Impact case study (REF3b)

Institution: University of Aberdeen

Unit of Assessment: 1- Clinical Medicine

Title of case study: Automated screening systems for the early detection of diabetic retinopathy: development and incorporation into a national screening programme

1. Summary of the impact

Diabetic retinopathy is a leading cause of blindness in people of working age. Screening programmes for its early detection are therefore crucial. Following the introduction of screening programmes for diabetic eye disease, research carried out at the University of Aberdeen enabled the resulting images to be analysed by computer rather than manually, a technique that has now been adopted by Scotland's national screening programme. This has achieved a significant impact on patient health, as well as economic impacts for the taxpayer, through cost savings, and for the company that developed the screening software commercially.

Therefore this research has had impact in health and welfare by influencing decisions and care practices by a health service.

2. Underpinning research

Since 1996 the number of people with diabetes in the UK has increased from 1.4 million to 2.9 million and, according to statistics produced by Diabetes UK, is predicted to rise to 5 million by 2025. In the western world, diabetic retinopathy - a serious complication of diabetes - is the leading cause of loss of sight among individuals of working age and can progress to an advanced stage without any noticeable symptoms. Screening programmes are therefore essential for the early detection of the disease. Approximately 20% of people diagnosed with type 2 diabetes have early signs of retinopathy, but with early diagnosis and treatment, blindness will be prevented in 90% of those cases.

Since 1993, the University of Aberdeen has conducted a research programme comprising two elements. In the first instance the team (Dr John Olson, NHS Consultant Ophthalmic Physician; Professor Peter Sharp, Head of the Department of Biomedical Physics and Bioengineering (became Emeritus in August 2012); and Professor John Forrester, Professor of Ophthalmology (became Emeritus in 2011) developed software to detect those features common to the early onset of diabetic retinopathy; microaneurysms, haemorrhages and exudates. Secondly, they evaluated the clinical benefit of the software and concluded there was a strong case both for commercialising the software itself and for introducing it into screening programmes for diabetic retinopathy.

The Aberdeen programme started at a time when retinal imaging technology was analogue and the early work on microaneurysm imaging involved the time-consuming and invasive technique of injecting dye prior to imaging (fluorescein angiography) - an approach that was inappropriate for routine clinical screening. In 1997, the team developed the first fully automated programme for detecting microaneurysms in fundus (retinal) camera images [1].

As digital fundus cameras came on the market, the Aberdeen team was funded by the NHS Health Technology Assessment (HTA) programme to look at the value of digital imaging in diabetic retinopathy. The findings of this project (2007) showed, for the first time, that [2]:
- digital imaging was an effective method for detecting referable (potentially sight-threatening) retinopathy, with technical failure rates lower than those of conventional photography,
- dilation of the pupils was not normally required, thereby reducing patient discomfort,
- a single image of each eye (rather than the usual two) was sufficient,
- automated grading could improve efficiency by correctly identifying just under half the population as having no retinopathy (though it was suggested that for automated grading

- to perform reliably, confirmation from a larger trial was needed),
- manual screening alone would be insufficient to deal with the increasing prevalence of diabetes,
- there was strong evidence that digital imaging was fit for incorporation into the national screening service.

In 2003, with funding from Scotland's Chief Scientist Office, a multidisciplinary team in Aberdeen evaluated the efficacy and cost-effectiveness of the automated grading system using 14,406 images from 6,722 consecutive patients attending a regional diabetic retinopathy screening programme. The software performed disease/no disease decision-making based on detection of microaneurysms and dot haemorrhages, and furthermore was able to assess image quality - something that had not previously been considered. The automated system was found to be as effective as the manual grading system but more economical to operate. It was estimated that, if implemented within the national screening programme [3,4], it would save the National Health Service in Scotland approximately £200,000 per year.

In a further study begun in 2005, the team recruited over 25,000 patients from three Scottish screening centres with a view to monitoring the performance of a new algorithm that incorporated macular exudate and blot haemorrhage detection, both signs that may require referral to an ophthalmology clinic. This demonstrated conclusively that the detection of observable/referable retinopathy was improved [5].

3. References to the research

[1] Cree MJ, Olson JA, McHardy KC, Sharp PF, Forrester JV. (1997). A fully automated comparative microaneurysm digital detection system. *Eye,* 11: 622-628. *This paper addressed, for the first time, the difficult task of detecting microaneurysms in fundus camera images in a fully automated way (98 citations).*

[2] Sharp PF. Olson JA, Strachan F et al. (2003). The value of digital imaging in diabetic retinopathy. *Health Technology Assessment,* 7:1-119. *A health technology study on the value of digital fundus cameras which demonstrated that automated screening for diabetic retinopathy was feasible (33 citations).*

[3] Philip S, Fleming AD, Goatman KE et al. (2007). The efficacy of "disease/no disease" grading in a systematic screening programme. *Br J Ophthalmol*, 91: 1512-1517. *This looked at the performance of the software in a clinical screening programme (62 citations).*

[4] Scotland GS, McNamee P, Philip S, et al. (2007). Cost-effectiveness of implementing automated grading within the national screening programme for diabetic retinopathy in Scotland. *Br J Ophthalmol*, 91: 1518-1523. *This assessed the cost-effectiveness of the software and was a companion paper to 4 (30 citations).*

[5] Scotland GS, McNamee P, Fleming AD et al. (2010). Costs and consequences of automated algorithms versus manual grading for the detection of referable diabetic retinopathy. *Br J Ophthalmol,* 94: 712-719. *This extended the number of clinical features that the software could detect to look at its ability to detect referable retinal eye disease, i.e. that which is at an advanced stage.*

Relevant Grant Funding:
- 1995-1997: £388,644, NHS HTA Programme. The value of digital imaging in diabetic retinopathy. PF Sharp, JV Forrester, A Grant.
- 2003-2005: £220,854, Chief Scientist Office. SEHD. The role of automated grading of diabetic retinopathy in a primary care screening programme. JA Olson, PF Sharp, P McNamee, G Prescott.
- 2005-2007: £183,743, Chief Scientist Office. SEHD. The role of automated level two grading within the Diabetic Retinopathy Screening Collaborative Network. JA Olson, PF

Sharp, K Goatman, A Fleming, P McNamee, G Prescott, S Philip, G Williams, G Leese, K Swa, M Virdi, W Wykes.

- 2008 -2012: £432,174, NIHR HTA Programme Improving the value of screening for diabetic macular oedema using surrogate photographic markers. JA Olson, PF Sharp, K Goatman, G Scotland, P McNamee, G Prescott, S Philip, K Swa, R Newsom.
- 2010-2013: £232,460, Medalytix Ltd. Salary support for research fellow for 3 years. PF Sharp.
- 2011-2012: £25,992, Chief Scientists Office, SGHD The contribution of automated retinopathy grading to predicting 5-year cardiovascular disease risk in people with diabetes in Scotland. A Fleming, S Philip, G Prescott, JA Olson, PF Sharp, K Goatman.
- 2012-2014: £179,617, Chief Scientists Office, SGHD Can automated analysis of sequential retinal images of people attending diabetic retinal screening predict future referral to Ophthalmology? S Philip, JA Olson, PF Sharp, G Prescott.

4. Details of the impact

The research carried out at Aberdeen has improved the quality and cost-effectiveness of screening for diabetic retinopathy and has been central to the enhancement of Scotland's national screening programme. Thus, it has achieved a significant impact on patient health and welfare, as well as economic impacts for the taxpayer, through cost savings for NHS Scotland, and for the company that developed the screening software commercially.

In 2006, the research team was approached by a new start-up company, Medalytix [a]. The team, supported by Scottish Health Innovations [b], negotiated a licence agreement with Medalytix on the automated grading software. Following a number of further licence agreements and patents, and a £2 million investment package from (amongst others) the business-venture arm of the Spanish National Organisation for the Blind, the company developed a commercial version of the software known as iGrading. This, according to a 2010/11 report by Scotland's Diabetic Retinopathy Screening Programme [c], was successfully piloted. In 2012, Medalytix agreed a sub-licence with Digital Healthcare to market the product. Medalytix's current sales figures are not known, but a condition of the licensing was that the products should be made available to the Scottish screening service free of charge. Thus not only has industry benefitted, but NHS Scotland has had free use of the software.

Following a 2009 independent review by the Scottish Diabetic Retinopathy Screening collaborative (made up of individuals from all NHS Boards in Scotland) on behalf of the Scottish Government, it was recommended that "automated grading should replace level 1 manual grading in Scotland." This recommendation was implemented in 2010, with the result that the Scottish Diabetic Retinopathy Screening Service's screening centres now use the automated software developed by the Aberdeen research team. The workload of screeners has been reduced by nearly 40% through the new method, and the estimated annual cost saving for NHS Scotland is around £200,000 per year.

Since 2008, interest in using the software has also been shown by centres in other parts of the UK, Europe, South America, Africa and Australia. The Aberdeen team has worked actively to increase awareness and understanding of diabetic retinopathy and the case for automated screening among clinicians, professional and interest groups, and the general public. In 2010 the team presented details of its findings to medical ophthalmologists at the World Congress of Ophthalmology in Berlin and to retinal screeners at the British Association of Retinal Screeners' annual general meeting. In 2012, as part of the University's outreach programme, they explained the details and implications of their work to the general public through the University's series of informal public talks (the Café Med series).

A review of NHS Screening Services in NHS Scotland in 2012 by Deloitte (currently private and confidential) concludes that autograding is proving to be as effective as level-1 graders. It notes that as the diabetes population is increasing (4-5% per annum) automated grading will be invaluable in processing the increasing volume of images.

The National Collaborative Coordinator for the Scottish Diabetic Retinopathy Screening (DRS) Service has confirmed: "Without the research and development of this software, undertaken by Aberdeen University the programme would have no option but to continue to manually grade patient's photographs….DRS patients require to be screened for diabetic retinopathy annually and with the growing numbers the automated grader system will be an essential asset in helping the NHS in Scotland to continue to provide a high quality screening programme for all eligible patients with diabetes in an efficient and effective manner [f].

The research findings have reached non-specialist audiences through the pages of the Aberdeen Press and Journal and the Aberdeen *Evening Express* (January 2008, combined circulation over 110,000). The blog, *Diabetic Retinopathy News* [d], explained the system of automated grading and the reduction in workload it achieves through an article in October 2011, which is still available online. Further coverage appeared in the professional journal, *The Engineer* (March 2009, circulation over 30,000), whose website also retains it [e].

5. Sources to corroborate the impact

[a] Medalytix Company Web site (http://www.medalytix.com/). *Explains the application of the product to the national screening programme and its clinical validation of the technology in a live screening programme and availability for use.*

[b] Scottish Health Innovations Ltd, I-Grading Software description (http://www.shil.co.uk/Products/igradingtm-platform-diabetic-retinopathy-screening-software.html) *– detailed description of the technology and its developmental background, and its central role in the national screening programme.*

[c] The National Diabetic Retinopathy Screening Programme, Scotland (http://www.ndrs.scot.nhs.uk/). In the 2010/11 report the Lead Clinician states "*We have been piloting an automated-grading system in NHS Grampian for the last year. ...... We have now just started work to provide a national version for Scotland using a centrally hosted model. All NHS Boards will be able to access this automated grading system. We are confident that it will contribute to national efficiency savings despite of increasing demands from a rising diabetic population.*"

[d] Diabetic Retinopathy News – describes the use of I-grading and reduction in workload (http://www.diabetic-retinopathy.org/2011/10/automated-grading-of-digital-retinal.html). *Highlights the reduction in workload of manual graders by 38% using the software and its accuracy in the national diabetic retinopathy screening programme of 93% to 100% depending on the severity of the changes.*

[e] The Engineer (http://www.theengineer.co.uk/news/software-scans-retinas/310559.article) *Explanation of product, its importance and the company has acquired £2M of European Investment through ONCE (business arm of Spanish National Organisation for the Blind) to market internationally and benefit countries where there is insufficient screening infrastructure emphasised.*

Testimonials:

[f] National Collaborative Coordinator for Diabetic Retinal Screening

[g] Lead Author of independent review for Scottish Diabetic Retinopathy Screening Collaborative

[h] Director, National Services Division, NHS Scotland

[i] Senior Manager, Scottish Health Innovations Ltd., NHS Scotland