



<b>Section A</b>		
<b>Institution:</b> University of St Andrews		
<b>Unit of Assessment:</b> UoA 01: Clinical Medicine		
<b>Title of case study:</b> Development, evaluation and implementation of low-cost diagnostic and training tools for eye care		
<b>Period when the underpinning research was undertaken:</b> 2015 - 31 December 2020		
<b>Details of staff conducting the underpinning research from the submitting unit:</b>		
<b>Name(s):</b>	<b>Role(s) (e.g. job title):</b>	<b>Period(s) employed by submitting HEI</b>
Andrew Blaikie	Senior Lecturer	01 March 2014 - present
<b>Period when the claimed impact occurred:</b> 2017 - 31 December 2020		
<b>Is this case study continued from a case study submitted in 2014?</b> No		
<b>Section B</b>		
<b>1. Summary of the impact</b>		
<p>According to the WHO about 285,000,000 people globally have significant visual impairment with over 30,000,000 people being blind with mostly avoidable cases. At the University of St Andrews, our research in developing, evaluating, and implementing Arclight, a robust, lightweight, solar-powered ophthalmoscope and otoscope, used to screen for eye and hearing conditions, and distributing it as widely as possible has resulted in:</p> <ul style="list-style-type: none"> <li>• <b>Increased global ophthalmic capacity:</b> i) distributing over approximately 27,000 devices in almost 100 countries, and ii) training workshops to over approximately 4,500 people (health workers) using low-cost eye simulation teaching tools</li> <li>• <b>Mobilising knowledge in eyecare</b> through worldwide educational and information strategies, which has established the device as a credible and sought-after diagnostic device, as evidenced by the new of units sold and ranking on Google search terms</li> <li>• <b>Reduced unnecessary blindness with improved diagnostic and wider clinical practice</b> throughout Africa and other low resource regions which has led to <b>governmental adoption and policy change in Tanzania</b></li> </ul>		
<b>2. Underpinning research</b>		
<p>The greatest burden of blindness is found in low and middle-income countries (LMICs), where access to educational and diagnostic services is least.</p>		
	<p>Together with Arclight Medical Ltd, we have driven the development, evaluation and implementation of diagnostic and training tools that overcome these barriers. Traditional instruments such as direct ophthalmoscopes or otoscopes are <i>expensive, complex, and heavy</i>. Within LMICs few hospital-based health workers have access to these essential devices and almost none at the mid or community level. Dr <b>Blaikie</b> and his team have actively introduced as well as conducted research demonstrating the utility and effectiveness of the Arclight in LMICs.</p>	
<p>We have focused on the major causes of blindness (cataract, glaucoma and trachoma) as well as the newer growing causes of loss of vision amongst children (retinopathy of prematurity) and working age adults (diabetic retinopathy).</p>		
<p>The Arclight, despite its simplified, stripped-down and low-cost design (R1), and has been shown to perform as well, and in several ways, even better than orthodox, far more expensive devices.</p>		

This has been shown in research conducted in Malawi identifying both retinal diseases (R2) such as diabetes, as well as red reflex abnormalities (R3) for identifying cataract in babies and eye cancer. Furthermore, the health care workers scored the Arclight as significantly easier to use than standard ophthalmoscopes. Both the paediatricians and optometry students preferred the new device and felt the appearance was more child friendly. Research has also encompassed increasing the evidence base to support, implement and expand ophthalmic capacity in LMICs. The Brückner reflex test is a quick and effective means to screen for eye disease and amblyogenic risk factors. This test is however rarely performed in low resource settings due to lack of access to ophthalmoscopes and trained health care workers. In a study conducted in India, the Arclight was demonstrated to be effectively used to perform the BRT, and moreover, the utility of the device was demonstrated even when performed by a non-expert the results are highly specific and moderately sensitive (R4).

We have, in addition, developed ultra-low-cost simulation/teaching eyes to help users build practical skills early on (R3 and R5). They are already a core resource for trainee engagement (R6). Along with the Arclight device, the simulation eyes have become an effective vehicle for Interprofessional Education (IPE), assisting in teaching eye care in a collaborative way to nursing, medical, ophthalmic and clinical officer students (R6). Student evaluation has confirmed that using the Arclight and simulation tools was relevant to the strengthening of eye care in Rwanda, and more recently, became an important tool to overcoming reduced face-to-face teaching opportunities in the COVID-19 era (R5). No other research team is actively working on a similar device and tools in as wide a range of LMIC settings. Our work is unique.



Training with Simulation Eyes in Rwanda

### 3. References to the research

Research publications are published in highly regarded peer-reviewed academic journals and R2 is part of the UoA 01 REF output submission. Research has been conducted in low-and-middle-income countries and was supported by peer-reviewed Scottish Research Council, Global Challenges Research Funding.

- R1. **Blaikie** A, Sandford-Smith J, Tuteja SY, Williams CD, O'Callaghan C (2016) Arclight: a pocket ophthalmoscope for the 21st century. *BMJ*, 355, DOI: [10.1136/bmj.i6637](https://doi.org/10.1136/bmj.i6637)
- R2. Blundell R, Roberts D, Fioratou E, Abraham C, Msosa J, Chirambo T, **Blaikie** A (2018) Comparative evaluation of a novel solar powered low-cost ophthalmoscope (Arclight) by eye healthcare workers in Malawi. *BMJ Innovations*, 4:98-102, DOI: [10.1136/bmjinnov-2017-000225](https://doi.org/10.1136/bmjinnov-2017-000225).
- R3. Doole E, Kousha O, Msosa J, Ndaule E, Abraham C, Parr J, O'Hare B, **Blaikie** A (2020) Comparative evaluation of a low cost direct ophthalmoscope (Arclight) for red reflex assessment among healthcare workers in Malawi. *BMJ Innovations*, 6:113-116, DOI: [10.1136/bmjinnov-2019-000361](https://doi.org/10.1136/bmjinnov-2019-000361)
- R4. Tuteja SY, **Blaikie** A, Kekunnaya R (in press) Identification of Amblyogenic Risk Factors with the Brückner Reflex Test using the low-cost 'Arclight' Direct Ophthalmoscope, *Eye* DOI: [10.1038/s41433-020-01341-9](https://doi.org/10.1038/s41433-020-01341-9)
- R5. Hetherington MJ, Kousha O, Ali AA, Kitema F, **Blaikie** A (2020) Comment on: Reshaping ophthalmology training after COVID-19 pandemic. *Eye*, DOI: [10.1038/s41433-020-01139-9](https://doi.org/10.1038/s41433-020-01139-9)
- R6. O'Carroll V, Sagahutu JB, Ndayambaje D, Kayiranga D, Kitema GF, Rujeni N, **Blaikie** A (2020) Evaluation of a Pilot Interprofessional Arclight™ Workshop for Healthcare Students in Rwanda: Promoting Collaborative Practice in Eye Health, *Journal of Interprofessional Care*, DOI: [10.1080/13561820.2020.1782356](https://doi.org/10.1080/13561820.2020.1782356)

### 4. Details of the impact

The WHO estimates that over 285,000,000 people suffer from significant vision impairment, of

which the majority is considered preventable or treatable if diagnosed promptly. The consequences of this are broad, including reduced quality of life and reduced access to education and employment reducing long-term economic productivity. Increasing dependency of those affected on young family members additionally limits access to school and the workplace of a further otherwise unaffected swathe of society.

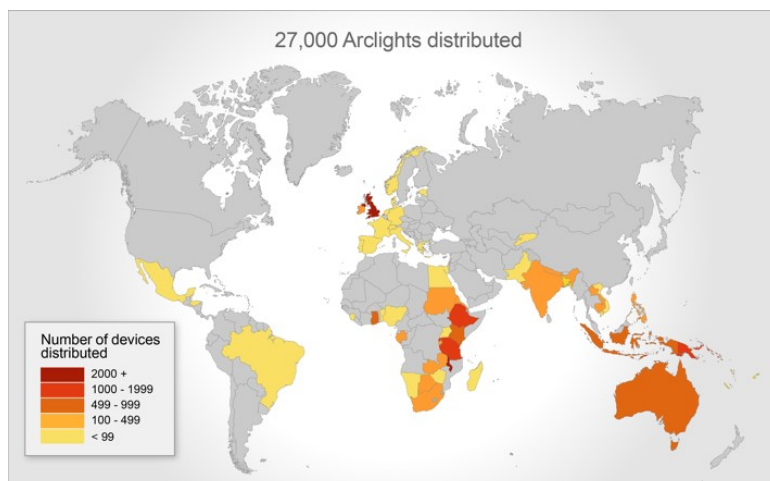
It is recognised that the greatest burden of blindness is found in LMICs, where access to educational and diagnostic services is least developed. Early identification and treatment, particularly of those conditions affecting the front of the eye (cornea and lens), and back of the eye (retina and optic nerve) relies respectively upon a range of diagnostic tools including a direct ophthalmoscope. Dr **Blaikie** has worked closely with William J Williams, the original creator of the Arclight who is an Honorary Research Fellow at the School of Medicine, to develop the Arclight tool from the first prototype to the current version. This close partnership has ensured that the research has informed the refinement of the device, which is now on its 4th iteration.

Our research using Arclight, a low-cost, solar powered, ophthalmoscope and otoscope, has focussed on the needs of health care users in LMIC settings, and has targeted the lack of provision of relevant and effective low-cost diagnostic tools, and associated teaching packages.

Through our research and implementation activities the St Andrews team has **increased global ophthalmic capacity** and has **mobilised knowledge in eyecare**. Additionally, the development, evaluation, and implementation of Arclight in Africa is increasing diagnostic capacity and **reducing unnecessary disability from blindness**.

### Increased global ophthalmic capacity

With the areas of greatest burden of disease having the least access to diagnostic tools and training, the team's research and implementation activities have focussed on extending the reach of Arclight globally. A university social enterprise established by the St Andrews team sells the Arclight in the UK and other high-income countries, using profits to support distribution and training in some of the poorest countries worldwide. The enterprise has to date sold over 1,300 units typically at GBP48 (traditional scopes are between GBP200 and GBP800); a saving of between GBP200,000 and GBP1,000,000, for a device that has been demonstrated to be equivalent in performance (R2, R3 & R5); 4,500 units have also been distributed via the Medical Defence Union in the UK – these usually go to junior doctors and again help raise the profile and aims of the whole endeavour. This has in turn funded cost price (GBP10) distribution in LMICs. Using this social enterprise, we have been able to provide diagnostic capabilities and expertise where typically none existed. In excess of 27,000 Arclight devices have been distributed (S1). To firmly embed its use, we have developed and evaluated ultra-low-cost simulation eyes assisting in the manufacture of 27,000 units. These eyes reinforce examination skills and clinical knowledge in novel and highly engaging ways (R3 and R6). Used in workshops in over 12 countries now, this equates to approximately 4,500 people (LMIC participants) having gained direct benefit from our work (S1).



### Mobilising knowledge in eyecare

Interest and awareness in the Arclight has been enhanced through research publications such as the 2016 BMJ article (R1) which led to media coverage, including an interview with the [BBC World Service's Newday Program](#) (S2), which had a record level of audience members at the time of recording (The Newday circulation in 2017: 372,000,000) (S3).

Three different Medical and professional magazines and websites published articles on the team and device. This included [an article in the 'The Ophthalmologist'](#), world's biggest eyecare trade magazine confirming the reach of the device, as well as the [Royal Academy of Engineering's magazine 'Ingenia'](#). Recognition of its innovation is reflected in the V&A Dundee Museum nominating the team as a 'Design Champion'. The museum selected inspirational designers creating high-quality work and helping to enhance people's lives, and in their [blog](#), the V&A highlighted the Arclight project as "*using design to simply and radically improve the lives of people around the world*" (S4, p.3).

Evidence of the increased global awareness of the device is reflected in 'low-cost ophthalmoscope' Google searches. The Arclight occupies the top 10 places (search performed 18 December 2020). This is a departure from prior to 2014, when it did not appear in any top 20 searches (S5).

Face-to-face delivery of training and education was delivered throughout the entire length of Africa by the [Tandem Arclight Africa Expedition Team](#). In October 2018, St Andrews students, set out on the 9,656km journey passing through 10 African countries, providing training and devices for Health Care Workers (see map). Over 1,000 devices were distributed and 705 people (community members) were trained with Arclight over the course of the 7-month journey (S6). This expedition further promoted and enhanced the adoption of the device in this region and, through extensive media coverage, more globally (S6).



### **Reduced unnecessary blindness with improved diagnostic and wider clinical practice**

The widespread distribution of Arclight in East Africa, allied with training activity and capacity building, has had a positive influence in the health of people across the region. Arclight is becoming 'the' standard tool for opportunistic diabetic retinopathy and glaucoma screening and training healthcare workers.

In Malawi, between 2015 and 2019 all ophthalmic clinical officers, and many of the optometrists in all the districts of the country were taught how to screen for diabetic retinopathy with the Arclight (S7). When describing Dr **Blaikie's** work with the Arclight device, the lead for Vision 2020 Diabetic retinopathy screening in Malawi says "*The simulation tools and training materials that have been developed complement the device really well and have helped the implementation process. I really do not know how we would have delivered the training and equipped the health care workers without it. I know what we have done is making a difference to blindness in Malawi from diabetes and the other common blinding diseases found in Malawi*" (S7).

Its adoption by training institutions, governments and NGOs globally is directly related to St Andrews work in developing simulated eyes to complement the device (R3) and research into educational strategies with African colleagues (R2, R3 & R5). This is evidenced by our interaction with Sense International, a global deafblind charity across East Africa. Using Arclight, over 100,000 people (children) underwent eye health and red reflex tests in Kenya and Uganda (S8). A Board member of Sense International, Kenya, says "*Dr Blaikie was instrumental in the successful implementation of this project through the advice and guidance he provided when establishing screening and early intervention protocol and through the on-the-ground training he provided to local doctors and nurses on how to use the Arclight*" (S8).

In Tanzania, more than 38,000 people (children) have been screened – identifying in a timely way 500 people (children) who were then referred for further diagnosis and interventions (S9). The Country Director, Sense International, Tanzania, says: "*The Arclight has positively changed the direction and mode of delivery of our Early screening project in Tanzania. From an original plan of*

*having traditional more expensive ophthalmoscopes in each of our 4 facilities in Temeke Municipality to a potential 24 health facilities in Temeke District conducting basic eye tests, but this approach was only possible after sourcing additional Arclights and training with support from Dr. Blaikie. The use of the Arclight by CHWs has made it possible to avoid long service queues at the Early Intervention facilities because eye screening is now being conducted at lower level health care facilities only referrals are sent to the hospitals." (S9).*

These successful programs have led to governmental adoption and policy change and improved diagnostic and wider clinical practice. In Tanzania, the Ministry of Health recommended the Arclight become the tool for red reflex screening of one of the country's most common cancer in children – retinoblastoma. Tanzanian Ministry of Health training resources for nurses and health workers in primary health centres, contains a [video module for the use of the Arclight for checking the Red Reflex in children](#) (S10). In their 5-year Strategy plan for Paediatric Oncology Services in Tanzania, published with the Tanzanian Ministry of Health, Tumiani la Maisha, a leading NGO providing cancer care for children in Tanzania, recommended the Arclight to be used for red reflex screening throughout Paediatric Oncology National Network of Tanzania (S11, p. 38).

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

- S1. Spreadsheet of the training activities conducted by the St Andrews team with countries, organisations and numbers of participants listed and email from Arclight Medical (W. Williams) for the number of Arclight devices distributed
- S2. Link to the BBC world service interview with Dr Blaikie on the Arclight that was broadcast on the 12th January 2017 on the Newsday program
- S3. Web page with World service audience figures
- S4. The V&A Museum blog describing the Arclight team as a Design Champion
- S5. Google search results for low-cost ophthalmoscope
- S6. Websites documenting the Tandem Arclight Africa Expedition, which distributed Arclight devices the length of Africa, and also provided training in their use
- S7. Lead for Diabetic Retinopathy Screening in Scotland and Lead of NHS Fife-Malawi Vision 2020 Diabetic Retinopathy Screening Link.
- S8. Board member of Sense International, Kenya, providing evidence of the number of children that underwent eye health and red reflex tests in Kenya and Uganda using the Arclight, and Dr Blaikie's role in the implementation Arclight in their project
- S9. Supporting document from Country Director, Sense International, Tanzania providing evidence of the number of children screened, and the number who were then referred for further investigations.
- S10. Email from Director of TLM
- S11. 5-year Strategy plan for Paediatric Oncology Services in Tanzania