Institution: London School of Hygiene & Tropical Medicine (LSHTM)

Unit of Assessment: 1

Title of case study: Smartphone technology for innovative targeted treatment of poor vision and blindness

Period when the underpinning research was undertaken: 2012-2020

Details of staff conducting the underpinning research from the submitting unit:

Name(s):	Role(s) (e.g. job title):	Period(s) employed:
Andrew Bastawrous	Clinical Research Fellow; Associate Professor	22/08/2011-current
Helen Weiss	Professor	01/01/1997-current
Hannah Kuper	Professor	01/05/2002-current
Matthew Burton	Clinical Assistant Professor, Clinical Professor	01/05/2007-current
Allen Foster	Professor	01/01/1999-current
& associated research teams		

Period when the claimed impact occurred: 2013-2020

Is this case study continued from a case study submitted in 2014? No

1. Summary of the impact (indicative maximum 100 words)

Peek Vision, a social enterprise born out of LSHTM research, introduced innovative research-defined technology in eye health programmes to address the huge burden of visual impairment worldwide and lack of access to treatment. By providing programme implementers with expertise and apps to deliver data-driven and coordinated quality eye health care, Peek created powerful new solutions for approaching and delivering access to care. The Peek vision check app, Peek Acuity, was used in over 100 countries and was downloaded over 50,000 times. Peek Solutions (product and service package) delivered health system improvements in Kenya, Botswana, India, Zimbabwe and Pakistan. Peek's ground-breaking system and national programmes have enabled an entire generation of schoolchildren in these countries to access eye care and improve eye health.

2. Underpinning research (indicative maximum 500 words)

Approximately 1.1 billion million people worldwide live with vision loss, 90% of them in low- and middle- income countries (LMICs). The number of people with visual impairment and blindness is predicted to treble in the next 3 decades, despite the existence of cost-effective, proven treatments: 90% of the blindness is treatable or preventable. In rural areas, access to specialist eye health personnel and facilities is extremely limited. Eye screening equipment is typically large and cumbersome, and requires expert training to use.

Bastawrous saw the challenges during his LSHTM PhD research on eye disease in Kenya between 2012 and 2014. Peek Vision was conceived to address these challenges. Alongside his PhD, Bastawrous, with the team in Kenya and LSHTM staff at the International Centre for Eye Health (ICEH), led a partnership with NHS Scotland, the University of Strathclyde and independent software developers, to develop prototype apps and devices to test vision and conduct eye imaging so that smartphones could be used as mobile eye clinics. LSHTM staff at the ICEH included Burton, Kuper, Foster and Weiss.

Peek Acuity, the world's first clinically-tested smartphone vision check app, allows anyone to test visual acuity using only an Android smartphone. It was designed to screen and identify people who need further eye examination. The app was developed drawing on LSHTM's world-leading

expertise in international eye health, and expertise in biomedical engineering and ophthalmic research at the University of Strathclyde and NHS Glasgow Centre for Ophthalmic Research.

But the app itself was not enough; to make an impact, it is important to be able to access populations in need, screen, and follow up. LSHTM led and coordinated the trials below to demonstrate the feasibility and efficacy of screening using Peek products. These products include the app (Peek Acuity), the Peek Retina smartphone attachment which allows the user to view and take images of the optic nerve, and the wider range of Peek Solutions including support, data analysis and SMS reminder functionality (Peek Capture).

i) In a 2013-14 validation study, Peek Acuity was found to be as accurate as conventional tests, and as reliable, for assessments of visual acuity both in the home and clinics, and the app was readily accepted by Kenyan community health workers (3.1).

ii) In 2015, Peek with the ICEH at LSHTM and in partnership with the Kenyan Ministry of Health, carried out a cluster randomised control trial. The study involved 25 teachers screening 21,000 school children in Trans Nzoia County in Kenya. It demonstrated the feasibility of effective task-shifting from ophthalmologists to teachers using Peek Acuity embedded in Peek Capture, to identify and refer children with sight problems. It also showed that this system substantially increased the proportion of patients who attended referral appointments (within 8 weeks of screening) from 22% to 54% of those identified with sight problems (3.2, 3.3).

iii) LSHTM has also conducted research into another known 'leak' in the world of eye health, spectacle adherence, i.e. whether people wore the glasses they were prescribed. The research undertaken in the Peek school eye health programmes in Botswana and India found that a higher proportion of children were wearing their spectacles than reported elsewhere. In Botswana, compliance was higher than in previous African studies and the study gave important information on factors which predicted spectacle adherence, such as gender, school level and visual acuity, to guide use in practice (3.4, 3.5).

Obtaining reliable population-level eye health data requires a robust sampling strategy. RAAB - the Rapid Assessment of Avoidable Blindness - is a proven methodology for defining eye health need for a population. It was first developed in 1997 by Hans Limburg, an LSHTM MSc alumnus working with ICEH staff, initially as the Rapid Assessment of Cataract Surgical Services. In 2004, ICEH staff updated and modified it to create RAAB.

RAAB has been coordinated through ICEH since 2004 and RAAB7, the latest evolution of RAAB, was developed by and delivered on Peek's platform. It includes new features to deliver higher integrity data and track avoidable blindness live (3.6).

3. References to the research (indicative maximum of six references)

3.1 Bastawrous A, Rono HK, Livingstone IA, **Weiss HA,** Jordan S, **Kuper H, Burton MJ.** 2015. Development and Validation of a Smartphone-Based Visual Acuity Test (Peek Acuity) for Clinical Practice and Community-Based Fieldwork. *JAMA Ophthalmology*. 133(8):930-7. doi: 10.1001/jamaophthalmol.2015.1468.

3.2 Rono HK, **Bastawrous A**, **Macleod D**, Wanjala E, Di Tanna GL, **Weiss HA, Burton MJ.** 2018. Smartphone-based screening for visual impairment in Kenyan school children: a cluster randomised controlled trial. *Lancet Global Health*. 6(8):e924-e932. doi: 10.1016/S2214-109X(18)30244-4.

3.3 Lodhia V, Karanja S, **Lees S, Bastawrous A**. 2016. Acceptability, usability, and views on deployment of Peek, a mobile phone mHealth intervention for eye care in Kenya: qualitative study. *JMIR mHealth and uHealth*. 9;4(2):e30. doi: 10.2196/mhealth.4746.

3.4 McCormick I, Morjaria P, **Mactaggart I,** Bunce C, Bascaran C, Jeremiah M, Foster A. 2019. Spectacle Compliance and Its Determinants in a School Vision Screening Pilot in Botswana. *Ophthalmic epidemiology.* 26(2):109-116. doi: 10.1080/09286586.2018.1523441.

3.5 Morjaria P, Bastawrous A, **Murthy GVS, Evans J**, Sagar MJ, Pallepogula DR, Viswanath K, **Gilbert C**. 2020. Effectiveness of a novel mobile health (Peek) and education intervention on spectacle wear amongst children in India: Results from a randomized superiority trial in India. *EClinicalMedicine*. 28:100594. doi: 10.1016/j.eclinm.2020.100594.

3.6 Mactaggart I, Wallace S, Ramke J, **Burton M, Bastawrous A**, Limburg H, Qureshi MB, **Foster A, Kuper H**. 2018. Rapid assessment of avoidable blindness for health service planning. *Bulletin of the World Health Organization*. 96(10):726-728. doi: 10.2471/BLT.18.217794.

We believe this body of research meets the 'at least 2*' definition given its reach, significance and rigour.

4. Details of the impact (indicative maximum 750 words)

Peek Vision developed from proof of concept to a fully-fledged social enterprise, with innovative health solutions that have been rolled out in Kenya, Pakistan, Zimbabwe, and Botswana. Peek's ground-breaking system reduced the need for expensive and bulky eye health equipment, and its national programmes have allowed an entire generation of schoolchildren in these countries to receive low-cost comprehensive eye care services — screening, referral and treatment to reduce poor vision and blindness.

Global partnerships for impact

Peek was developed from LSHTM as an independent social enterprise organisation in 2015, retaining close links to LSHTM through the ICEH. In 2016, Peek became independently owned by the newly established charitable foundation, the Peek Vision Foundation, consisting of the Foundation and its trading arm, Peek Vision Ltd. Profits generated by Peek Vision Ltd belong to the Foundation, which reinvests its funds in building eye care capacity in low- and middle- income countries (5.1).

Peek's products and services include: the Peek Acuity app, Peek Retina (mobile camera adapter), Peek School Eye Health and Community Eye Health programmes, eye health surveys (RAAB), and real time data reporting and analysis. Since 2016, Peek has been a registered manufacturer of medical devices under the UK Government Medicines and Healthcare Products Regulatory Agency. Peek Acuity Pro and Peek Retina (launched in 2017) are registered class 1 medical devices and CE certified. By the end of May 2019, Peek Acuity had been downloaded over 50,000 times in 137 countries by programme staff including teachers and healthcare workers. It was winner of 'Tech for Social Impact' prize in 2016, voted for by Google and McKinsey (5.2), having previously been awarded the 2015 Index Project Award alongside Tesla and Duolingo (5.3). In 2018, the Peek team's work in Kenya won the All African Public Service Innovation Award from the African Union.

Screening and treatment for poor vision

High quality research, programmes, and collaboration with local and international experts using Peek helped screen almost 300,000 individuals in Botswana, Kenya, India, Pakistan and Zimbabwe. A further 20,000 were assessed and 7,000 requiring treatment were treated as part of programmes to improve poor vision (5.1). The original Kenyan trial was scaled up by the Ministries of Health and Education to a countywide programme beginning in 2015, and this was replicated and further developed in India and Botswana. In 2016, the Botswana government, alongside local and international partners, joined with Peek to implement Peek vision screening in over 120,000 schoolchildren. Over 90% of children attended follow-up appointments. The successful pilot led to the commitment in 2017 by the Ministry of Health and Wellness in Botswana to deliver a government-funded national programme to screen every schoolchild and teacher in the country, and to deliver appropriate eye care services as needed (5.4).

Strengthening health systems

The Peek system gave programme implementers access to live, real-time field data to drive systematic improvements, while support from partners enabled increased growth. The partnership

with disability and development non-governmental organisation CBM facilitated rapid progress in Pakistan and Zimbabwe. In Pakistan, the CBM-Peek programme fully integrated Peek into a large-scale community eye health programme in 2019, screening over 30,000 people (5.1). Before Peek was introduced, 40% of eye consultations for eye health services at local hospitals were related to refractive errors. Since adopting Peek, this was reduced to 1%, as these issues could be solved by local optometrists, leaving eye health hospitals better placed to treat more complex eye conditions. Peek also provided data on the number of 'lost' individuals, which meant these individuals were followed up, triaged and an applicable intervention was delivered (e.g. surgery or spectacles provision). The Peek data allowed the partners to improve their service provision, increasing compliance with referrals to eye exams from 58% to 82% over 6 months. In Zimbabwe, the CBM-Peek partnership introduced Peek tools to 2 further school eye health programmes and a community eye health programme.

WHO's *Universal eye health: a global action plan 2014-19* cites the RAAB as a standard method for generating epidemiological evidence for the magnitude and causes of visual impairment as well as on eye care services (5.5). RAAB was used in more than 330 surveys in over 70 countries, and has evolved to a recognised standard that informs both district level eye health planning and global data on visual impairment. Delivered on the Peek platform since 2015, this software was used in Cambodia, Pakistan, Palestine, Zimbabwe and Nepal. mRAAB6, developed by Peek as a front-end mobile data collection system for RAABs, and the predecessor to the current version RAAB7, was used 125 times between 2015 and 2019 (representing populations in excess of 100 million people) (5.6).

Advocacy to move eye health up the agenda

Alongside development of the Peek software and associated activities (training and partnerships with local eye health organisations to deliver screening and treatment), Bastawrous and Peek have achieved policy impact by advocating the importance of eye health as part of universal health coverage. On Commonwealth Day in March 2018, Bastawrous addressed Her Majesty The Queen, other senior members of the Royal Family, the then UK Prime Minister, and delegates from the 53 Commonwealth countries at Westminster Abbey on the life-changing work of Peek (5.7). In April 2018, 53 Commonwealth heads of government agreed to take action to ensure all citizens have access to quality eye care. Peek was involved in supporting and calling for this development as a partner of the 'Vision for the Commonwealth' consortium (5.8), made up of 6 leading eye health organisations who have joined efforts to end avoidable blindness and poor vision across the Commonwealth.

Bastawrous co-founded and is global ambassador of the 'Vision Catalyst Fund' working with major banks, eye health organisations and funders to develop innovative financing modes for eye health, the subject of his 2018 TED talk, which has been viewed over 1.4 million times (5.9).

5. Sources to corroborate the impact (indicative maximum of 10 references)

5.1 PEEK Vision Foundation. Annual Report and Consolidated Financial Statements. 31 December 2018.
PEEK Vision Foundation. Annual Report and Financial Statements December 2019.

- Product details, company structure, profits, key programme activities.

5.2 Winner of 'Tech for Social Impact' prize, 2016, tech EU. Accessed at: https://tech.eu/brief/digital-top-50-awards-slush/

5.3 The INDEX Project Winners and Finalists. Peek Retina, 2015. Accessed at: https://theindexproject.org/award/winnersandfinalists/peek-retina-index-award-2015-winner-body-category

5.4 Peek Press release 20 October 2017. Botswana set to become first country in the world to provide eye health services to a generation. Accessed at:

https://www.peekvision.org/en_GB/news/story/botswana-set-to-become-first-country-in-the-world-to-provide-eye-health-services-to-a-generation

Andersen T, Maipelo J, Thamane K, Littman-Quinn R, Dikai Zambo, Kovarik C and Ndlovu K (2020). Implementing a school vision screening program in Botswana using smartphone technology. Telemedicine and e-Health. Vol 26 No 2. https://doi.org/10.1089/tmj.2018.0213

- Gives numbers of children screened, referral rates and spectacle provision in Botswana

5.5 World Health Organization. Universal eye health: a global action plan 2014–2019. Geneva: World Health Organization; 2013.

- Pg 19/ Appendix 4 cites the RAAB as standard methodology for generating epidemiological evidence for eye care

5.6 RAAB repository accessed at: http://raabdata.info/

- Contains data on surveys and countries RAAB was used in

5.7 Dr Andrew Bastawrous 2018 Commonwealth Service reflection. YouTube. Accessed at: https://www.youtube.com/watch?v=n3FKBfHZFvE

5.8 Commonwealth Heads of Government Meeting. London 2018. Commonwealth Heads of Government Meeting Communique 'Towards a Common Future'.

- Includes commitment to take action towards achieving access to quality eye care for all, pg 7, paragraph 33

5.9 Andrew Bastawrous TED talk, 2018. Accessed at:
https://www.ted.com/talks/andrew_bastawrous_a_new_way_to_fund_health_care_for_the_most_vulnerable?language=en