The Portable Eye Examination Kit

A smartphone-based system brings ophthalmic diagnostic tests to remote settings.

BY CALLAN NAVITSKY, SENIOR EDITOR

According to the World Health Organization, an estimated 285 million people worldwide are visually impaired, and 39 million are blind. About 90% of individuals with visual impairment live in developing countries, and 80% of all visual impairment is avoidable or curable. Therefore, access to proper diagnostics and treatment inarguably remains a great need for many populations.

Recognizing that, in many low-income countries, more people have access to mobile phones than to running water, Andrew Bastawrous, BSc (Hons), MB ChB, FHEA MRCOphth, of the International Centre for Eye Health, London School of Hygiene and Tropical Medicine, saw an opportunity to bring eye care to these underserved patient populations via a smartphone-based ophthalmic tool. Peek—the Portable Eye Examination Kit—was developed to carry out a full range of ophthalmic diagnostic tests in even the remotest settings.

With trials ongoing in both Kenya and Glasgow, the potential for this smartphone-based system is being recognized in low and middle-income countries and in high-income settings. Retina Today spoke with Dr. Bastawrous and cofounder Iain Livingstone, of the Glasgow Centre for Ophthalmic Research, to learn more about Peek, its capabilities, and its performance thus far in the field.

CREATION AND DEVELOPMENT

In his career as an ophthalmologist and research fellow, Dr. Bastawrous has worked in Sierra Leone, Peru, Belize, Sri Lanka, Madagascar, and Uganda; he credits his motivation to develop Peek to his experiences in these regions.

“I’ve been fortunate enough to work in various low-income countries throughout my career, mostly on short-term projects, and have continually been struck by the impact having sight restored can have on an individual and their community,” Dr. Bastawrous told Retina Today. "What becomes clear after some time is that those who are most in need of eye care are the least likely to receive it. It is in communities that are beyond roads that most people suffering with visual impairment live.”

As Dr. Bastawrous explained, these individuals rarely, if ever, have the opportunity to see a health care professional and struggle to travel to more urbanized areas where hospital facilities are based. Fortunately, he had the opportunity to meet several “fellow tech geeks” (in his words), who shared his vision of making a social impact via Peek. Collaborating with Dr. Bastawrous are Stewart Jordan, application (app) engineer and cofounder of Golden Gekko (one of the largest mobile app developers in Europe); Mario Giardini, PhD, a photonics engineer and lecturer in digital health at the University of Strathclyde; and Dr. Livingstone, an ophthalmologist and research fellow at the Glasgow Centre for Ophthalmic Research.

Dr. Livingstone, who previously brought a UK standard children’s acuity test to the iPhone and iPad with the iSight app, began corresponding with Dr. Bastawrous about iSight, sparking an email correspondence and eventual meeting of the minds, he explained to Retina Today.

Together with Dr. Giardini, they looked at ways of using a mobile phone to give a view of the fundus. The goal was to create something that did not involve the use of an ophthalmoscope because “that was the very expensive middleman in this equation,” Dr. Livingstone explained.

After experimenting with these concepts and various prototypes, Dr. Giardini realized that it was possible to miniaturize the whole system, and, within the space of a day, the team had its first prototype of the retinal camera. With time and additional efforts, they developed a fundoscopy adapter, which can be used to visualize the red reflex and retina, and Mr. Jordan played a key role in developing the software to back it up.

The result was Peek—a mobile app and clip-on hardware that transforms an Android smartphone into an eye examination and diagnostic suite. The Peek system can be used to diagnose blindness, visual impairment, cataracts, glaucoma, macular degeneration, diabetic
retinopathy, and other retinal and optic nerve diseases, as well as indicators of brain tumor and hemorrhage.

With Peek, a nonexpert with minimal training can gather detailed clinical information. Images are graded and patients can be diagnosed either through an automated process or via cascading of the digital images to a network of experts around the world. In addition, the system stores contact information and GPS data for each patient screened, and Google Map integration allows a novel way to follow patients.

IN THE FIELD: THE KENYA PROJECT

In 2011, Dr. Bastawrous began working at the International Centre for Eye Health and began preparation to move to Kenya to commence a cohort study of eye disease, following up on 5000 participants who were examined in a comprehensive survey in 2007-2008, the Nakuru Posterior Segment Eye Disease Study, led by Wanjiku Mathenge, MBChB, MMed, MRCOphth.
Now called the Nakuru Eye Disease Cohort Study, Dr. Bastawrous’ and the Peek team’s efforts involve going to 100 locations throughout the country and retracing the original participants (Figure 1).

Each of these individuals undergoes a detailed ophthalmic and general health examination including logMAR visual acuity, autorefraction, corrected visual acuity, anterior slit-lamp examination with gonioscopy and IOP measurement, visual fields, anthropometry, detailed health review, detailed risk factors and socioeconomic status interview, dilated slit-lamp exam of the lens and fundus, and detailed retinal photography with state-of-the-art equipment, which is transported daily to various examination centers (schools, churches, or someone’s home). These same individuals are separately examined using Peek. Health care workers with the Peek team often travel by motorbike or on foot and wear a backpack with a solar panel that charges the smartphone (Figure 2).

“The day before we arrive at the examination center, an advance team goes door to door, finding the study participants and inviting them to attend the following day. As part of this visit, they use Peek to assess the participants, and these data are then sent to Moorfields Eye Hospital Reading Centre for grading and comparison to the data collected in the cohort study,” Dr. Bastawrous told Retina Today.

The populations being evaluated (the participants of the Nakuru Eye Disease Cohort Study) are aged 55 years and older and from a wide range of ethnic backgrounds, socioeconomic statuses, and rural and urban areas (Figures 3 to 5). The Peek team is also beginning validation studies on school children and a program in children’s homes in Nakuru. According to Dr. Bastawrous, the conditions most commonly diagnosed in these individuals are cataract, refractive error, glaucoma, diabetic
retinopathy, age-related macular degeneration, corneal scarring, and occasionally trachoma.

The Peek team is currently initiating a quantitative analysis, led by Sarah Karanje, a social scientist based in Nairobi, who is conducting structured interviews with patients, testers, and policy makers to analyze the perception people have of the smartphone-based system. “Our impression in the field so far has been universally positive,” Dr. Bastawrous said. “Mobile phones are almost universally accessible in Kenya (more people having access to a mobile phone than to water or sanitation services), and so when Peek health care workers pull out a smartphone to perform a test, there is an instant acceptance to it being used, as it is nonintimidating and familiar [Figure 6]. We often find neighbors asking to be tested and intrigued that they can be shown images of their eyes.”

APPLICATIONS IN DEVELOPED MARKETS

In addition to Peek’s application in Kenya, the team recognizes that there is great potential for its use in developed markets. Dr. Livingstone told Retina Today. In Glasgow, his focus is to evaluate the technology’s potential for use in the National Health Service and take it through the certification process while providing validation, tailoring the suite to make it as efficacious as possible, and ensuring that the data are reproducible. Dr. Livingstone is also interested in Peek’s capability to better gather information on pediatric patients by offering a suite of well-validated vision tests for children.

Dr. Livingstone explained that, as a registrar, it would be much easier for one of his juniors to send him a photograph of what he or she is seeing rather than to describe it over the phone and require him to examine that patient. The Peek system streamlines the process. This, in turn, will help to triage patients and provide them with improved access to appropriate and timely care.

“The smartphone has loads of features that lend it well to ophthalmic diagnostics, and, on top of that, the ability to cascade whatever you get, whether it is information from a vision test or a photo of a glaucomatous disc, and send that material to a reading center or to a processing cloud for automated grading really offers something significant,” he said. “I think the barriers to ophthalmoscopy are the learning curve but also the lack of confidence in interpreting what has been seen,” Dr. Livingstone said. “I see the Peek fundus camera as being a disruptive technology that will replace the ophthalmoscope because the field is bigger and it provides the opportunity to forward images to a colleague for a second opinion.”

As the trend toward a paperless environment continues to permeate ophthalmology via electronic health records and data management systems, Peek would seemingly integrate well into practice in developed markets. “What has really allowed this to happen is the convergence of so many technologies at the same time—the high resolution display, the advanced optics, the connectivity—all of that at the same time as the move toward electronic health records creates the perfect storm for a solution like this.”

FUTURE EFFORTS

As Dr. Bastawrous explained, the primary aim of the Kenya project is to answer 2 questions: (1) Does Peek work? and (2) Is it acceptable to patients, testers, and policy makers? Once these questions are answered and the app is refined accordingly through a process of continuous feedback and improvement, there are several additional questions the Peek team wants to answer. They include the following:

- Does Peek increase access to eye care?
- Can Peek improve the quality of eye care at the hospital level?
- Can Peek be used for diabetic retinopathy screening?
- Can Peek be a tool for performing research and surveys?
- Can Peek be used to screen children in schools and children’s homes?

“We have plans to run these various studies commencing very soon, and we will also be looking at options to roll out and scale up once we have enough data to ensure that Peek is both safe and effective,” Dr. Bastawrous said.

“It should be noted that Peek does not itself treat people; there are many hardworking health care workers of various cadres working long hours, in government and nongovernmental organizations, providing excellent services to communities across the globe,” he continued. “Our hope is that Peek will facilitate the ongoing work and make it possible for more people to access services in the hope that the goals of Vision 2020: The Right to Sight, might be realized, as well as potentially provide support for those with a non-treatable form of impairment.”

Vision 2020: The Right to Sight is a global initiative to eliminate avoidable blindness. The program is a partnership between the World Health Organization and the International Agency for Prevention of Blindness, an umbrella organization for professional groups and nongovernmental organizations involved in eye care. The aim of the initiative is to eliminate avoidable blindness by the year 2020.”