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DETECTION AND DIAGNOSIS VIA TELEAUDIOLOGY

De Wet Swanepoel

1. Dept of Speech-Language Pathology & Audiology, University of Pretoria,
2. Ear Sciences Centre, School of Surgery, University of Western Australia,
3. Ear Science Institute Australia, Subiaco, Western Australia

2

Learning Objective

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

3

OUTLINE

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

4

WHAT IS TELEHEALTH?

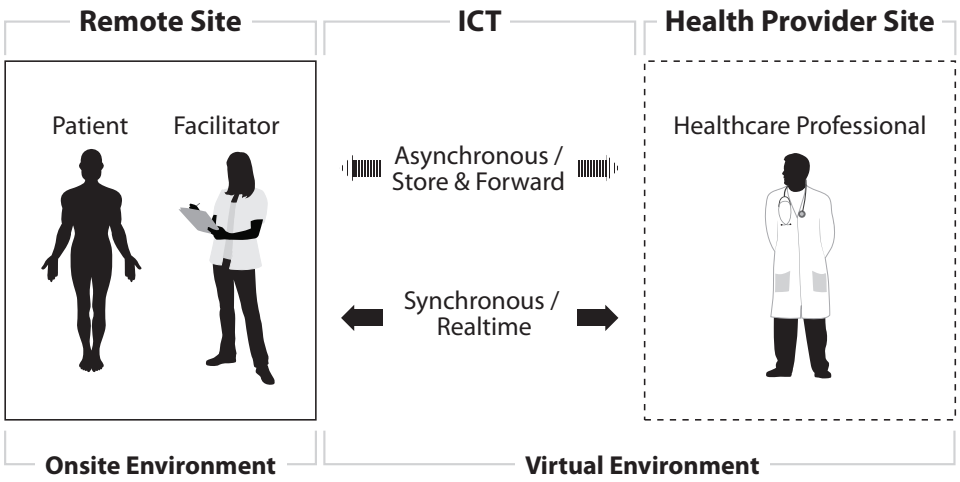
- Telehealth literally means "**health care at a distance**"
- Provision of health services from one location to another using a **telecommunications medium**
- Refers to "**utilization of information and communication technology in health care**"
- Terminology: telemedicine, online health, e-health,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

5

Concept as old as telecommunication mediums

6

TELEHEALTH MODELS



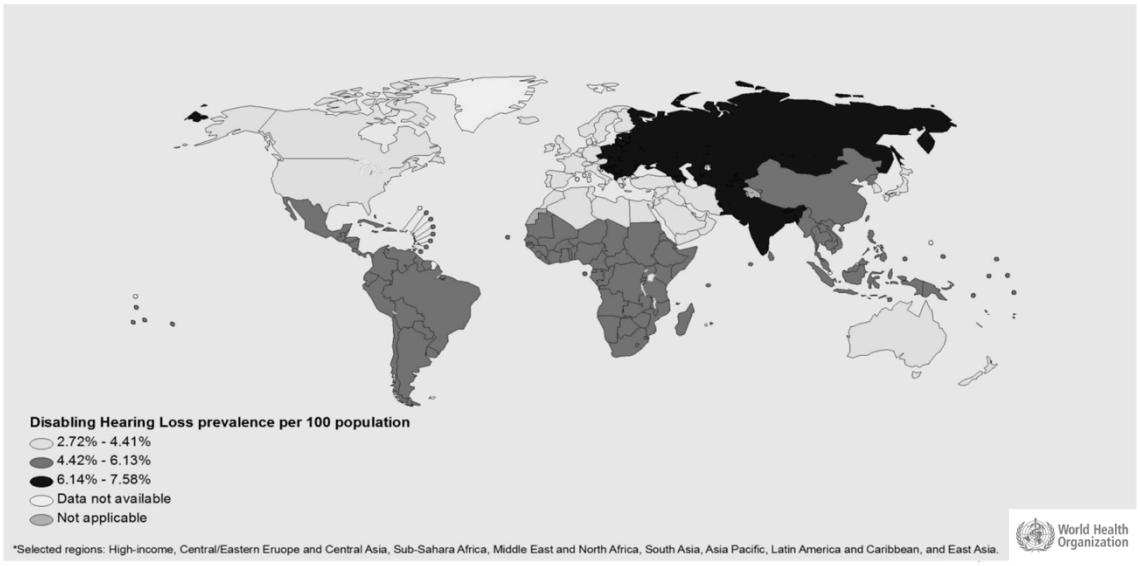
7

WHY TELEHEALTH? [DETECTION & DIAGNOSIS]

- 1st 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

8

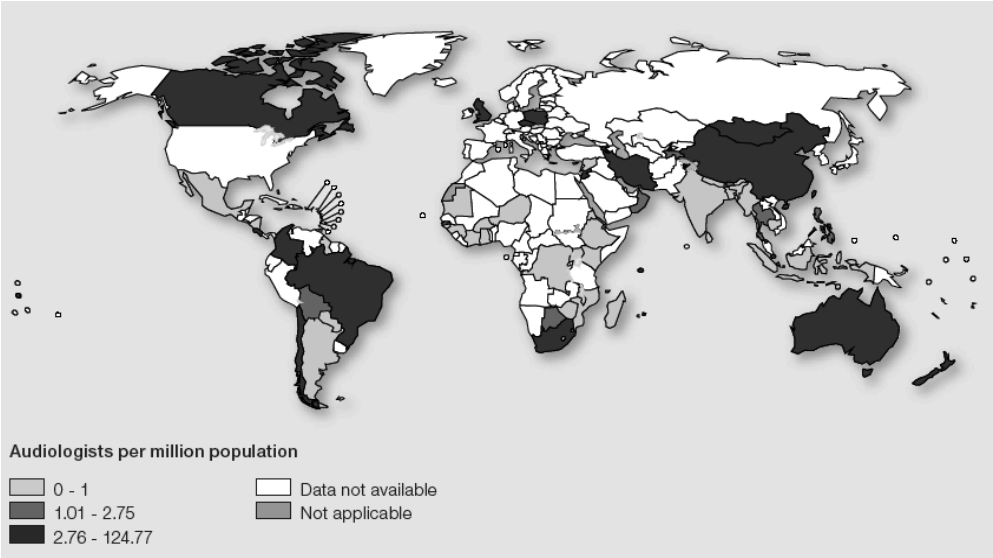
WHY TELEHEALTH? [PREVALENCE]



Prevalence of Disabling Hearing Loss (>40 dB for adults; >30 dB for children) for all populations

9

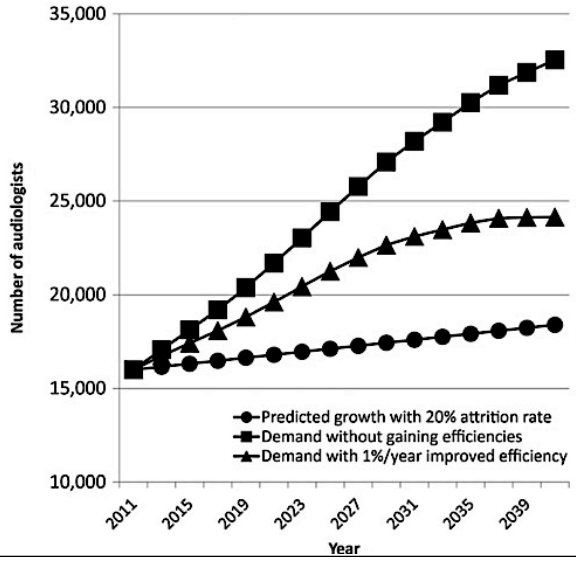
WHY TELEHEALTH? [ACCESS]



WHO, 2013

10

WHY TELEHEALTH? [ACCESS]



Projected demand for audiology services over next 30 years (US)

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

Windmill & Freeman, 2013

11

TELEAUDIOLOGY EVIDENCE

A Systematic Review of Telehealth Applications in Audiology

De Wet Swanepoel, Ph.D.,[1,2] 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

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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

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DIAGNOSTIC TELEAUDIOLOGY

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	
Puretone audiometry	Store-and-forward or real time	Can be automated	Older children and adults

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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 Soer[1]

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

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DIAGNOSTIC TELEAUDIOLOGY

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	
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

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CHANGING LANDSCAPE

Telehealth → Digital Health

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

18

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.

19

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/

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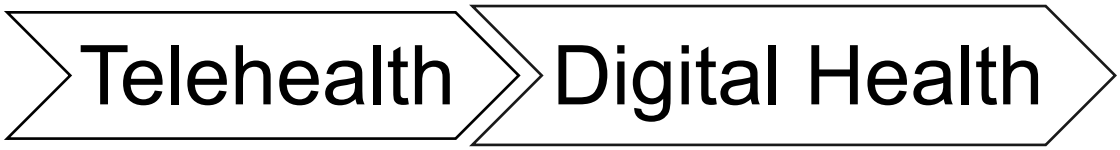
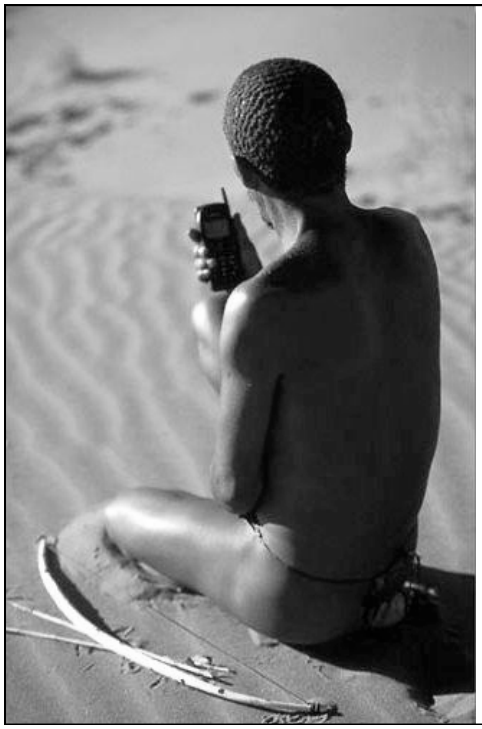
CHANGING LANDSCAPE



DRIVERS

- Access to care
- Cost-efficiency
- Automation

- Ubiquitous connectivity
- Exponential technology
- Wellness & self-monitoring
- Big data analytics



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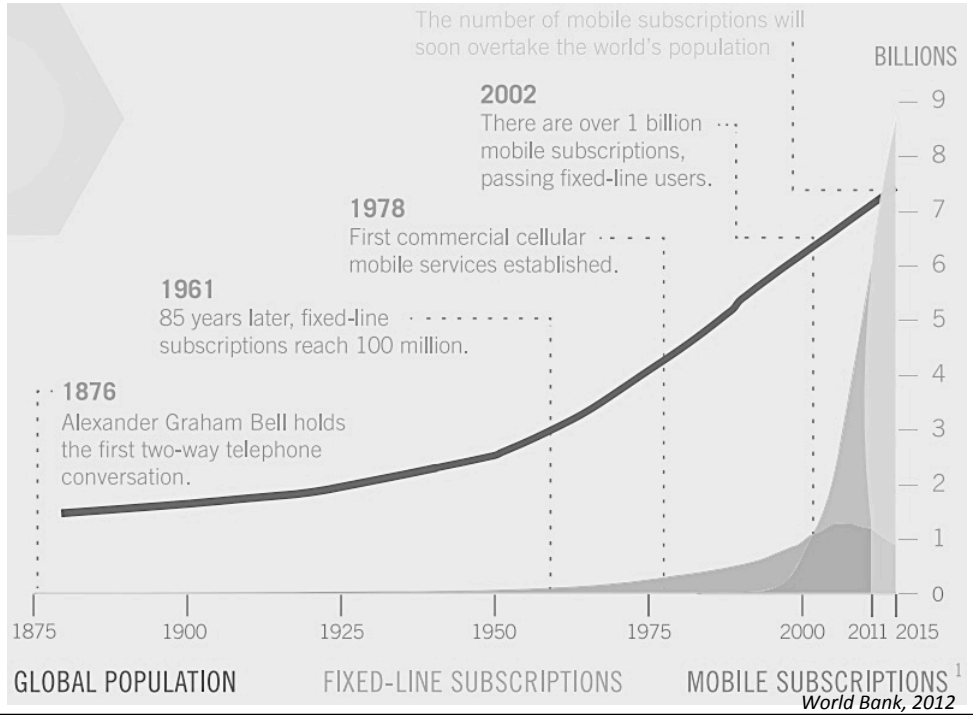
UBIQUITOUS CONNECTIVITY

"**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

22



World Bank, 2012

23

UBIQUITOUS CONNECTIVITY

mHealth

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

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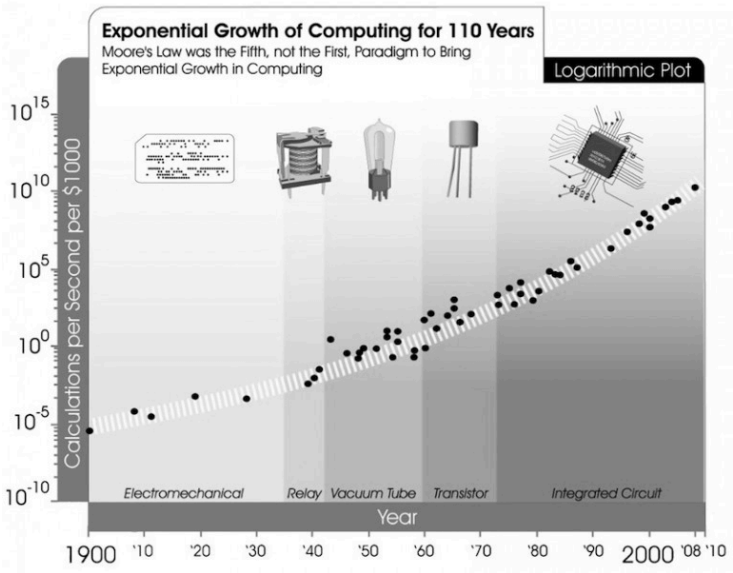
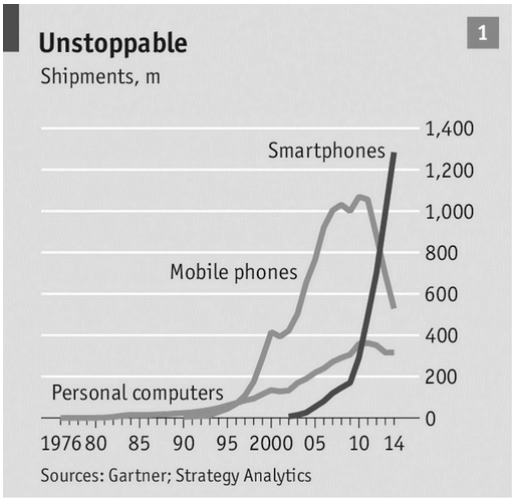
EXPONENTIAL TECHNOLOGY

Technologies where the power and/or speed are doubling, and/or the cost is halved every year



25

Today half the adult population has a smartphone in 2020 80% will



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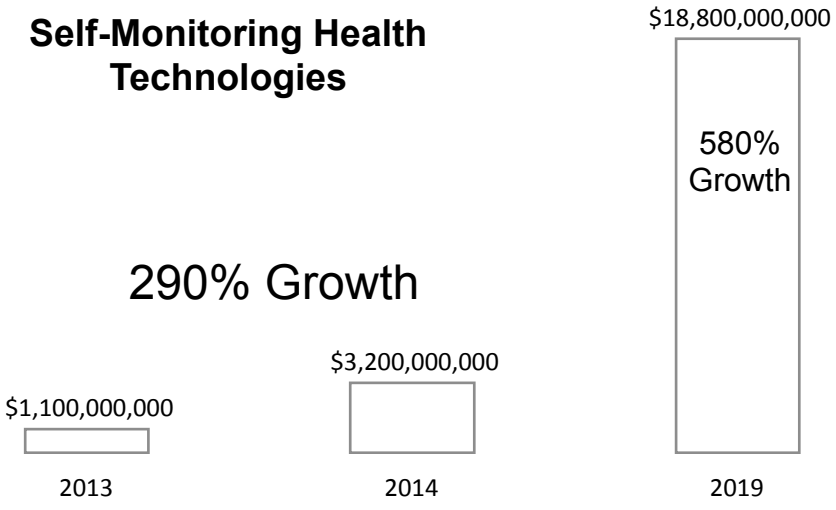
WELLNESS & SELF-MONITORING



*Mobi Health News: http://www.mobihealthnews.com/44873/global-health-tracking-technology-market-to-reach-18-8b-in-2019

27

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

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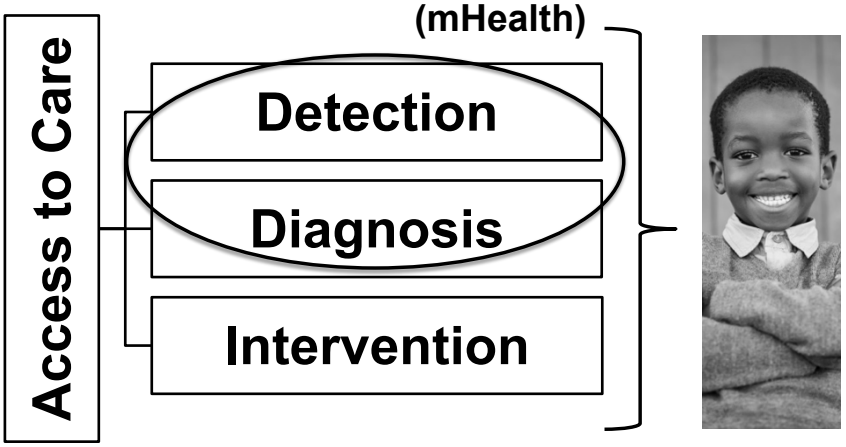
EXPLORING NOVEL SOLUTIONS

3 examples - digital health (mHealth)



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EXPLORING NOVEL SOLUTIONS

DETECTION AND DIAGNOSIS

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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)
Dr Faheema Mahomed (PhD student)
Ms Jenni-Mari Potgieter (PhD student)
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

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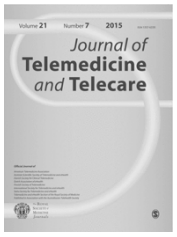
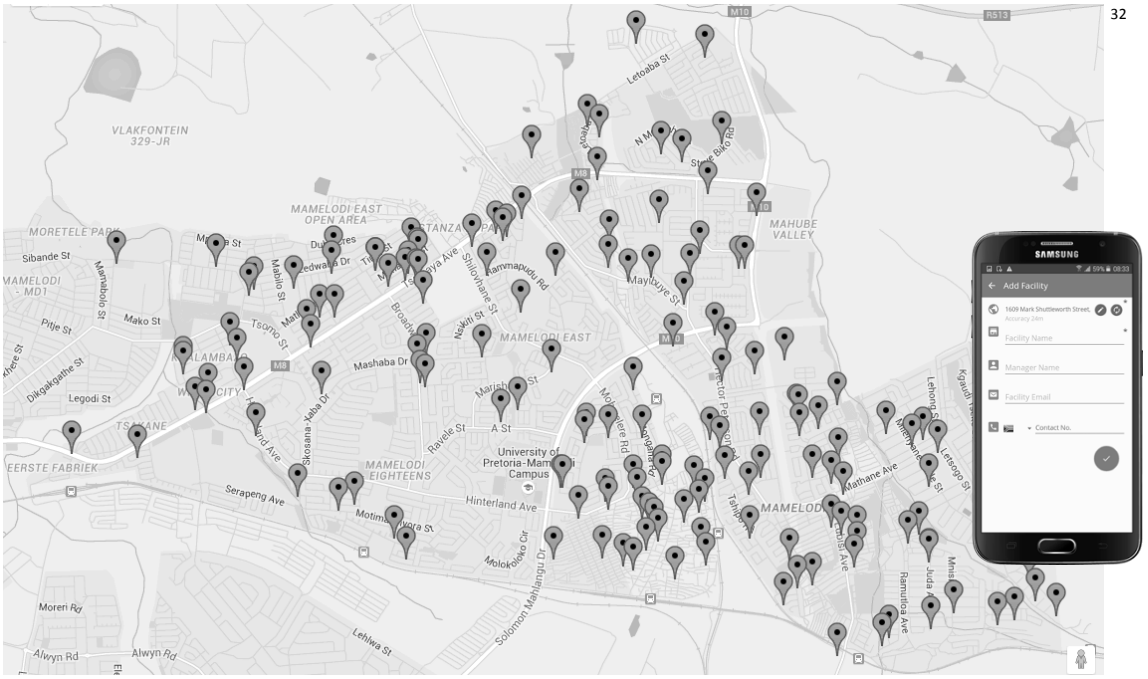
EVIDENCE-BASED

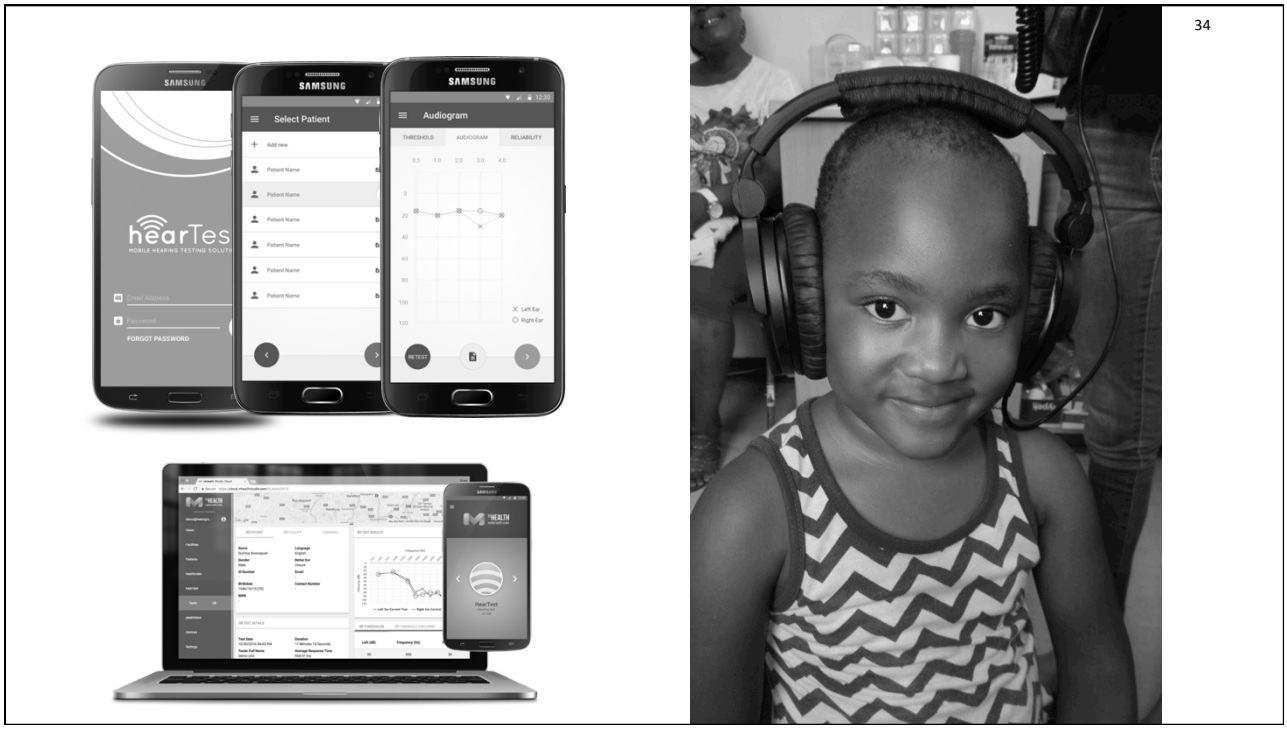
	hearScreen
Accurate & reliable	✓
Time efficient	✓
Cost-effective	✓
Noise monitoring	✓
Trained laypersons	✓



32




33
SAMSUNG
Testing Patient Name
SAMSUNG
Test Results
Refer
Severity : Moderate loss
Impairment Type : Unilateral loss
Patient Kate Wooding
Protocol Child (35dB) DEFAULT (SEVERITY)
Freq Test 1 Test 2
kHz L R L R
1.0
2.0
4.0
text


34
SAMSUNG
SAMSUNG
Select Patient
SAMSUNG
Audiogram
THRESHOLD
AUDIOGRAM
RELIABILITY
FORGOT PASSWORD
RETEST

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HEALTHY HEARING FOR HEALTHY LEARNING

HEALTHY VISION?

peek

Vision and Health for Everyone

LONDON SCHOOL of HYGIENE &TROPICAL MEDICINE

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VIDEO:

hearScreen Mamelodi

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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**

(WHO, 2013; Acuin, 2004)

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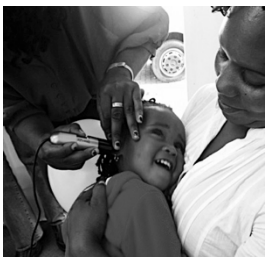
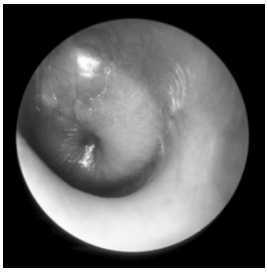
REMOTE DIAGNOSIS OF EAR DISEASE





Biagio L, Swanepoel D, Laurent C, Lundberg T (2014). Video-otoscopy recordings for diagnosis of childhood ear disease using telehealth at primary health care level. ***Journal of Telemedicine and Telecare***, 20(6):300-306.

Lundberg T, Biagio L, Laurent C, Sandström H, Swanepoel D (2014). Remote evaluation of video-otoscopy recordings in an unselected pediatric population with an otitis media scale. ***International Journal of Pediatric Otorhinolaryngology***, 78(9):1489-1495.

Biagio L, Swanepoel D, Adeyemo A, Hall JW III, Vinck B (2013). Asynchronous video-otoscopy by a telehealth facilitator. ***Telemedicine and e-Health***, 19(4):252-258

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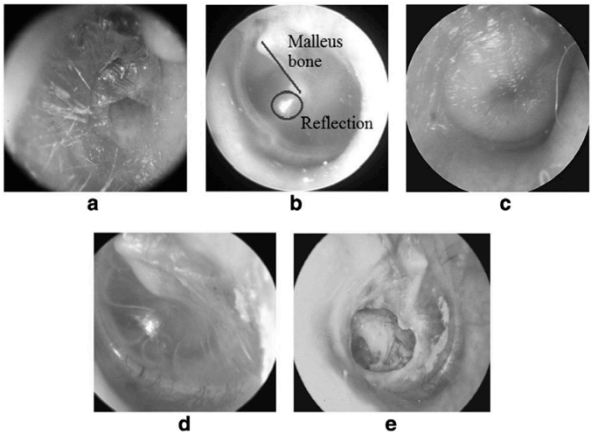
AUTOMATED DIAGNOSIS OF EAR DISEASE

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**



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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

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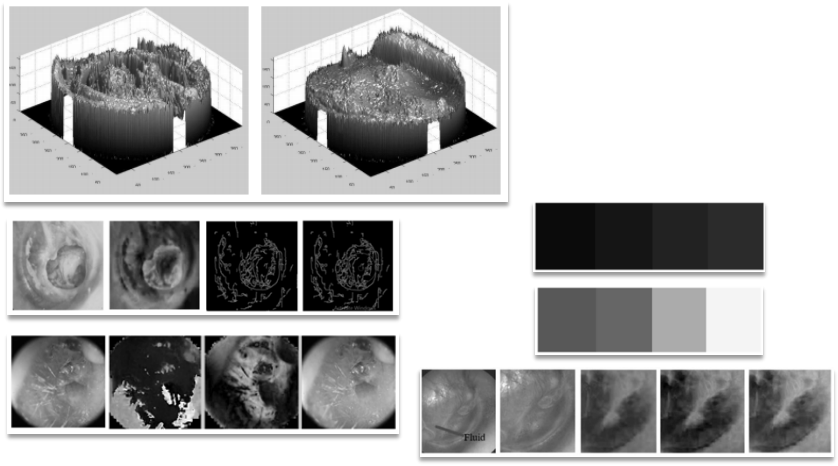
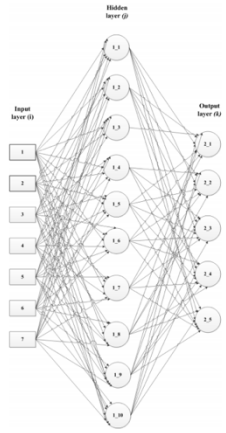
AUTOMATED DIAGNOSIS - SOFTWARE

- Feature extraction





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EBioMedicine
Supported by CellPress | THE LANCET

Otitis Media Diagnosis for Developing Countries Using Tympanic Membrane Image-Analysis

Hermanus C. Myburgh [a], Willemien H. van Zijl [a], DeWet Swanepoel [b,c,g], Sten Hellström [d,e], Claude Laurent [b,f,*]

[a] Department of Electrical, Electronic and Computer Engineering, University of Pretoria, Pretoria, South Africa
[b] Department of Speech-Language Pathology and Audiology, University of Pretoria, Pretoria, South Africa
[c] Ear Sciences Centre, School of Surgery, The University of Western Australia, Nedlands, Australia
[d] Department of Audiology and Neurotology, Karolinska University Hospital, Stockholm, Sweden
[e] CLINTEC/Otorhinolaryngology, Karolinska Institutet, Stockholm, Sweden
[f] Department of Clinical Science, University of Umeå, Umeå, Sweden
[g] Ear Science Institute Australia, Subiaco, Western Australia

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

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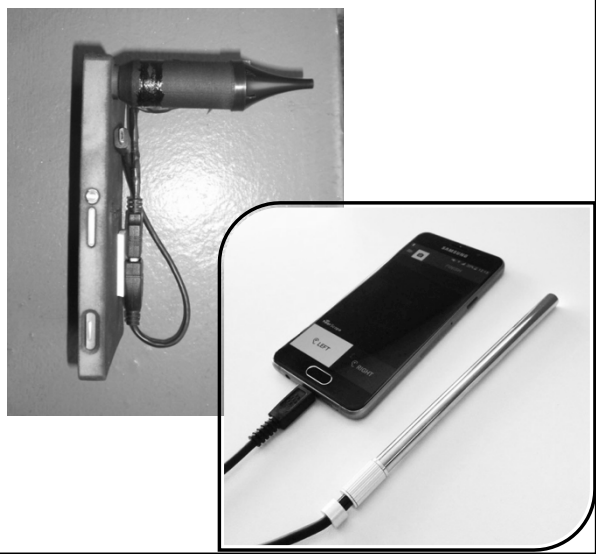
SMARTPHONE OTOSCOPY

- Smartphone video-otoscopy
- High-quality, low cost
- Automated image analysis and diagnostic system



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hearZA

NATIONAL HEARING TEST
OF SOUTH AFRICA

Developed by the University
of Pretoria

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What is it

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

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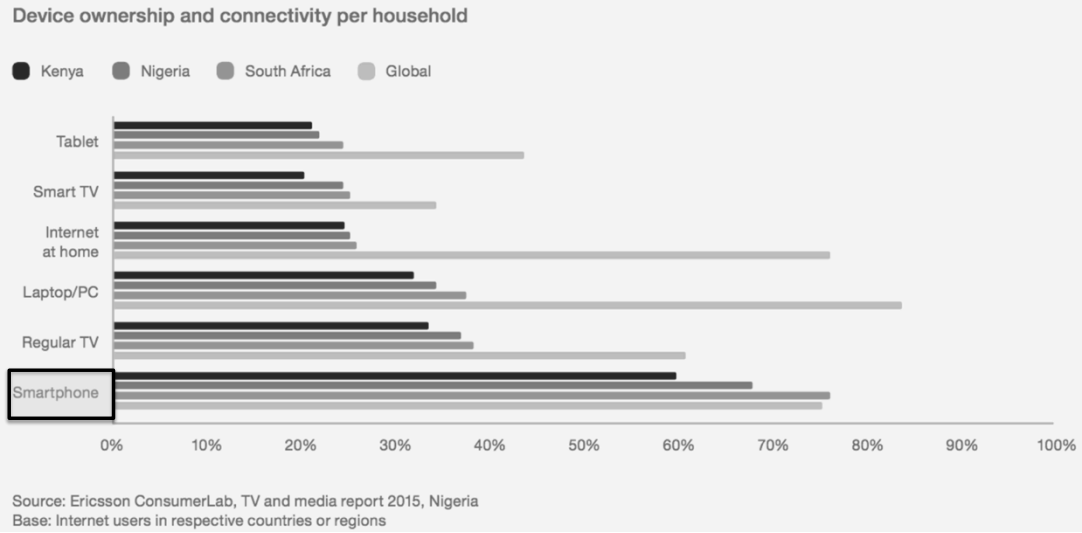
Access



AIMS

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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)

1. ACCURATE TESTING

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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

Potgieter, Swanepoel, Myburgh , Smits (2016). Development and validation of a smartphone-based speech-in-noise hearing test in South African English. International Journal of Audiology, In Press

Sens/Spec =

95% / 87%

4. Phase IV: Performance of EAL speakers on the smartphone digits-in-noise test compared to native English speakers.

Potgieter, Swanepoel, Myburgh , Smits (2016). Smartphone digits-in-noise hearing test: performance of English additional language speakers. Ear and Hearing, In Review

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1. ACCURATE TESTING

Headphone type effect

No signf effect (p=0.84)

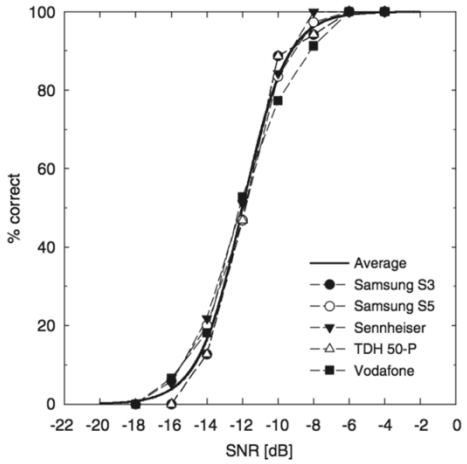

Figure 2. The average speech recognition probabilities for digit-triplets at each SNR conducted using five different headphone types presented using the smartphone application.

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1. ACCURATE TESTING

1

ANDROID APP ON Google play

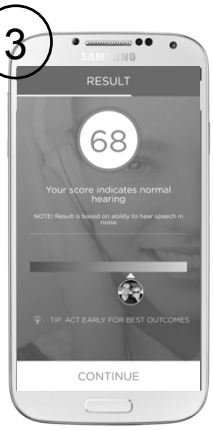
Available on the App Store

Download the hearZA App

2

Identify three digits in background noise

3



Hearing scored based on your SNR

2. PUBLIC AWARENESS TOOL

55

2. PUBLIC AWARENESS TOOL

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VIDEO:

Nataniel

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2. PUBLIC AWARENESS TOOL

vodacom

sivantos
the hearing company

oticon
PEOPLE FIRST

EAR INSTITUTE
WORLD-CLASS HEARING
for your family!

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3. HEARING HEALTH TRACKING

- Personalized hearing score
- Annual in-app reminders
- Hearing scoreboard

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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

60

4. LINKAGES TO HEARING CARE

ANDROID APP ON Google play
Available on the App Store

22 113
DOWNLOADS

23 978
TESTS

7178 (30%)
TEST FAILURES

728 (10%)
REQUESTS FOR FOLLOW UP

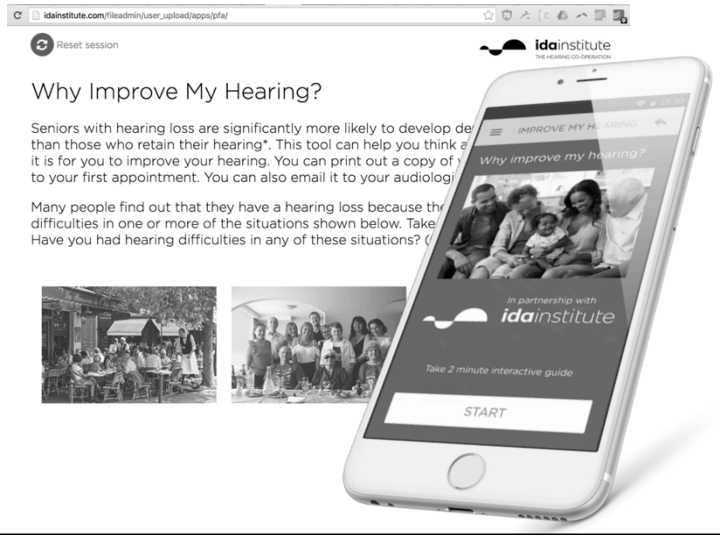
61

5. DECISION-SUPPORT

Ida Telecare tools
Adapted for hearZA

Decision support

n=659



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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)

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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

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QUESTIONS

dewet.swanepoel@up.ac.za