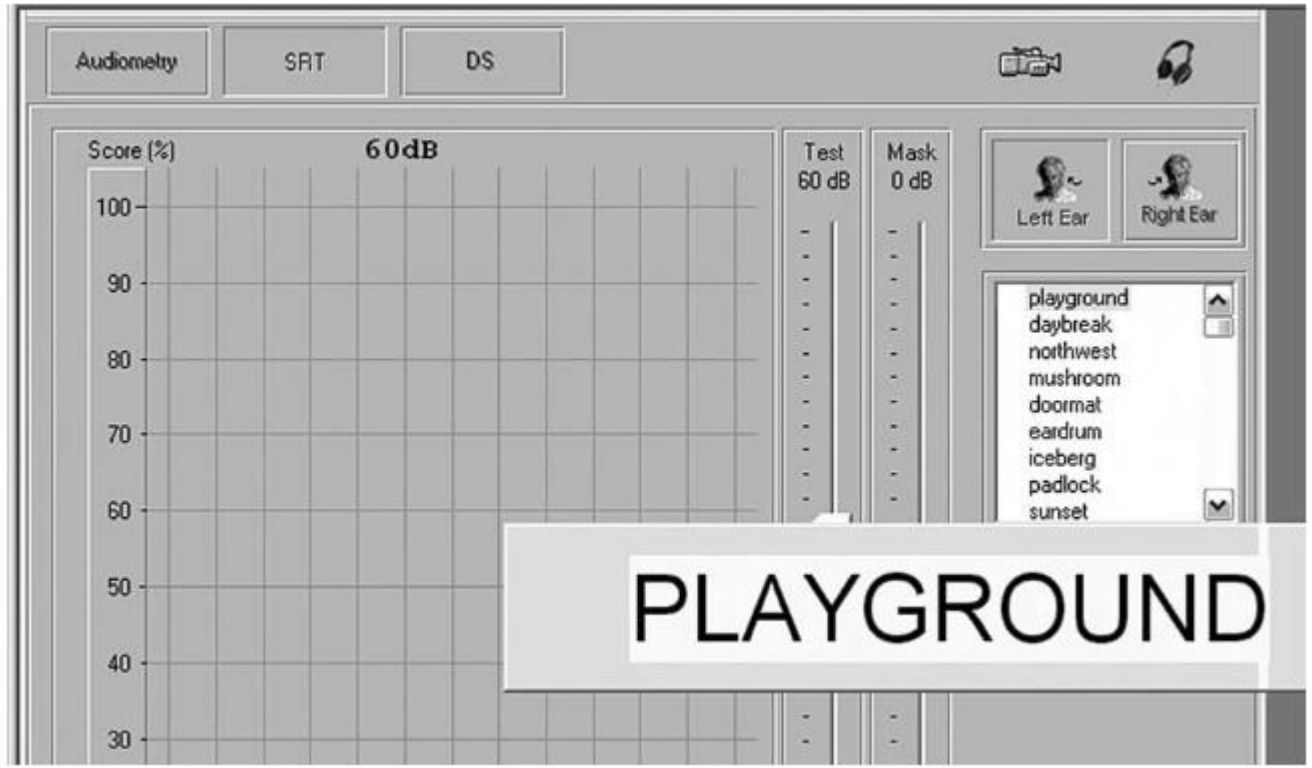



**Figure 4** A partially completed audiogram obtained by application sharing. In the client raised her hand to indicate that she was hearing pure tone stimuli



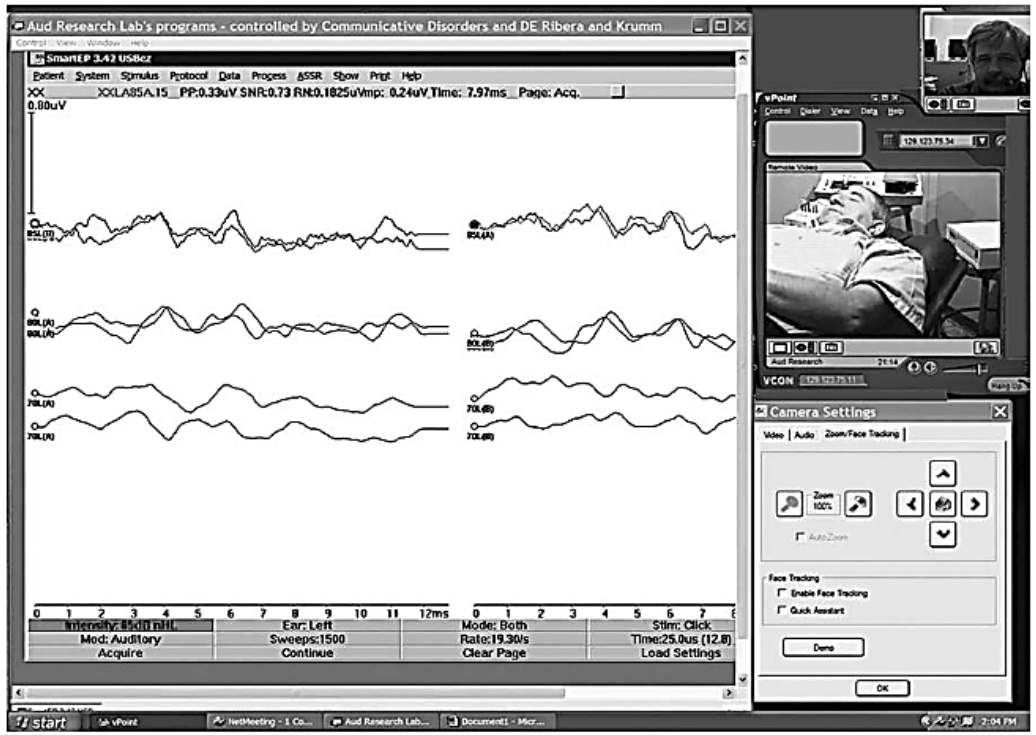



**Figure 6** An auditory brainstem response (ABR) being obtained via real-time telemedicine. The monitor shows the ABR controls as well as the patient's ABR tracings. The patient can be observed (right) through a webcam, together with the audiologist who is conducting the test from a remote site (upper right hand window)

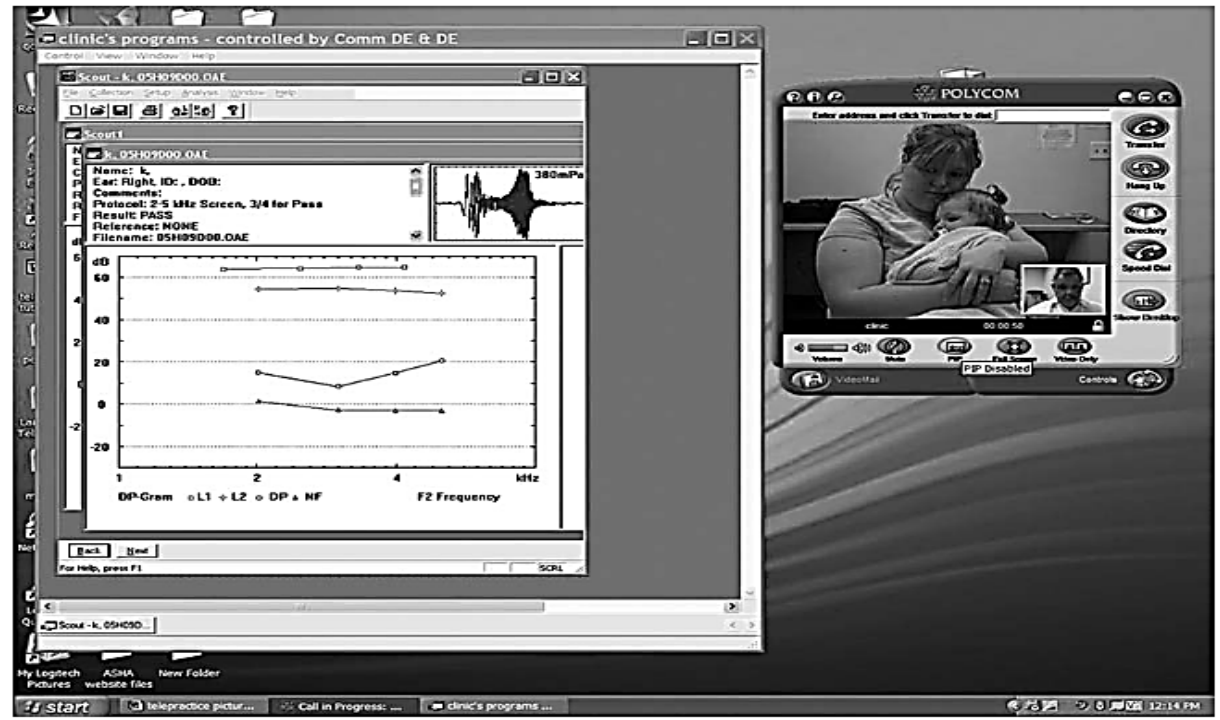



**Figure 8** Distortion product otoacoustic emissions (DPOAE) testing being conducted by telemedicine on a paediatric client. The clinician can control intensity levels, test frequencies and algorithms to enhance DPOAE responses. Application sharing also permits other diagnostic protocols, such as transient otoacoustic emissions (TEOAEs) and spontaneous otoacoustic emissions (SOAEs)

# OAE

- OAEs are a useful tool both for hearing screenings and for diagnostic testing.
- OAEs can supplement other audiologic testing and beneficial when included in a test battery. It is true in tele-audiology systems.
- The feasibility of remote OAE testing and the validity of remote OAE results must be evaluated. Remote OAE testing has been performed in pilot studies using interactive video and desktop sharing software
- However, the results suggest that testing DPOAEs through a remote system yields reliable results.

# REMOTE WORKING IN AUDIOLOGY SERVICES DURING COVID-19 AND BEYOND

## Vestibular services

- Vestibular testing: As vestibular function testing is unavailable services should aim support patients remotely in order to minimise the progression of patients to chronic dizziness with or without anxiety (i.e. persistent postural perceptual dizziness, PPPD). This can be done through:
- Phone consultations
- Questionnaires by post

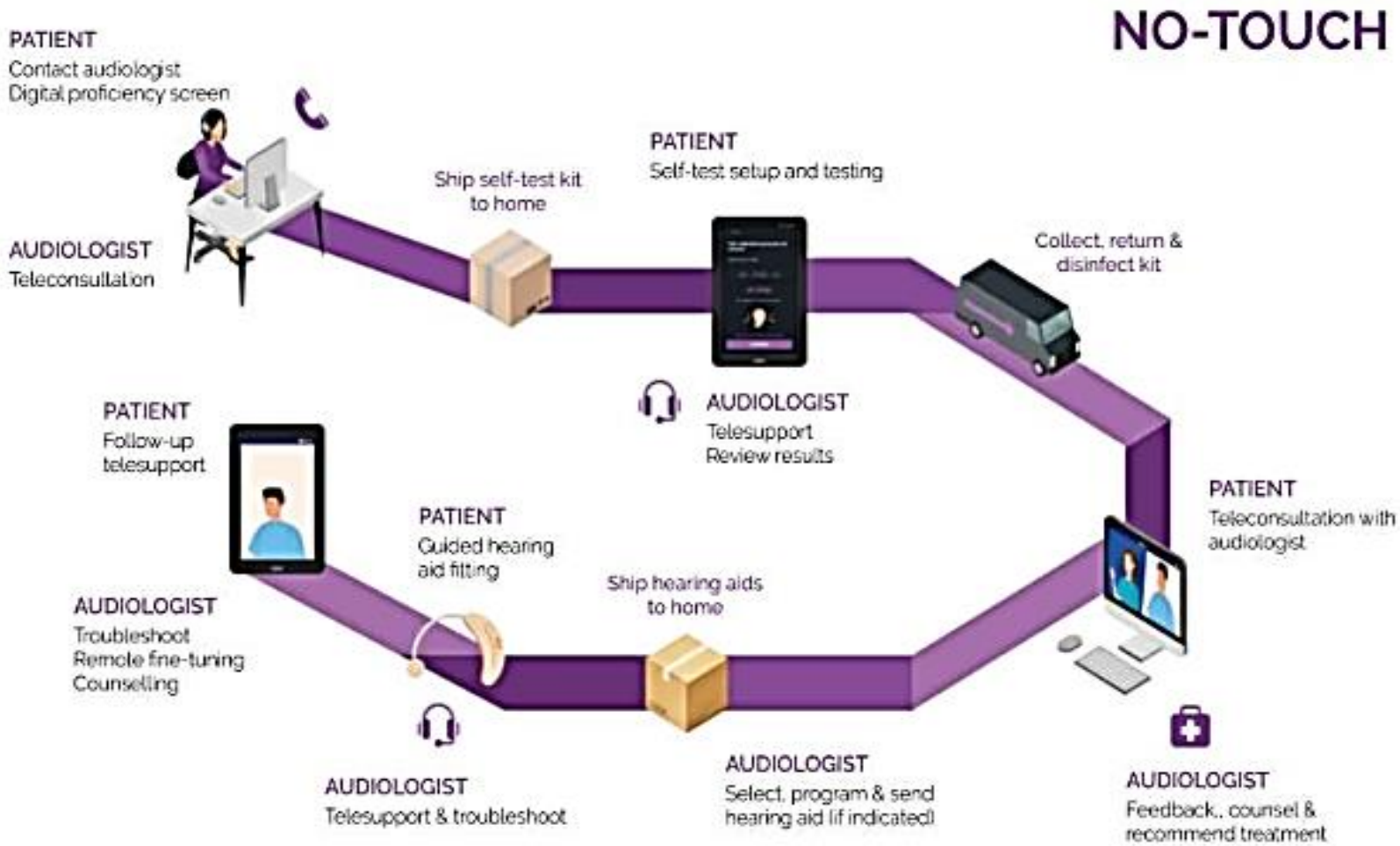
Caution should be taken to select patients carefully, however, to ensure that such home-based plans will not put the patient at risk of falls, anxiety, worsening of symptoms or cause neck injuries, and that home based PRM are not contraindicated. They should only be given if follow-up and close supervision/support is available.

TABLE 1: a summary of remote vestibular resources.

| Resource | Information | Where to find/link/reference |
|---|---|---|
| **VRBQ**<br>**DHI** | Both evidence based questionnaire that could be sent to identify level of patient symptoms | **Vestibular rehabilitation handicap questionnaire:**<br>http://resource.isvr.soton.ac.uk/audiology/vrbq.htm<br>**Dizziness handicap questionnaire**<br>http://www.rehab.msu.edu/_files/_docs/Dizziness_Handicap_Inventory.pdf |
| **Abbreviated dizziness questionnaire** | Questionnaire to help differentiate between central and peripheral causes of dizziness. To help identify potential pathology and allow triaging into appropriate testing slots. | Lindell et al., (2018)<br>Noda et al., (2011)<br>Roland et al., (2015) |
| **Pod cast: telehealth in VR** | Useful discussion on this subject | http://www.neuropt.org/special-interest-groups/vestibular-rehabilitation/podcasts (39) Telehealth in VR |
| **Particle repositioning manoeuvres (PRM) performed by patient** | There are several PRM used in clinics which have home variants that could, at the discretion of the clinician be self-administered. The traditional Epley and Semont (and their home variants) both have good evidence for their effectiveness. It is up to the clinician to evaluate whether home-treatment could be used for all patients with suspected BPPV or reserved for those whom BPPV has previously been diagnosed, and this is thought to have returned. A physical neck screen (in addition to verbal questions to rule out contraindications) could be performed over the phone to ensure suitably. | Note there are many videos on You tube showing poor technique so choose carefully. Videos and handouts are essential.<br>Left home semont<br>https://www.youtube.com/watch?v=z2KUrQoZ-sU<br>right home semont<br>https://www.youtube.com/watch?v=A72UjulJSzE<br>Left home epley<br>https://www.youtube.com/watch?v=lh72suV2p20<br>right home epley<br>https://www.youtube.com/watch?v=BY4UeRmTYmA<br>Brandt-Daroff video (if Epley and Semont not possible)<br>https://www.youtube.com/watch?v=voZXtTUdQ00 |
| **Free downloadable booklets** | **Balance retraining:** enables a patient to devise their own basic VR program consisting of gaze stabilization and habituation exercises. Patient is walked through a 'motion sensitivity quotient- type' way of identifying a correct starting level of 6 basic exercises. | http://www.menieres.org.uk/files/pdfs/balance-retraining-2012.pdf |
| **Web based VR** | **Online version** of the above designed specifically for the over 50s but suitable for all. | https://balanceretrainingh s.lifeguidewebsites.org |

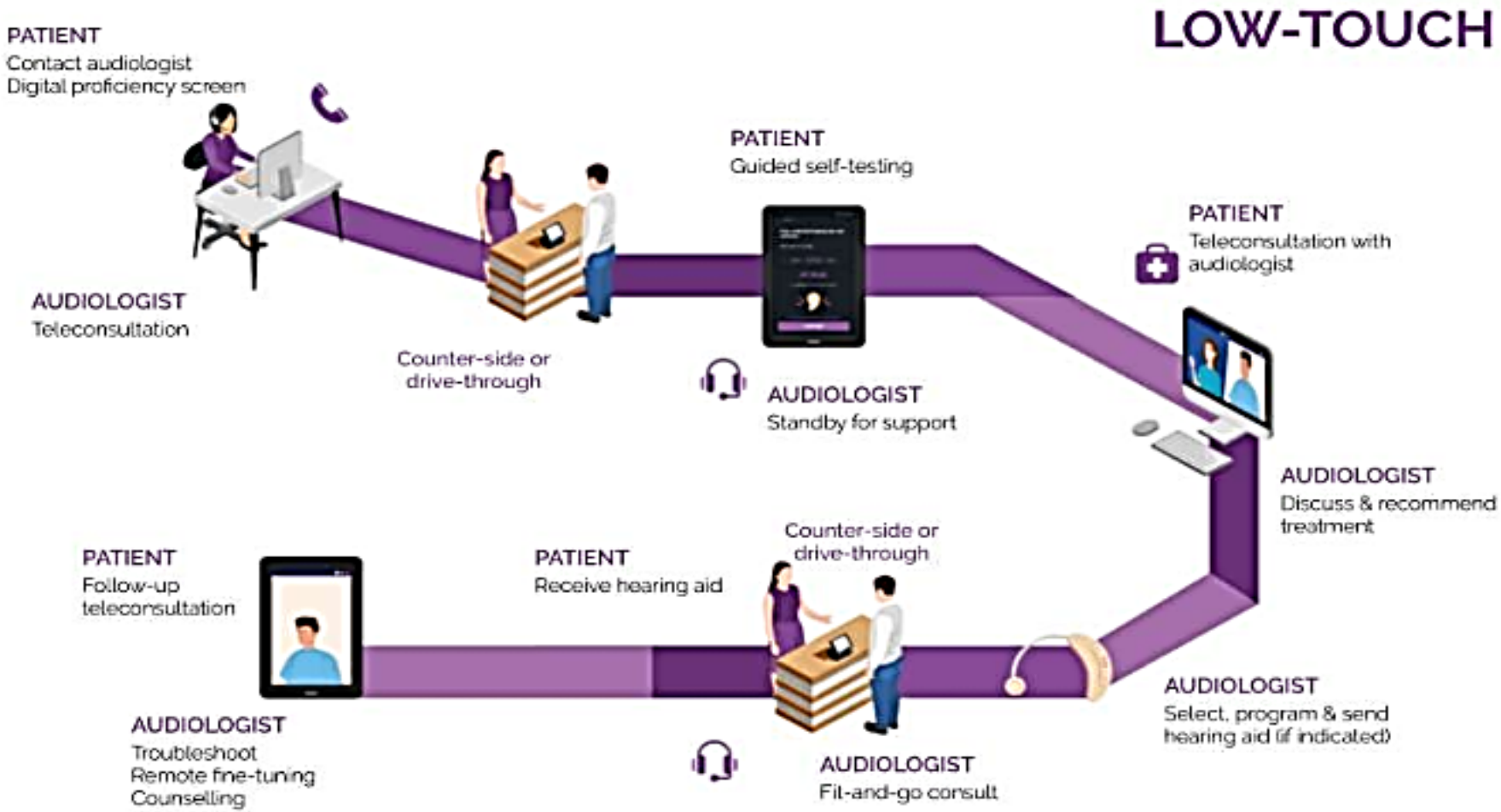
# Hearing Assessment Without Direct Patient Contact: The Time for Tele-Audiology Has Come

## *No-Touch Services*



# Hearing Assessment Without Direct Patient Contact: The Time for Tele-Audiology Has Come

## *Low Touch Services*



# Hearing Assessment Without Direct Patient Contact: The Time for Tele-Audiology Has Come

## *Minimizing Risk and Maximizing Clinical Value*

## (From Swanepoel & Hall, 2020)

**Table 1. General COVID-19 considerations for high-, low- and no-touch audiology services**

| Audiology service | Setting | Infection risk ** | Contraindication considerations | Infection controls** |
|---|---|---|---|---|
| **High-touch** | Clinic and sound-booth | Medium to high | >65 years of age<br>Comorbidity risk* | Social distancing, hand hygiene, surface decontamination, personal protective equipment, and universal source control |
| **Low-touch** | Counter-side<br>Drive-through | Low to medium | Comorbidity risk*<br>Digital proficiency | Social distancing, hand hygiene, surface decontamination |
| **No-touch** | Home-based | Low | Digital proficiency<br>Significant other<br>Degree of loss<br>Privacy and confidentiality | Surface decontamination<br><br>Decontamination of earphones |

* Examples: Cardiovascular and respiratory disease, diabetes
** CDC, 2020

| | | |
|---|---|---|
| | | teenagers and adults only). |
| Hear Glue Ear App | https://play.google.com/store/apps/details?id=com.camdh.app.HGE&hl=en_GB | Songs, games and books to support children with glue ear as well as links to further information for parents. Has a hearing screening tool, but this is uncalibrated so could be misleading |
| Sound Scouts | https://www.soundscouts.com/en-gb/ | Hearing assessment for a range of ages of children and adults. Validated for children aged 5 and above. Based on speech in noise, speech in quiet and tones in noise. Needs someone with normal hearing for basic calibration. Costs c. £1.99 per assessment. Gives results in or outside normal range |
| Nuheara | https://www.nuheara.com/hearing-check/ | Digits in noise test. Free. Emails you a traffic-light result. Reportedly unsuitable for children under 15 years, but may be suitable with some adjustments to scoring |

| | | |
|---|---|---|
| Tinnitus | https://www.tinnitus.org.uk/Pages/Category/resources | Links to the leaflets and resources specifically for children: |
| LittleEars Questionnaire™ | https://www.medel.com/en-gb/about-hearing/hearing-test/little-ears-auditory-questionnaire | Evaluates listening ability (aided or unaided) in children up to 2 years old. Can be done online by parents. |

Recent surveys suggest that most audiologists possess a **positive attitude towards tele-audiology**, especially when considering adult-focused services related to follow-up clinical services (Eikelboom & Swanepoel, 2016; Singh et al., 2014).

- Results suggest a low level of overall experience (15.5%) with tele-audiology

# New Models for Teleaudiology ... Low and No Touch Services

COVER STORY

## Making Audiology Work during COVID-19 and Beyond

By De Wet Swanepoel, PhD, and James W. Hall III, PhD

The COVID-19 crisis has ushered in a new era in hearing health care that requires a radical rethinking of service delivery in audiology. Low- and no-touch services are now necessary for audiology patients—who are typically at the highest risk for COVID-19 morbidity and mortality due to their age—to access medical care. Fortunately, audiology is a technology-driven profession in terms of providing assessment and intervention, allowing unique opportunities to leverage remote and telehealth hearing care solutions. While traditional diagnostic assessment to differentiate hearing loss due to ear disease, which has a low prevalence, requires a sound-treated environment and a comprehensive test battery, a less controlled environment with fewer tests could suffice for hearing aid fittings. This means that more than 95 percent of adults with hearing loss could be served using alternative low- or no-touch models of audiological care. While very concerning, the ongoing pandemic also offers a unique opportunity to redefine and innovate how hearing health care professionals reach and serve patients in more responsive, efficient, and person-centered ways. Exploring alternative patient journeys is crucial to evolve audiology during the COVID-19 crisis and beyond.

### A NEW ERA OF HEARING HEALTH CARE

According to the Centers for Disease Control and Prevention (CDC) guidelines, audiological services pose a medium to high risk for COVID-19 infection, considering the proximity, test setup, and length of appointments.[1] The fact that the majority of people who require audiology services (those over 65 years of age) are also the ones at the highest risk of COVID-19-related mortality and morbidity underscores the importance of reassessing how hearing care is delivered.

Traditionally, audiological care has been a high-touch service with several face-to-face appointments in confined sound-treated spaces for initial assessments, hearing aid fittings, follow-up troubleshooting, and counseling. In this respect, how audiologists have been providing services to adults with hearing loss has remained very much the same over the past five decades. The sudden requirement for physical distancing and even long-term lockdown recommendations for older adults render this traditional audiological care pathway untenable at present.

**Dr. Swanepoel**, left, is a professor of audiology at University of Pretoria and the editor-in-chief of the International Journal of Audiology. His research capitalizes on digital health technologies for innovative hearing services with greater access and affordability. **Dr. Hall** is an audiologist with over 40 years of clinical, teaching, research, and administrative experience. He is a professor of audiology at Salus University and the University of Hawaii.

### CHANGING TIMES REQUIRE CHANGES IN CARE DELIVERY

In the era of COVID-19, wherein low- or even no-touch services are necessary, audiological care needs to be responsive with alternative modes of service delivery. In our technology-driven field, unique opportunities to leverage connected solutions for remote and telehealth services exist. Where accessibility, convenience and efficiency have been the primary drivers of telehealth, COVID-19 has made it about safety first and foremost, considering the vulnerable profile of audiology patients.

Over the past several years, we've witnessed tremendous growth in digital hearing health care solutions from web- and app-based screening to mobile audiometry that has made decentralized community-based hearing care services possible.[2-5] These assessment options have typically relied on facilitators or assistants to guide patients through testing. Also, hearing aid manufacturers have been particularly good at including telehealth tools for remote device troubleshooting, counseling, fine-tuning, and tracking usage.



**Table 2. Conventional and alternative point-of-care for adult hearing assessments**

| | Conventional clinic (high-touch) | Alternative points of care (low- or no-touch) |
|---|---|---|
| **Primary purpose** | Assessment for diagnostic purposes<br>Possible medical treatment | Assessment towards hearing aid fitting<br>Referral for ear disease risk |
| **Test environment** | Sound-treated room/booth | Home, office, counter-side, drive-through, primary care facility |
| **COVID-19 risk** | Medium to high risk | Low to medium |
| **Pure tone audiometry** | Air and bone-conduction<br>Minimum -10 dB<br>125 - 8000 Hz | Air conduction<br>Minimum 20 or 25 dB<br>500 - 8000 Hz |
| **Speech audiometry** | Essential | Self-test options e.g. digits-in-noise |
| **Tympanometry** | Essential | Optional and unlikely pending tech advances |
| **Otoacoustic emissions** | Essential | Optional and unlikely pending tech advances |
| **Otoscopy** | Essential | Optional |
| **Ear disease risk** | Using test battery results<br>Air-bone gap<br>Case history | Test findings to screen (E.g. Asymmetry hearing loss; speech-in-noise)<br>CEDRA<br>FDA waiver option |
| **Operation** | Audiologist | Self-test (remote assistance option)<br>Facilitator or assistant |