Ototoxicity Monitoring with ACEHearing & Open mHealth

The Problem

Ototoxicity refers to damage to the auditory and/or vestibular system, resulting in hearing loss or disequilibrium which is directly attributed to specific (ototoxic) drugs. It is an unfortunate side-effect of certain essential medication that otherwise benefits hundreds of million of patients in combating some of the world's major diseases of epidemiological importance, including multidrug-resistant tuberculosis and malaria. There are also suggestions that some anti retroviral drugs used for HIV may be associated with ototoxicity.

The potential side effect of ototoxicity is well recognised but it is only fairly recently that measures are being taken to detect and prevent this debilitating treatment complication. For example, South Africa's official policy on MDB-TB now recommends regular hearing tests for patients. However, formal audiology services are severely under capacitated in much of the developing world and medical professionals are suggesting that hearing screening at point-of-care may be extremely helpful in managing very high burdens of disease where treatment is associated with ototoxicity.

The Solution

ACEScreening is the world's first clinically-verified, accurate hearing assessment technology for mobile devices. The award-winning technology allows anyone with a smartphone to perform a self-administered hearing test. Combined with Open mHealth, we have developed a platform that makes it practically possible to monitor many more patients for ototoxicity, even in low-resource environments.

The platform is comprised of three parts: a mobile app for physicians; a mobile app for patients; and a cloud server based on ohmage. All three parts communicate with each other using the Open mHealth architecture.

In a typical scenario, the physician is able to use the ACEScreening for Physicians app to log the patient's progress and the prescribed medication and dosage. The information is automatically uploaded and stored on the server.

Instructed by the physician, the patient can periodically use the ACEScreening for Patient app to perform a self administered audiogram to monitor his or her hearing health before the next scheduled doctor's appointment   The results are also uploaded on to the server where the results can be flagged and reviewed by the physician.

The ACEScreening Server is the final component where all data are received and stored. Based on the open-source ohmage project, the Server supports data visualization and real-time feedback;
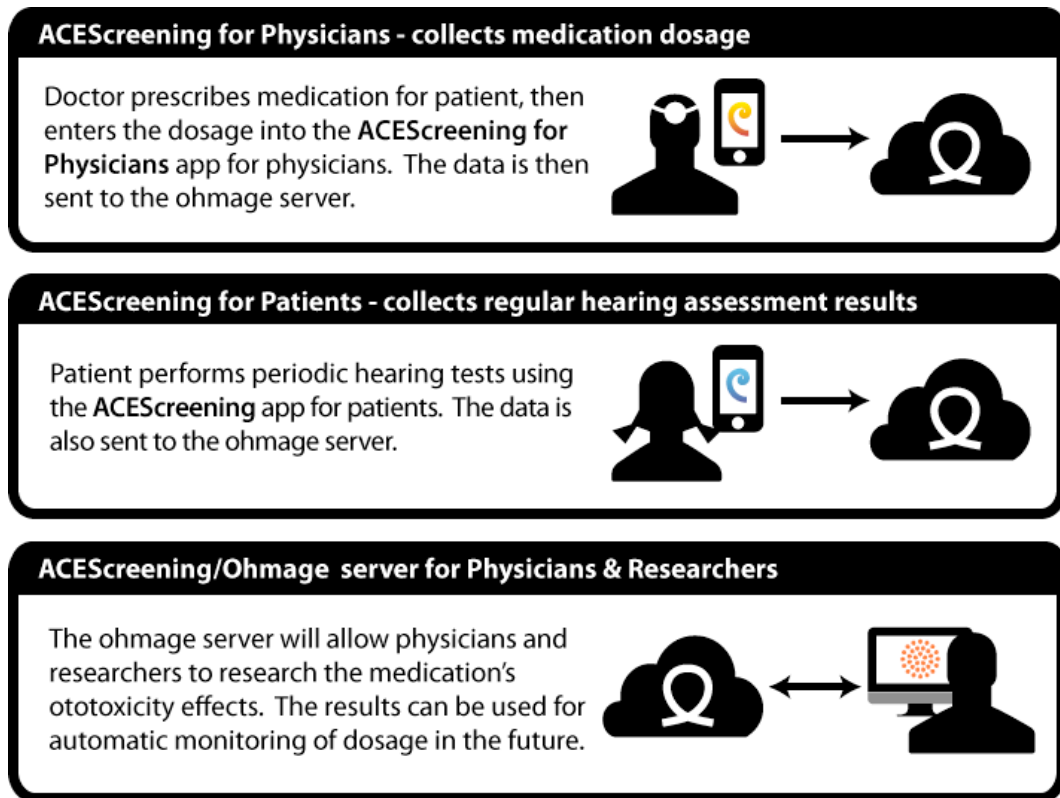
ACEScreening for Physicians - collects medication dosage

Doctor prescribes medication for patient, then enters the dosage into the **ACEScreening for Physicians** app for physicians. The data is then sent to the ohmage server.

ACEScreening for Patients - collects regular hearing assessment results

Patient performs periodic hearing tests using the **ACEScreening** app for patients. The data is also sent to the ohmage server.

ACEScreening/Ohmage server for Physicians & Researchers

The ohmage server will allow physicians and researchers to research the medication's ototoxicity effects. The results can be used for automatic monitoring of dosage in the future.

Fig 1. Overview of the ACEScreening Ototoxicity Monitoring Platform

privacy respecting secure data management; and extensible data exploration. All captured data are automatically timestamped, geocoded and uploaded for analysis and visualization.

This solution is designed to yield a high volume of excellent quality raw data that makes monitoring and further research possible for ototoxicity. There is considerable potential to conduct far more extensive research based on this data, than was previously practically possible. Physicians and Researchers have a tool with which they can readily monitor and better understand Ototoxicity. The platform sets the stage for computerized monitoring and automatic alerts to be generated and should enable the effects of ototoxicity to be far better understood; identified as early as possible and optimally managed.

The Potential Impact

Ototoxic medication has for decades been a necessary evil in fighting some of the world's top killing diseases. Although a need for regular hearing health monitoring has long been recognized, the resource-intensive nature of hearing assessments has so far prevented any realistic effort to safeguard the patients hearing health, as well as perform much needed research in this area.

The ACEScreening Ototoxicity Monitoring Platform is being implemented in South Africa, first in cooperation with MDR-TB and soon within HIV/AID communities. Because of the ground-breaking nature in terms of the scale and the reach of this platform, there is interest from the local government, healthcare providers, the health insurance industry and of course the patients. The data gathered and the resulting research will have far-reaching benefits for government healthcare policy, medical practice, health insurance policy and the quality of life for the patients all over the world.

Technical Details

Supported Platforms:	• Android 2.3 and above • iOS 5.0 and above
Wireless Requirements:	• Wifi • Cellular data plan (2G/3G/LTE)
Hearing Assessment Requirements:	• Quiet room with less than 50dB background noise, such as a normal meeting room or bed room • A pair of ear buds or headset

Test Range of the Hearing Assessment:

Test Range (dB HL)	Frequency (Hz)					
	250	500	1000	2000	4000	8000
Minimum	-10	-10	-10	-10	-10	-10
Maximum	55	60	65	70	70	60

Clinical Trials:	• Clinical evaluation of a computerized self-administered hearing test system • Clinical evaluation of a computerized audio signal modification system • Clinical evaluation of a computerized self-administered tinnitus measurement system • Can hearing impaired and mainstream populations benefit from new technology implemented on mobile phones?
Medical Publication:	Kam, A.C.S., Sung, J.K.K., Lee, T., Wong, T.K.C., & van Hasselt, C.A. (2012). Clinical evaluation of a computerized self-administered hearing test. *International Journal of Audiology, 51(8):606-10*
Awards:	• 2011 Wall Street Journal Asian Innovation Awards - Bronze Award • 2011 Wall Street Journal Asian Innovation Awards - Audience Choice Award