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DETECTION AND DIAGNOSIS VIA TELEAUDIOLOGY

De Wet Swanepoel

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2. Ear Sciences Centre, School of Surgery, University of Western Australia,
3. Ear Science Institute Australia, Subiaco, Western Australia

Learning Objective

• Learners will be able to describe how teleaudiology can be employed for detection and diagnosis of hearing loss.
OUTLINE

• What is telehealth?
• Why telehealth for detection & diagnosis of HL?
• Does it work? Evidence
• Digital health – a changing landscape
• Examples - detection & diagnosis

WHAT IS TELEHEALTH?

• Telehealth literally means “health care at a distance”
• Provision of health services from one location to another using a telecommunications medium
• Refers to “utilization of information and communication technology in health care”
• Terminology: telemedicine, online health, e-health, telepractice. “Tele” i.e. Tele-audiology, tele-therapy, tele-intervention etc
Concept as old as telecommunication mediums

**TELEHEALTH MODELS**

- **Remote Site**: Patient, Facilitator
- **ICT**: Asynchronous / Store & Forward
- **Health Provider Site**: Healthcare Professional

**Onsite Environment**: Synchronous / Realtime

**Virtual Environment**
WHY TELEHEALTH? [DETECTION & DIAGNOSIS]

• 1\textsuperscript{st} step to intervention and improved outcomes

• Bridging the MASSIVE NEED & POOR ACCESS

• Distances, geographical, weather obstacles can be bridged

• Equitable distribution of professional expertise - urban/rural, developed/developing

WHY TELEHEALTH? [PREVALENCE]

Prevalence of Disabling Hearing Loss (>40 dB for adults; >30 dB for children) for all populations
Projected demand for audiology services over next 30 years (US)

Audiologists to serve the required need:
- 2015 – 80%
- 2030 – 64%

Windmill & Freeman, 2013
A Systematic Review of Telehealth Applications in Audiology

De Wet Swanepoel, Ph.D.,¹² and James W. Hall, III, Ph.D.³,¹

VOL. 16 NO. 2 • MARCH 2010  TELEMEDICINE and e-HEALTH

• 386 Reports (3 databases) - final within study scope 26
• Reports: 5 screening; 12 diagnostics, 7 intervention; 2 patient perceptions
• Populations: Children & Adults
• Models: Synchronous & Asynchronous

TELE-AUDIOLOGY REPORTS

DETECTION

• Telephone & internet – possible and accepted

• DPOAE & AABR screening in infants – equivalent results

• Otoscopy, immittance & PT AC in pre-school children – equivalent results
TELE-AUDIOLOGY REPORTS

DIAGNOSTICS

- **Balance** disorder consultation and testing
- **PT AC & BC** audiometry - equivalent findings
- **Video-otoscopic** images - equivalent findings
- **HINT** results - comparable findings
- **ABR** and **OAE** testing - comparable results
- **Intraoperative monitoring** – CI device check and responses

### Diagnostic Teleaudiology

<table>
<thead>
<tr>
<th>Diagnostic Procedure</th>
<th>Telehealth Modes Applicable</th>
<th>Automation</th>
<th>Populations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case history</td>
<td>Store-and-forward or real time</td>
<td>Can be automated</td>
<td>All</td>
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<tr>
<td>Video-otoscopy</td>
<td>Store-and-forward</td>
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<td>All</td>
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<tr>
<td>Tympanometry</td>
<td>Store-and-forward or real time</td>
<td>Automated</td>
<td>All</td>
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<tr>
<td>Acoustic reflexes</td>
<td>Store-and-forward or real time</td>
<td>Automated/ semiautomated</td>
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<tr>
<td>Puretone audiometry</td>
<td>Store-and-forward or real time</td>
<td>Can be automated</td>
<td>Older children and adults</td>
</tr>
</tbody>
</table>
AUTOMATED AUDIOMETRY

Validity of Automated Threshold Audiometry: A Systematic Review and Meta-Analysis

Faheema Mahomed,1 De Wet Swanepoel,1,2,3 Robert H. Eikelboom,1,2,3 and Maggi Soer1

Ear & Hearing 2013;34;745–752

- 29 reports (method of limits and method of adjustment); 1956 - 2011.
- Meta-analysis test-retest and accuracy for automated audiometry was within typical test-retest variability for manual audiometry
- Accurate measure of hearing threshold, but data limited for (i) automated BC audiometry; (ii) children and difficult-to-test populations and; (iii) different types and degrees of hearing loss

DIAGNOSTIC TELEAUDIODYLIOLOGY

| Summarizing Applications of Common Diagnostic Audiologic Procedures Using Telehealth |
|---------------------------------|-----------------|-----------------|----------------|
| **Diagnostic Procedure**        | **Telehealth Modes Applicable** | **Automation** | **Populations** |
| Case history                    | Store-and-forward or real time | Can be automated | All             |
| Video-otoscopy                  | Store-and-forward | – | All             |
| Tympanometry                    | Store-and-forward or real time | Automated | All             |
| Acoustic reflexes               | Store-and-forward or real time | Automated/ semiautomated | All             |
| Puretone audiometry             | Store-and-forward or real time | Can be automated | Older children and adults |
| Speech audiometry               | Real time | – | Older children and adults |
| Otoacoustic emissions           | Store-and-forward or real time | Automated | All             |
| Auditory brainstem response     | Real time | – | All             |
| Intraoperative monitoring       | Real time | – | All             |
| Balance testing                 | Real time | – | Older children and adults |
CHANGING LANDSCAPE

Telehealth » Digital Health

Convergence of digital and genomic revolutions with health, healthcare, living, and society

DIGITAL HEALTH

Includes categories like mHealth, health IT, wearables, telehealth and telemedicine, and personalized medicine

Empowering us to better track, manage, and improve our own and our family’s health,

To live better, more productive lives, and improve society.
DIGITAL HEALTH

Reduce inefficiencies; Improve access; Reduce costs; Increase quality; and Make medicine more personalized (FDA, 2017)

Patients and consumers can use digital health to better manage and track their health and wellness related activities

Advancements are leading to a convergence of people, information, technology and connectivity to improve health care and health outcomes

https://www.fda.gov/MedicalDevices/DigitalHealth/

CHANGING LANDSCAPE

Telehealth Digital Health

DRIVERS

- Access to care
- Cost-efficiency
- Automation
- Ubiquitous connectivity
- Exponential technology
- Wellness & self-monitoring
- Big data analytics
“Mobile communication has arguably had a bigger impact on humankind in a shorter period of time than any other invention in human history”

Minges, 2012 – World Bank Report
UBIQUITOUS CONNECTIVITY

Kathy Calvin, chief executive of the United Nations Foundation, mobile phones have the potential to "have as big an impact on global healthcare as Sir Alexander Fleming's 1928 discovery of penicillin."

*Telemedicine and e-Health Bulletin, October 26, 2010*

EXPONENTIAL TECHNOLOGY

Technologies where the power and/or speed are doubling, and/or the cost is halved every year
Today half the adult population has a smartphone in 2020 80% will

WELLNESS & SELF-MONITORING

Self-Monitoring Health Technologies

$1,100,000,000

2013

$18,800,000,000

580% Growth

$3,200,000,000

2014

$18,800,000,000

580% Growth

2019

BIG DATA ANALYTICS

1. Cost reduction
2. Faster, better decision making
3. New products & services

Analysis in motion in real-time as it streams in can help predict onset, respond instantly from new insight that will help transform healthcare

EXPLORING NOVEL SOLUTIONS

3 examples - digital health (mHealth)

Access to Care
- Detection
- Diagnosis
- Intervention
EXPLORING NOVEL SOLUTIONS

DETECTION AND DIAGNOSIS

TEAM

Prof De Wet Swanepoel (Project lead)
Dr Herman Myburgh (UP project co-lead)
Prof Claude Laurent (Co-investigator, Sweden)
Prof Robert Eikelboom (Co-investigator, Australia)
Dr Cas Smits (Co-investigator, Netherlands)
Prof Jannie Hugo (Co-investigator)
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Ms Christine Louw (PhD student)
Ms Shouneez Yousuf (PhD student)
Ms Jessica van Tonder (M student)
Mr Mathieu van der Aerschot (M student)
Dr Josefin Sandstrom (PhD student – Sweden)

Disclosure: Co-founder and advisor. hearX Group Pty Ltd
# EVIDENCE-BASED

<table>
<thead>
<tr>
<th>hearScreen</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Accurate &amp; reliable</td>
<td>✓</td>
</tr>
<tr>
<td>Time efficient</td>
<td>✓</td>
</tr>
<tr>
<td>Cost-effective</td>
<td>✓</td>
</tr>
<tr>
<td>Noise monitoring</td>
<td>✓</td>
</tr>
<tr>
<td>Trained laypersons</td>
<td>✓</td>
</tr>
</tbody>
</table>
HEALTHY HEARING FOR
HEALTHY LEARNING

HEALTHY VISION?
VIDEO:

hearScreen Mamelodi
EAR DISEASE - THE PROBLEM

- Global burden from chronic OM affect 65 – 330 million
- 28 000 deaths annually (most from India & sub-Saharan Africa)
- COM – 1) risk of hearing loss and 2) life-threatening complications (e.g. meningitis, brain abscesses)
- Largely preventable and effective medical management
- Early detection and treatment at primary care can reduce long-term morbidity and mortality

BUT - Poor access to specialist personnel limit diagnosis and appropriate treatment

(REMOTE DIAGNOSIS OF EAR DISEASE)


AUTOMATED DIAGNOSIS OF EAR DISEASE

Study aim

to develop and validate a new image analysis system to classify images obtained from commercial video-otoscopes into one of 5 diagnostic groups

METHOD

489 images with diagnoses in agreement between two experienced otologists (approximately 50% from children)

Distribution: O/W (n=120), n-TM (n=123), AOM (n=80), OME (n=80), and CSOM with perforation (n=86).

80% of images (n = 391) were randomly selected to develop the feature extraction algorithms to develop a decision tree

Remaining 20% (n = 98) were used for the validation study
CONCLUSIONS

- Accuracy of proposed classification system compares well with accuracy of general practitioners and pediatricians (~64% to 80%) using traditional otoscopes.

- Holds promise for making asynchronous automated diagnosis of otitis media in medically underserved populations.
SMARTPHONE OTOSCOPY

- Smartphone video-otoscopy
- High-quality, low cost
- Automated image analysis and diagnostic system
hhearZA
NATIONAL HEARING TEST
OF SOUTH AFRICA

Developed by the University
of Pretoria
What is it

- Ability to understand speech-in-noise
- Relative calibration = any headphone
- Digits = low linguistic load
- Quick and simple

Access

Device ownership and connectivity per household

Source: Ericsson ConsumerLab, TV and media report 2015, Nigeria
Base: Internet users in respective countries or regions
### AIMS

1. Accurate detection of hearing loss
2. Strategic public awareness tool
3. Personalized hearing health tracking
4. Linking to hearing health providers
5. In-app decision support (Ida telecare)

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### 1. ACCURATE TESTING

**DEVELOPMENT**

1. **Phase I:** Recording and equalization of the digits
2. **Phase II:** Development of the smartphone application and test procedures
3. **Phase III:** Smartphone digits-in-noise test headphone type effect and norms

**Sens/Spec =**

95% / 87%

---


1. ACCURATE TESTING

Headphone type effect

No signf effect (p=0.84)

Figure 2. The average speech recognition probabilities for digit-triplets at each SNR conducted using five different headphone types presented using the smartphone application.

1. ACCURATE TESTING

1. Download the hearZA App
2. Identify three digits in background noise
3. Hearing scored based on your SNR
2. PUBLIC AWARENESS TOOL

VIDEO:

Nataniel
2. PUBLIC AWARENESS TOOL

3. HEARING HEALTH TRACKING

- Personalized hearing score
- Annual in-app reminders
- Hearing scoreboard
4. LINKAGES TO HEARING CARE

PARTNERSHIP WITH ASSOCIATIONS
National initiative

REFERRAL DATABASE
In-app referral to closest provider
Secure cloud-based referral system

n=368 practices

4. LINKAGES TO HEARING CARE

22 113 DOWNLOADS
23 978 TESTS

7178 (30%) TEST FAILURES
728 (10%) REQUESTS FOR FOLLOW UP
5. DECISION-SUPPORT

Ida Telecare tools
Adapted for hearZA
Decision support
n=659

RAPIDLY CHANGING WORLD

“I have not found anything in these tests, as yet, that seems to be of any assistance…. I plead guilty of being a mere otologist. The more I see of the audiometer the more respect I have for the tuning fork and Galton Whistle.”

(Dr Max Goldstein, Transactions of the American Otological Society, 1922)
CONCLUSION

Growth in connectivity, technology and data analytics can support hearing health care by:

1. access for more people
2. improved efficiency and quality of health care
3. new models of health prevention and delivery
4. personalised hearing health

QUESTIONS

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