Tele-Health Principles and Practices Applied in Audiology

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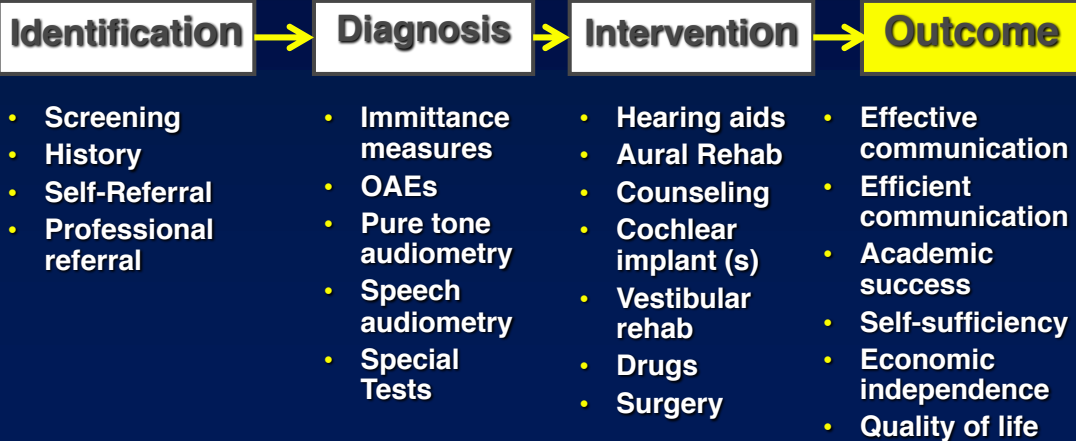*jwhall3phd@gmail.com   www.audiologyworld.net*

Tele-Health Principles and Practices Applied in Audiology

- ❑ The global challenge … so many ears and so few audiologists
- ❑ Terminology
- ❑ Tele-audiology: Technologies and strategies
- ❑ Tele-audiology: Rationale and venues
- ❑ Tele-audiology is evidence based
- ❑ Future directions in tele-audiology

Audiology Applications of Tele-Health:
The global challenge … so many ears and so few audiologists

Tele-Health Principles and Practices
Applied in Audiology: *Focusing on the Goal*

Identification → **Diagnosis** → **Intervention** → **Outcome**

Identification	Diagnosis	Intervention	Outcome
• Screening • History • Self-Referral • Professional referral	• Immittance measures • OAEs • Pure tone audiometry • Speech audiometry • Special Tests	• Hearing aids • Aural Rehab • Counseling • Cochlear implant (s) • Vestibular rehab • Drugs • Surgery	• Effective communication • Efficient communication • Academic success • Self-sufficiency • Economic independence • Quality of life

Tele-Health Principles and Practices Applied in Audiology

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- ❑ **Future directions in tele-audiology**

Tele-Health Principles and Practices Applied in Audiology: *Terminology and Concepts*

- ❑ **Tele-Health = clinical and non-clinical services**
  - • **Medical education and training (e.g., video-conferencing)**
  - • **Administration**
  - • **Research**
- ❑ **Tele-Medicine = provision of clinical medical service**
  - • **Real time service delivery (synchronous)**
  - • **Store-and-forward techniques (asynchronous)**
- ❑ **Real-time transmission of data for remote**
  - • **Clinical screening, assessment or management**
  - • **Analysis**
  - • **Interpretation**
- ❑ **Remote monitoring (e.g., cardiac parameters, EEG)**

Tele-Health Principles and Practices
Applied in Audiology:
Tele-Health in Other Disciplines

- ❏ Tele-radiology*
- ❏ Tele-cardiology
- ❏ Tele-dermatology*
- ❏ Tele-obstetrics and tele-gynecology
- ❏ Tele-neurology
- ❏ Tele-pediatrics
- ❏ Tele-pharmacy
- ❏ Tele-psychiatry
- ❏ Tele-dentistry
- ❏ Tele-surgery (robotic surgery)
- ❏ Tele-pathology*

* Common applications are asynchronous (store-and-forward)

Tele-Health Principles and Practices
Applied in Audiology

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- ❏ Tele-audiology: Technologies and strategies
- ❏ Tele-audiology: Rationale, populations, and venues
- ❏ Tele-audiology is evidence based
- ❏ Future directions in tele-audiology

Tele-Health Principles and Practices
Applied in Audiology: *Technologies and Strategies*

- ❑ Tele-audiology is the audiology application of tele-health
- ❑ Two general categories of tele-audiology
  - ● Asynchronous (store-and-forward)
  - ● Synchronous (real time or live)
- ❑ Tele-consultation regarding challenging patients
- ❑ Tele-education
  - ● Students in audiology training programs anywhere
  - ● Technicians
  - ● Audiologists
    - ✓ Advanced training
    - ✓ Continuing education

Tele-Health Principles and Practices
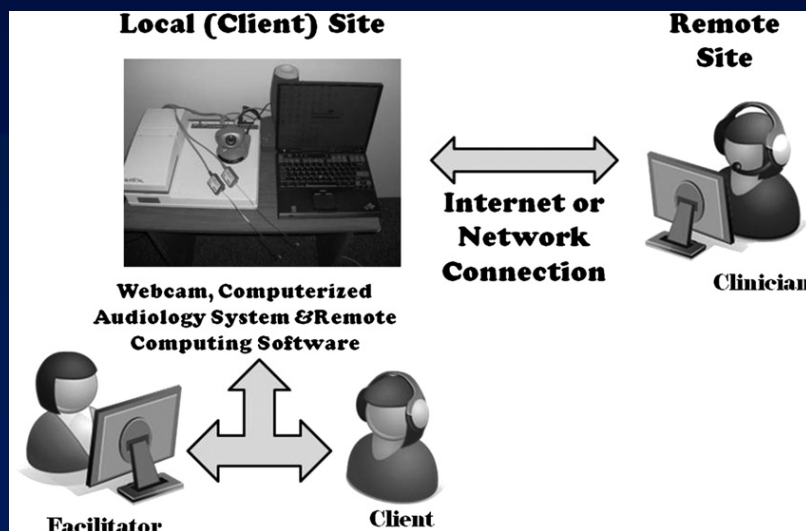### Applied in Audiology: *Technologies and Strategies*

- ❑ Asynchronous (store-and-forward) tele-audiology
  - ● Most commonly used
  - ● Any type of test information, e.g.,
    - ✓ Audiogram
    - ✓ Tympanogram
    - ✓ ABR recordings
    - ✓ Video-otoscopy image
  - ● May include findings from automated testing
  - ● Transmitted via
    - ✓ Email
    - ✓ Fax
    - ✓ Direct storage (e.g, DropBox)

Tele-Health Principles and Practices
Applied in Audiology: *Technologies and Strategies*

- ❑ **Synchronous (real time or live) tele-audiology: Model 1**
  - ● **High quality interactive video (e.g., dedicated 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 test equipment using**
    - ✓ **Application sharing software**
    - ✓ **Internet connection**
  - ● **Technician test skills and training are not important**

Tele-Health Principles and Practices Applied in Audiology:
General Synchronous Technology Set Up
(Krumm M & Syms MJ. Teleaudiology. Otolaryngol Clinics North America, 44, 2011)

Local (Client) Site — Webcam, Computerized Audiology System & Remote Computing Software — Facilitator — Client — Internet or Network Connection — Remote Site — Clinician

Tele-Health Principles and Practices Applied in Audiology: *Technologies and Strategies*

❑ **Equipment requirements 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**
- **Two internet connections**
- **Desktop sharing software**
- **Constant real-time images**
- **Adjustable audio**

Tele-Health Principles and Practices Applied in Audiology: *Automated Audiometry with a Facilitator*

KUDUwave Automated Audiometer

❑ **Swanepoel D, Maclennan-Smith F & Hall JW III (2013). Diagnostic pure tone audimometry in schools: Mobile testing without a sound-treated environment.** *JAAA, 24,* 992-1000

❑ **Matthysen C, Swanepoel D, Hall JW III (2014). Automated pure tone audiometry outside a sound-booth using earphone attenuation and integrated ambient noise monitoring.**

Facilitator Training:
International Hearing Care Technician Certificate
(www.aicme.com)

Jackie Clark, Ph.D.

James W. Hall, III, Ph.D.

James Saunders, M.D., F.A.C.S.

Spanish Language Instructors

Alexandra Feliz, Au.D.

Abraham Garcia, Au.D.

International Hearing Care Technician Certificate:
Curriculum

Core Curriculum:
Designed to provide general knowledge and skills required by a hearing care technician who will work under the supervision and direction of a physician, otolaryngologist or audiologist. Successful completion of the core curriculum leads to a Hearing Care Technician Certificate.

Each Course Features:
A 48-60 minute instruction through a narrated PowerPoint presentation on a focused topic. Presentations include text, figures, and video demonstrations to enhance the learning experience.

Selected readings and resources, including websites and other internet sources information, are recommended for each topic.

International Hearing Care Technician Certificate: *Courses are Grouped Into One of Three Categories*

Basic hearing courses cover general knowledge of sound, acoustics, auditory anatomy and physiology.

Auditory disorders courses provide a brief overview of disorders and diseases commonly encountered in patient population.

Assessment Techniques category provides information needed in preparation for conducting techniques commonly applied in hearing assessment, such as otoscopic inspection, pure tone hearing screening and threshold assessment, tympanometry, and measurement of otoacoustic emissions.

International Hearing Care Technician Certificate: *Grouping 1 (Basic Hearing Courses)*

- ❑ Auditory anatomy and physiology
- ❑ Sound and acoustics
- ❑ Professional responsibilities and liabilities
    - ✓ Universal precautions
    - ✓ Infection control
    - ✓ Patient confidentiality
    - ✓ Privacy and security
- ❑ History taking and record keeping
- ❑ Patient needs and counseling
- ❑ Medical and audiological terminology

International Hearing Care Technician Certificate: *Grouping 2 (Common Ear Disorders and Diseases)*

❑ **External ear**

❑ **Middle ear**

❑ **Inner ear**

❑ **Retrocochlear**
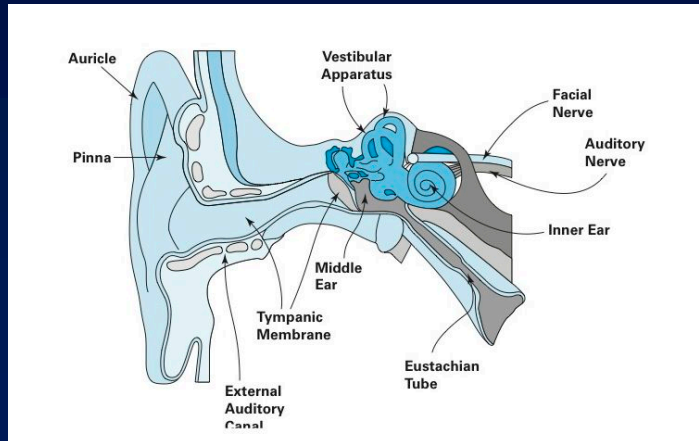
International Hearing Care Technician Certificate: *Grouping 3 (Assessment Techniques)*

❑ **Otoscopic inspection and ear examination**

❑ **Hearing Screening and identification of hearing loss**

❑ **Introduction to the audiometer**

❑ **Pure tone hearing test techniques:**

  ✓ **Air conduction**

  ✓ **Bone conduction**

❑ **Masking theory and techniques**

International Hearing Care Technician Certificate: *Grouping 3 (Assessment Techniques Continued)**

- ❑ **Audiogram patterns**
- ❑ **Simple speech audiometry**
- ❑ **Tympanometry**
- ❑ **Otoacoustic emissions**
- ❑ **Introduction to diagnostic hearing assessment**
- ❑ **Introduction to hearing aids and other management options**

* Special course modules are in preparation, e.g., hearing aids

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International Hearing Care Technician Certificate: *Student Performance...Measuring Outcomes*

- ❑ **Each course concludes with an assessment of learner outcome that includes questions within different domains of learning as defined by revised Bloom's Taxonomy, specifically:**
    - ✓ **Remembering (formerly knowledge)**
    - ✓ **Understanding (formerly comprehension)**
    - ✓ **Applying, analyzing, evaluating, and creating**

- ❑ **For each course, recommendations and guidelines are offered for acquisition of related clinical and technical skills by technicians enrolled in the core curriculum.**

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Audiology Applications of Tele-Health:
Rationale, Populations, and Venues … USA Perspective

❑ **Rationale**
- **Increase access to quality hearing care**
- **Reduce wait time for hearing care**
- **Decrease patient travel distance**
- **Enhance productivity (More services with fewer audiologists)**
- **Minimize hearing care cost**

❑ **Sample of populations**
- **Hearing services in large states with too few audiologists**
- **Persons living in remote or underserved regions**
  - ✓**Native Americans in southwest USA**
  - ✓**Alaska**
- **Veterans in rural areas distant from VA Medical Centers**

Audiology *Applications of Tele-Health:*
Alaska Experience

❑ **Hofstetter et al (2010). Impact of telehealth on wait time for ENT specialty care. Telemedicine J E Health, 16, 551-556 (Nome Alaska)**
- **16 year retrospective study**
- **Evaluated impact of store and forward technology**
- **Prior to use of tele-audiology, 47% of patients would wait 5 months or longer for an ENT appointment**
- **Within first 3 years of tele-audiology/tele-medicine, 8% of patients waited 5 months or longer**
- **After 6 years of tele-audiology/tele-medicine, only 3% of patients waited 5 months or longer**

Audiology Applications of Tele-Health:
Rationale, Populations, and Venues … Global Perspective

James W. Hall III
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"The World is My Classroom and Clinic"

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Audiology Applications of Tele-Health:
Global Burden of Hearing Loss
90% of World Population is Without Access to Hearing Care

- WHO estimated in 2005:
  - 278 million people (>40 dB HL)
    - 4.3 % of global population
  - 647 million people (>25 dB HL)
    - 9.9 % of global population

- In 2008:
  - 288 million people (>40 dB HL)
  - 664 million people (>25 dB HL)

(WHO, 2006)

Audiology Applications of Tele-Health:
Rationale, Populations, and Venues … Global Perspective

- ❑ **Rationale**
  - Increase access to quality hearing care anywhere
  - Deliver hearing care at lowest possible cost
  - Link general physicians and technicians with formally educated audiologists
  - Maximize impact of limited audiology personnel
- ❑ **Sample of populations**
  - Infants undergoing hearing screening or diagnosis in countries with large populations and few audiologists
  - Persons without access to complex clinical services, e.g.,
    - ✓ Cochlear implants
 - Persons in remote or underserved regions *… most of the developing world!*

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2014 AAA Convention: Featured Session
Tele-Health Principles and Practices Applied in Audiology

- ❑ Introduction *(J Hall)*
- ❑ Historical Overview of Tele-Health *(C Spankovich)*
- ❑ AAA White Paper on Status of Tele-Audiology *(D Swanepoel)*
- ❑ California Tele-Audiology Program: Remote Comprehensive Hearing Evaluations for Infants *(A Simon)*
- ❑ Tele-Audiology in Rural India *(V Ramkumar)*
- ❑ The VA Experience: Telehealth as a Transformational Initiative *(K Dennis)*
- ❑ The VA Experience: Current Practices and Lessons Learned in Tele-Audiology *(C Gladden)*
- ❑ Panel Discussion with Audience Participation

Tele-Health Principles and Practices Applied in Audiology
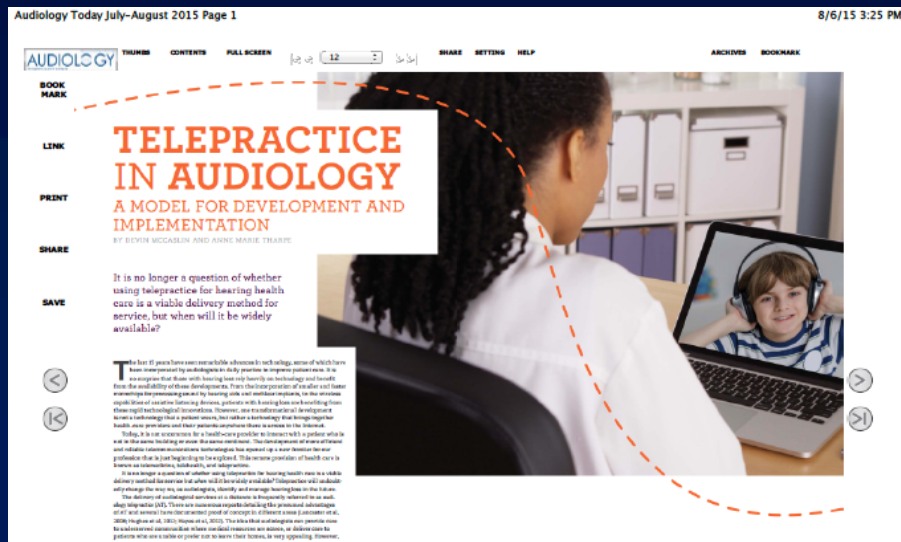
Tele-Health Principles and Practices Applied in Audiology:
Summary of Evidence-Based Applications

- ❑ **Video-otoscopy**
- ❑ **Pure tone audiometry**
- ❑ **Infant hearing screening (OAE and ABR)**
- ❑ **ABR estimation of hearing loss**
- ❑ **Diagnostic auditory assessment**
- ❑ **Vestibular assessment**
- ❑ **Rehabilitation**
  - ● **Counseling patients and families**
  - ● **Hearing aid fitting and programming**
  - ● **Cochlear implant programming**
  - ● **Aural rehabilitation**
  - ● **Tinnitus and hyperacusis management**

Tele-Health Principles and Practices Applied in Audiology
(www.audiologyworld.net)

A Systematic Review of Telehealth Applications in Audiology

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

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[2]Callier Center for Communication Disorders, School for Behavioral and Brain Sciences, University of Texas at Dallas, Texas.
[2]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 CHINAL) 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 pure-tone 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 278 million to a moderate and greater degree, hearing loss is clearly a significant global healthcare concern[3] 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.[4,5] 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.[6] 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,

informa healthcare

Telehealth in audiology: The need and potential to reach underserved communities

De Wet Swanepoel[1,2]
Jackie L. Clark[2,3]
Dirk Koekemoer[4]
James W. Hall III[5,1]
Mark Krumm[6]
Deborah V. Ferrari[7]
Bradley McPherson[8]
Bolajoko O. Olusanya[9]
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Abstract

Permanent hearing loss is a leading global health care burden, with 1 in 10 people affected to a mild or greater degree. A shortage of trained healthcare professionals and associated infrastructure and resource limitations mean that hearing health services are unavailable to the majority of the world population. Utilizing information and communication technology in hearing health care, or tele-audiology, combined with automation offer unique opportunities for improved clinical care, widespread access to services, and more cost-effective and sustainable hearing health care. Tele-audiology demonstrates significant potential in areas such as education and training of hearing health care professionals, paraprofessionals, parents, and adults with hearing disorders; screening for auditory disorders; diagnosis of hearing loss; and intervention services. Global connectivity is rapidly growing with increasingly widespread distribution into underserved communities where audiological services may be facilitated through telehealth models. Although many questions related to aspects such as quality control, licensure, jurisdictional responsibility, certification and reimbursement still need to be addressed, no alternative strategy can currently offer the same potential reach for impacting the global burden of hearing loss in the near and foreseeable future.

Sumario

La pérdida auditiva permanente es una importante carga para los cuidados de la salud a nivel mundial, con 1 de cada 10 personas afectadas en grado ligero o mayor. La escasez de profesionales entrenados en cuidados de la salud y de infraestructura asociada y la limitación de recursos determina que los servicios de salud auditiva no estén disponibles para la mayoría de la población mundial. La utilización de información y tecnología de la comunicación para los cuidados de la salud auditiva o teleaudiología, combinada con la automatización, ofrece oportunidades únicas para mejorar los cuidados clínicos, ampliar el acceso a los servicios y tener cuidados de salud auditiva costoefectivos y sustentables. La Teleaudiología ha demostrado un potencial significativo en áreas como las de educación y adiestramiento de profesionales de la salud auditiva, profesionales afines, padres y adultos con problemas auditivos; tamiz de problemas auditivos; diagnóstico de pérdidas auditivas y servicios de intervención. La conectividad global está creciendo rápidamente y ha aumentado de manera generalizada su distribución en comunidades con pocos servicios, en donde los servicios audiológicos pueden facilitarse a través de modelos de telesalud. No obstante, existen muchas dudas que deben resolverse y que están relacionadas con aspectos como control de calidad, regulación del ejercicio profesional, responsabilidad jurisdiccional, certificación y reembolso de servicios, pero no existe como alternativa ninguna otra estrategia que pueda ofrecer actualmente el mismo potencial, para impactar el peso global de las pérdidas auditivas en el futuro cercano o previsible.

Tele-Health Principles and Practices Applied in Audiology:
Summary of Evidence-Based Applications

DISABILITY and Rehabilitation
Assistive Technology

informa healthcare

REVIEW PAPER

Technology for hearing loss – as We Know it, and as We Dream it

Jackie L. Clark[1,2] and De Wet Swanepoel[1,3]

[1]Callier Center, University of Texas at Dallas, Dallas, TX, USA, [2]Department of Speech Pathology & Audiology, University of the Witwatersrand, Gauteng, South Africa, and [3]Department of Speech-Language Pathology and Audiology, University of Pretoria, Hatfield, South Africa

Tele-Health Principles and Practices Applied in Audiology: *Video Otoscopy in Adults*
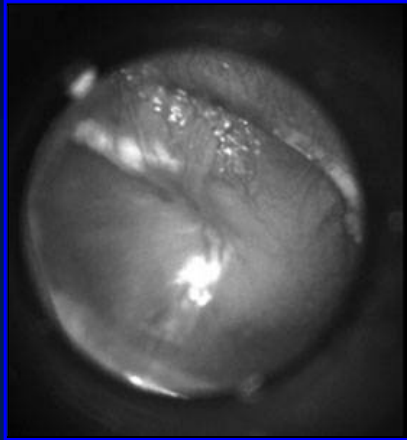
Video Otoscopy
(Acute Otitis Media)

Biagio L, Swanepoel D, Adeyemo A, Hall JW III & Vinck B (2013). Asynchronous video-otoscopy with a teleheatlh facilitator. *Telemedicine and e-Health, 19,* 1-7

Tele-Audiology: *Video Otoscopy is Comparable to Face-to-Face Otoscopy and When Performed by an Otolaryngologist versus a Facilitator*

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.

Table 3. Comparison of Asynchronous Assessment of Video–Otoscopic Images Acquired by an Otolaryngologist and a Clinic Facilitator (n=120 Ears)

	FREQUENCY THAT TM FEATURES COULD BE ASSESSED IN IMAGES BY		CONCORDANCE BETWEEN ASYNCHRONOUS VIDEO-OTOSCOPY IMAGES[a]	
	OTOLARYNGOLOGIST	FACILITATOR	κ VALUE	ASYMPTOTIC SE
TM surface structure	81.1	71.3	0.693	0.068
TM translucent/opaque	81.1	72.1	0.574	0.076
TM color	82.8	73.0	0.512	0.071
TM position	77.9	68.9	0.484	0.067
Diagnosis	–	–	0.596	0.070

[a]Concordance between asynchronous assessment of images acquired by the otolaryngologist and facilitator.
SE, standard error; TM, tympanic membrane.

Table 5. Concordance (Percentage) of Face–to–Face Otoscopy and Asynchronous Video–Otoscopy Using Images Acquired by an Otolaryngologist and a Clinic Facilitator (n=120 Ears)

	ASYNCHRONOUS VIDEO-OTOSCOPY CONCORDANCE	
FACE–TO–FACE OTOSCOPY DIAGNOSIS	OTOLARYNGOLOGIST IMAGES	FACILITATOR IMAGES
Normal	87.2	76.6
Abnormal	75.0	82.1

**Tele-Health Principles and Practices
Applied in Audiology: *Video Otoscopy in Children***

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

Tele-Health Principles and Practices Applied in Audiology: *Trans-Atlantic Pure Tone Audiometry (AAA, 2009)*


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

Equipment:
KUDUwave Automated
Audiometer

Tele-Health Principles and Practices Applied in Audiology:
Synchronous Technology for DPOAEs
(Krumm M & Syms MJ. Teleaudiology. Otolaryngol Clinics North America, 44, 2011)
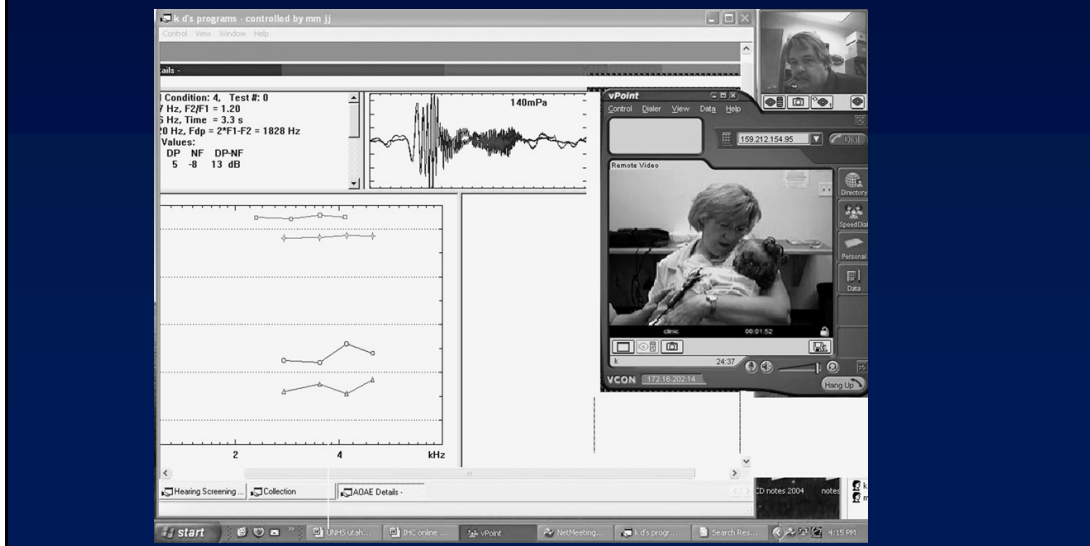
Tele-Health Principles and Practices Applied in Audiology:
Instrumentation for Remote ABR Measurement
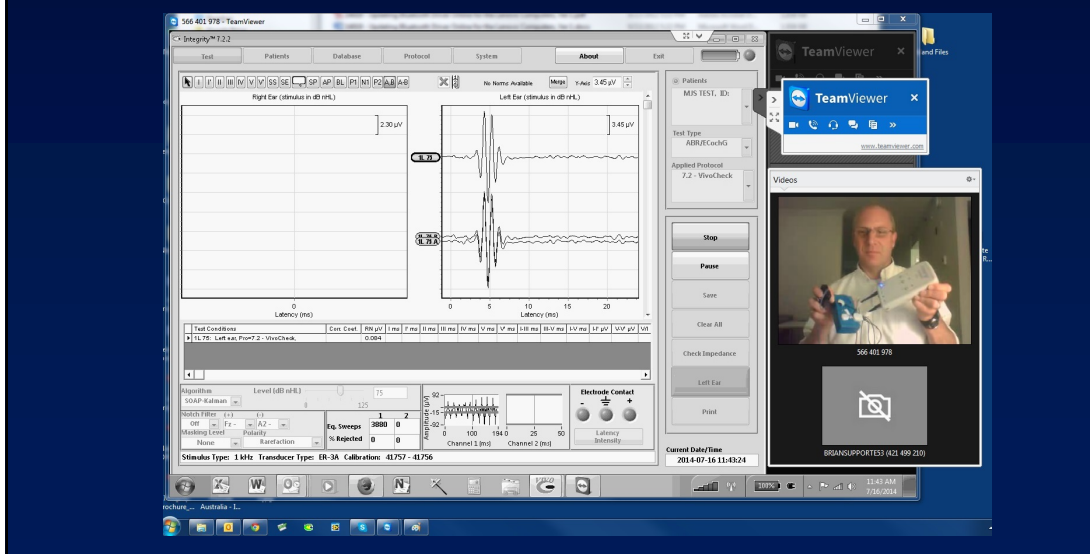
Tele-Audiology in Rural India:
Identification and Diagnosis of Infant Hearing Loss

Vidya Ramkumar,
Senior Lecturer, Part time-PhD,
Dept of Speech, Language and
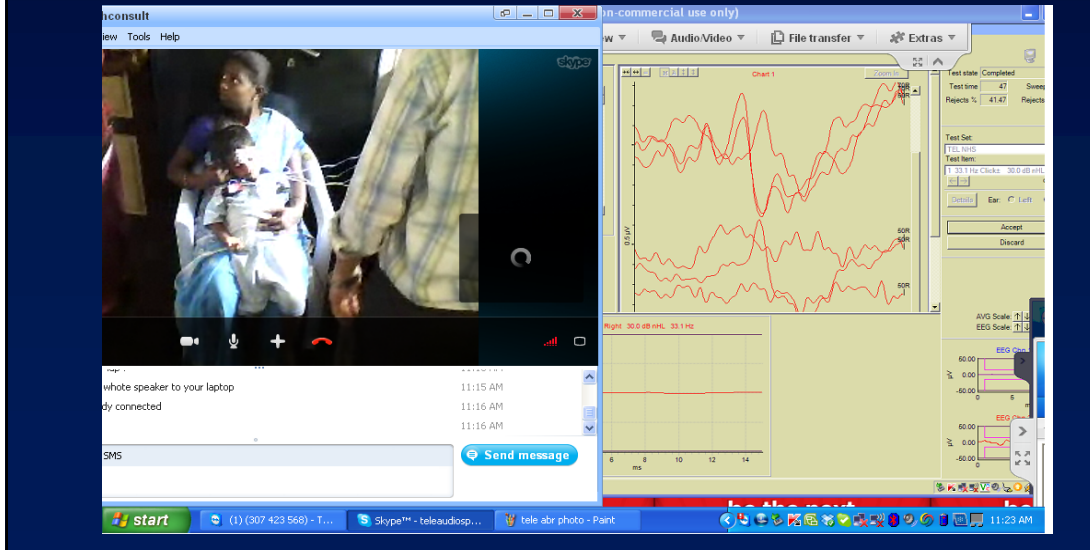Hearing Sciences,
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Chennai, India.

Fulbright Doctoral Research Fellow,
Dept of Speech pathology and Audiology,
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Validation of Remote identification (DPOAE) and Confirmation (ABR) of Infant Hearing Loss
(*Vidya.Ramkumar@gmail.com*)

Validation of Remote identification (DPOAE) and Confirmation (ABR) of Infant Hearing Loss (*Vidya.Ramkumar@gmail.com*)

Tele-Health Principles and Practices Applied in Audiology: *Breaking News About Technology*

Original Article

Smartphone hearing screening with integrated quality control and data management

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& Robert H. Eikelboom*[,†,‡]

*Department of Speech-Language Pathology and Audiology, University of Pretoria, Pretoria, South Africa, [†]Ear Sciences Centre, School of Surgery, The University of Western Australia, Nedlands, Australia, [‡]Ear Science Institute Australia, Subiaco, Australia, [#]Callier Center for Communication Disorders, University of Texas at Dallas, USA, and [$]Department of Electrical, Electronic and Computer Engineering, University of Pretoria, Pretoria, South Africa

Tele-Health Principles and Practices Applied in Audiology: *Calibration of SmartPhone*

Table 1. Smartphone acoustic calibration correspondence to reference equivalent threshold sound pressure levels (RETSPLs) at different intensities (20, 30, and 40 dB HL) using Sennheiser HD202 supra-aural headphones. Four smartphones (Samsung Galaxy Pocket Plus S5301) were calibrated at three intensity levels (20, 30, and 40 dB HL) using the same headphones according to RETSPLs for TDH39 supra-aural headphones (ISO 389-1:1998; ANSI/ASA S3.6:2010). Eight measurements (four in the left and four in the right) were made to approximate the RETSPL levels at every intensity for each smartphone.

	Calibration levels								
	20 dB HL			30 dB HL			40 dB HL		
	1 kHz	2 kHz	4 kHz	1 kHz	2 kHz	4 kHz	1 kHz	2 kHz	4 kHz
Average difference*	0.9	0.5	− 0.6	− 0.7	− 0.7	− 0.4	− 0.5	− 0.6	− 0.1
SD	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3
Maximum difference (abs)	1.0	0.8	0.8	1	0.9	0.7	0.8	0.8	0.4

*Average difference between smartphone calibration intensity and specified RETSPL for TDH39 supra-aural headphones (n = 8).

Tele-Health Principles and Practices Applied in Audiology: *Hearing Screening with SmartPhone*

Figure 5. Clinical hearing screening test on school child using smartphone with hearScreen™ application and HD202 headphones. Phone is held upside-down to ensure the microphone faces towards the test subject for environmental noise monitoring.

Table 3. Cross tabulation of screening outcomes for ears using conventional and mobile phone based hearing screening (n = 324 ears).

		Conventional screening		
		Pass	Refer	Total
Mobile phone screening	Pass	96.3% (312)	0.9% (3)	**97.2% (315)**
	Refer	1.2% (4)	1.5% (5)	**2.7% (9)**
	Total	**97.5% (316)**	**2.4% (8)**	

Audiology Applications of Tele-Health: A Key Strategy for Increasing Access to Hearing Care Globally

Access
to Quality Hearing Care
(Children and Adults) in a Country

Automated Audiometry	Tele-Audiology	Trained Technicians

Tele-Health Principles and Practices Applied in Audiology: *Questions?*

Political Map of the World, April 2000