

# Tele-audiometry – a ShoeBOX solution

Access to hearing assessment is a global challenge. In relation to the global burden of hearing loss World Health Organisation's (WHO's) recent estimate (2013) is that 360 million people in the world have disabling hearing impairment. Two-thirds of these people live in developing countries and 10% of all people with disabling hearing impairment are children (<15 years of age). There are many rural and underserved areas in the world.

Advances in technology and connectivity are shaping the way in which we deliver services. Tele-audiology is the use of telehealth to provide audiological services. 'Tele' is a Greek word meaning distance. It describes the generality of the practice of care over distance. Telehealth has a variety of applications in patient care, education, research, administration and public health. Although initially considered futuristic, experimental and outside of mainstream healthcare, telehealth is

a reality today and is growing in its application. It's evolving to the changing health needs and contexts of societies. We are starting to see more affordable solutions for remote areas and developing countries with these advances. In this spotlight we look at an innovative tablet based hearing test system. We talk to **Dr Matthew Bromwich**, Creator of ShoeBOX. We also hear from **Andrew Thamboo** about experiences testing over 600 children in Uganda with the system.



## Dr Bromwich, tell us a little about ShoeBOX audiometry

We wanted to bring audiometry to communities who didn't have access. The whole idea is to put everything you need for screening and clinical testing in a ShoeBOX. This initial version was developed for the iPad Air, leveraging all of the usual functions of an iPad - listening, playing games and accessing information to enable hearing screening in remote locations, with or without internet access.

While originally developed for children, we've since created a 'grown-up' version to support testing in audiology clinics, primary care and industrial settings. The model remains the same but the user interface uses graphics more appropriate for adults.

## What was the motivational drive behind designing this product?

Our children's hospital, CHEO, supports communities in northern Canada. Working with them we recognised a need for portable, simplified solutions to support those remote communities, so we built one.

### What ages can it assess and at what frequencies?

From age 3 and up, across 125-8000Hz.

### What validation tests have been done to show the sound delivered to the ear is comparable to traditional audiometry? What transducers can be used?

Several studies have been done and more are on the way validating the model in multiple environments and with multiple types of users. Any transducer can be used, but we have currently standardised on TDH 39, ER3A and B71.

### How does the system check ambient noise levels and false positive responses?

Ambient noise is first tested at the beginning of the test to ensure the test is likely to succeed, using the iPad microphone. It is then continually monitored to ensure each individual result is valid. False positives are managed with negative control trials. The final audiogram indicates, for each frequency, whether the result is valid or should be retested based on ambient noise or unexpected results.

### In theory, could a parent or teacher facilitate the test, or the child test themselves?

Yes – we just completed a study on this. Success rates are not quite as high primarily due to background noise and type of headphones. The product is great for screening. However, we feel that this is a great tool for the audiologist in diagnostic audiometry.

You can learn more about ShoeBOX at [www.clearwaterclinical.com/ShoeBOX](http://www.clearwaterclinical.com/ShoeBOX)

### Andrew Thamboo, you have been involved as a beta testing site for over 600 children assessments in Africa using ShoeBOX audiometry. This sounds like a really interesting project, can you tell us a bit about it? Could you also describe some of the challenges of access to hearing assessment in Africa?

There were six schools that were visited. The level of education varied between schools. Schools were either entirely private, partial public-private mix and others were entirely public. The six schools we visited were:

- Mbarara Mixed School
- Mbarara Primary School
- St Aloysius Primary School
- St Agnes Primary School
- Boma Primary School
- Mbarara Army Secondary School

In 2008 the WHO estimated that 664 million people have hearing impairment and that 80% of them live in low and middle income countries. Only 20% of the world's population has access to hearing testing and only 1 in 40 will be fitted with a hearing aid. In all of Africa there are only 160 audiologists for over 1 billion people. Demand for care vastly exceeds supply of equipment and professionals.

Hearing plays a critical role in the development of speech and communication skills in children. Undiagnosed hearing impairment in childhood interferes with normal social, emotional and cognitive development. Hearing testing in children is often challenging and labour intensive. Early childhood may be the most critical point in life for hearing testing due to the lasting effects hearing loss can have on development and the profound difference that can be made with intervention. Numerous physiological and behavioural tests have been designed specifically for testing children for hearing loss. Conditioned play audiometry (CPA) is a standard way to test the hearing of children who are still too young for a conventional audiometry test. During CPA testing, instead of simply raising one's hand in response to a sound, the child is engaged in a listening game. For example, a child may be instructed to hold a toy and wait for the sound, then drop the toy in a bucket when the sound is heard. The game is intended to keep the child interested in the listening task for the duration of the test. CPA tests are traditionally conducted with the child (and possibly the parent) seated in a sound booth. CPA testing is both operator dependent (audiologist) and time-intensive. Only special clinics within larger cities have audiologists who perform 'play audiometry' and this service is rarely available in low-income countries.

Apple's iPad, and other tablet platforms in general, present a valuable and portable medium to perform interactive tasks such as



CPA. The iPad has quickly become a popular toy among children. The intuitive nature of the interaction with the iPad enables children as young as two years old to tap, swipe, draw, play and learn using an array of apps. We have developed an entirely new method of testing hearing whereby the tools are given to the patient to perform point of care testing and where the user seeks the sound stimulus through an interactive and intuitive platform. This is a drastically different approach than the 'traditional' reactive-type testing. While other automated programmes have been developed on mobile platforms,







none have the ability to test children as young as three years of age.

The ShoeBOX audiometer enables children to perform their own hearing test by playing an iPad game. Our interactive testing method is entirely new, can be driven by the children themselves and is fast and age specific. The proposed iPad application fills a large void, as currently there is no automated hearing testing technology designed for young children. We have developed a prototype, calibrated it for use with standard audiometric equipment and tested the prototype on several dozen children aged 2.5 to 7 years of age, validating accurate (ANSI standards) and reliable testing in a screening setting. Automated play audiometry will enable a parent, teacher, nurse, or other healthcare worker to supervise the test if an audiologist isn't available. Standard audiometry takes at an absolute minimum of six minutes with young kids but usually closer to 15 minutes and the total cost associated with testing is approximately \$300 CAD. Because our



iPad application is more entertaining and intuitive, we are able to accurately test the hearing of young children in as little as 45 seconds. Our hope is that this product will enable more widespread and cost-effective testing resulting in earlier identification of children at risk or with hearing loss.

#### How did the children find these games?

They loved them! See the photos.

#### Were there any language and cultural barriers observed with the games?

While the tool was designed to be language independent (primarily images and icons), the Canadian / American English accent proved to be a barrier in having children test themselves. One on one – some children understood the task and were able to do the test on their own; however, for many of the children the test had to be administered by us because we had difficulty teaching them how to do it on their own, never having used

anything like an iPad before. There were also terminologies used that children did not understand – 'quiet sound', 'soft sound'.

#### How were the results facilitated and how are patients with difficulties followed up?

Testing was facilitated by teachers. Patients noted to have decreased hearing loss on their audiogram were followed up by our team where possible and referred to the local hospital to be seen by the otolaryngologist.

Thanks to Dr Matthew Bromwich, Dr Brian Westerberg and AndrewThamboo for taking time to contribute to this spotlight.

This product offers a new solution to measuring children's hearing on an innovative and interactive platform. It's an empowering and user friendly tool for hearing testing. We look forward to hearing more about the future games and the launch of the App.

#### Resources

<http://www.who.int/pbd/deafness/news/Millionslivewithhearingloss.pdf>  
[http://www.who.int/goe/publications/goe\\_telemedicine\\_2010.pdf](http://www.who.int/goe/publications/goe_telemedicine_2010.pdf)

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