PERTH TO THE PILBARA, THEN MARS

Many causes of blindness are treatable, and preventable, if you have access to an eye doctor. For communities in remote towns in Western Australia, this treatment has been hard to come by. Lions Eye Institute has democratised access to sight-saving interventions, while a commitment to its science and research has produced new treatments, medical devices, and a potentially revolutionary way to measure brain fluid pressure.

The Lions Eye Institute has been travelling around Western Australia for the past six years in its purpose-built, Lions Outback Vision Van, bringing eye care and help to remote Indigenous communities.

Identifying a lack of clinical care in communities around the Pilbara and Kimberley regions, from 2015–2019, it completed some 1800 surgeries, more than 15,000 consultations, dispensing close to 6,000 sets of glasses, and screening 23,321 people for diabetic retinothapy, an eye-disease related to diabetes.

"The issue is that by the time you finish travelling, it is a year before you are able to revisit past patients," explains Professor Bill Morgan, CEO, Lions Eye Institute.

To solve the issue, Lions Eye Institute is now setting up a clinic in Broome, in what was formerly a backpackers hostel, donated to the institute. Starting the building process in February 2020, the team was treating patients by August, with the works expected to be completed in 2021.

The long-term plan is to have a surgical theatre in the same facility, and convert it into a hub for eye-care teaching in a remote setting.

As Professor Morgan notes, "It is often difficult to attract optometrists and ophthalmologists in rural areas. By undertaking the training in Broome, the plan is to attract people that are much more amenable to working in rural areas."

Rural medical schools have shown this to be effective, with Lions Eye Institute bringing that line of thinking to eye-care.

The Lions Eye Institute is also a major partner with the University of WA for their upcoming optometry school. The Broome hub will be taking some students from Western Australia, along with its main Perth facility.

Basic research, advanced output

The major irreversible causes of blindness are macular degeneration, glaucoma, and diabetic retinothapy.

Lions Eye has recently commercialised a gene therapy for retinitis pigmentosa, an inherited eye disease in which the back of the eye (the retina) is damaged. Symptoms begin in childhood, and it is currently only treatable, not curable. With clinical trials expected to be undertaken in the next couple of years, it represents a possible breakthrough that could bring the privilege of vision back to those affected.

Glaucoma is a disease where the pressure distribution at the back of the eye is altered, causing damage to the nerve fibres.

Lions Eye Institute invented a glaucoma surgery in 1996, using a purpose-made gelatin stent. It involves inserting a 6mm tube into the eye with

incredible accuracy, with both the device and technique created by Professor Dao Yi-Yu and the current CEO, Morgan.

The breakthrough came from its basic research using micropipette technologies to examine blood vessel oxygen tension in the retina, and pressure distribution in the optic nerve.

From there, it gained the ability to manufacture and position the tubes in the eye using semi-robotic control systems made in its laboratory.

It is now used worldwide with over 100,000 Xen stents having been inserted. It is the most common form of glaucoma surgery in parts of the developed world.

Reading the brain through the eye

The glaucoma research into pressure distribution also unlocked a surprising twist: intercranial pressure (brain fluid pressure) is a major contributor to pressure distribution in the eye.

The only current viable methods of measuring brain fluid pressure involve drilling a hole into the skull, and putting a canula into the brain, or a needle into the spine, both of which are invasive and risky.

Finding a link between the distribution pressure in the eye and brain has opened up a new method of measurement.

For the last 10 years, Lions Eye has been working with colleagues in neurosurgery and neurology to develop a system to non-invasively measure intercranial pressure. Using the properties of the retinal blood vessels, the veins, and how they pulsate at the back of the eye, it has invented a system for mapping that pulsation across the retina, and derived mathematical algorithms to take those pressure measurements to calculate the intercranial pressure.

Thousands of people suffer from traumatic brain injuries every year. Idiopathic intercranial hypertension is a disease of unknown cause where brain fluid pressure spikes, causing trouble. Brain tumours and dementia are thought to be partly caused by changes in brain fluid pressure.

By being able to measure brain fluid pressure without invasive surgery, researchers could undertake the measurements much more often, filling the gaps in the knowledge base for how those changes align to disease progression.

Bringing WA research to NASA

For astronauts in space for six months or longer there is a 40% chance that their brain fluid pressure will rise significantly, with significant, semi-permanent changes in the optic nerve. Most will need reading glasses upon returning, with the optic nerve remaining swollen for years after returning to Earth.

While there are very few astronauts who spend several months in space at a time, solving the issue is crucial for future trips to Mars, which will take 10 months.

Past research on swimming goggles, and their effect on the eye is now being adapted as a treatment for astronauts in space. The goggles allow them to mimic the normal pressure distribution experienced on Earth.

Some questions remain unanswered, though: does it come on suddenly? Who is more likely to get it?

Lions Eye is now working on a portable, handheld system able to do the pulsation measurements, and calculate the intercranial pressure at any point in time. The end goal is to make it small enough to take into space, where every single gram is scrutinised.

At the moment, Lions Eye is measuring that pressure with a device the size of a hotel-refrigerator, in a process in which patients must remain seated. It is not portable, and cannot be taken into space.

Making that device smaller involves solving issues of engineering, computer science, and physiology.

Some 150 years ago, people could not measure blood pressure. Now, it is measured at almost every doctor visit, and Lions Eye is hoping the device it develops may make the brain fluid pressure measurements just as ubiquitous.