Chapter 1

Teleophthalmology: Eye Care in the Community

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Additional information is available at the end of the chapter

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1. Introduction

The difficulties of sustaining care in hospitals are forcing health economies to deliver health care closer to the home in the community. The increased use of Vasoactive Endothelial Growth Factor (VEGF) antagonists to treat patients with wet age related macular degeneration has exponentially increased the need for additional clinic and treatment capacity. New National Institute of Clinical Excellence (NICE) guidelines for glaucoma (2009) have increased the number of referrals into secondary care. This chapter will explore how additional capacity may be created using digital imaging transfer techniques, to allow patients to be seen in virtual clinics, which may be located in either primary or secondary care.

The learning goal of this chapter is better understanding of novel ophthalmic technology for retinal disease management and glaucoma assessment deployed in the digital health environment. This is a topic of considerable significance in retinal care given the explosion of relevant clinical imaging technology and the huge burden of certain retinal disease (age related macular degeneration, retinal vein occlusion and diabetic retinopathy) on National Health Service (NHS) services and which is set to expand even more with further new and welcome treatments for these conditions. It is also of importance in view of the increased glaucoma referrals into secondary care in the light of recent NICE guidance, increasing the need for more advanced imaging techniques in the diagnosis and investigation of these patients. Glaucoma patients are now more commonly undergoing Optical Coherence Tomography (OCT) scanning of the optic disc, or advanced disc imaging for follow up purposes and diagnosis.

Smarter ways of working, using new technology, are required to cope with this clinical need and organisational burden. The need includes better use of IT infrastructure; innovation in primary care to secondary care referral management and enhanced productivity in secondary care. The development of "Virtual Clinics" using this technology will be discussed.

Some clinical IT/imaging driven solutions to such challenges will be explored in this and with emphasis on retinal/glaucoma care pathways and treatment of eye emergencies.

Tele ophthalmology is a visual specialty with a long history. Therefore, the development of image and video transmission through a telephone line makes it possible to transfer ophthalmologic images over long distances. Li H (1999) reported a modern application in the late 1980s: NASA developed a real time transmission system of retinal images acquired using a portable video funduscope. Shimmra et. al (1998) used a conventional telephone system to transmit slit lamp images of the eye and evaluate the feasibility of real-time video and audio transmission. Yoshida A (1998) used video conferencing systems to transmit full-motion colour images between a university and hospital.

Using those early systems, an expert remote presenter who is trained in the use of the ophthalmic peripherals, hardware, and software can capture still and moving images of the eyes can transmit them to ophthalmologists. The current status of teleophthalmology applications has been limited to specific purposes such as doctor-to-doctor consultation, research and clinical trial collaboration, and distance learning for medical professionals. The purpose of this chapter is to demonstrate how refinement of this technology has successfully led to the clinical application of teleophthalmology systems for the benefit of patients.

Barsela and Glovinsky examined the feasibility of a low-bandwidth, Internet-based teleophthalmology system for consultation in an ophthalmic emergency room. Forty-nine patients were seen in the eye casualty by a resident and ocular images were taken using a slit-lamp connected to a video camera and transmitted to a senior ophthalmologist by email. A telephone was used for real-time audio communication of each case. Each case was re-examined by the same senior ophthalmologist the following day. Each case was assigned a feasibility score (0-100%), which was defined as the contribution made by the transmitted images in presenting clinical details which could not have been described verbally.

High feasibility scores from 85 to 90% were found for the following images: ocular surface, anterior chamber, anterior chamber angle, pupils, lens, optic nerve and macula. Images of vitreous and peripheral retina received low feasibility scores (mean score 65%). There was 100% agreement between the diagnosis made during consultation and the examination made by the consultant ophthalmologist later on. This illustrates the feasibility of teleophthalmoogy consultations in the emergency room. It has also proven to overcome the barriers and improve quality, access and affordability in eye care in South India, (John S et al 2012) in teleophthalmology mobile units in the community, a topic which will be discussed in more detail in section 3.

1.1. Eye care using wireless smart phone technology

Tele-ophthalmology is taking an increasing role in the provision of primary emergency services. Digital images, slit lamp video conferencing and transfer of fundus images allow the provision of substantial clinical care. Most urgent ophthalmic diagnosis may be made and treatment prescribed remotely. Decisions to transfer patients urgently can also be made. For instance the difference between acute iritis and acute angle closure glaucoma can be estab-

lished with slit lamp videos after telephone input of history. Urgent corneal conditions such as microbial keratitis, herpetic eye disease, etc can be initially managed urgently via elinks of photographs and videos. Images of optic discs can help in the diagnosis of papilloedema in an emergency setting. Images may now be transmitted to pads, phones and blackberry devices, so diagnosis and treatment may be made remotely.

The initial cost of investing in tele-ophthalmology in an emergency department is returned favourably by the savings in on call hours. This strategy is being employed at various rural centres across Australia, Wales and Canada. In Australia, most rural emergency departments now have tele links with one on call ophthalmologist covering several areas at once.

It has been shown to be feasible to apply satellite based tele-ophthalmology for making a presumptive diagnosis and planning further management of adnexal and orbital diseases based on live interaction and digital still images of the patients taken by a digital video slit lamp in rural areas of Tamil Nadu as demonstrated by Verma et al (2009). It has been demonstrated to be reliable in the assessment of ocular trauma as researched by Simon et al (2003).

In Sweden and Australia, General Practitioners have used these digital slit lamps in rural settings to gain experience in management of primary care emergencies and are supervised in the removal of corneal foreign bodies by the technology as shown by Hall et al (2005). A general ophthalmologist, Camara et al (2000) has used teleophthalmology to link up with an orbital surgeon to assist in the removal of a lateral orbital tumour.

Nurse Practitioners can be well trained to take anterior segment photographs on the slit lamp. (Kulshrestha MK, Williams C, Lewis D, Axford A (2010) A pilot trial of tele-ophthalmology services in North Wales. J Telemed Telecare;16:196-197).

Smart phones have been used in ophthalmology emergency departments to document visual acuity and examination findings. They have been used in dermatology and radiology to transfer images, but there is limited published use documented for image transfer in ophthalmology. The Foto-Ed Study by Lamirel et al (2012) compared the quality of images of non-mydriatic fundus images on a phone vs a computer screen, showing no loss of resolution of the image.

Smart phones, such as the iphone, therefore present a unique opportunity for a role in teleophthalmology. They have a high resolution “retinal” screen with 326dpi resolution located between two glossy panels of aluminosilicate glass (the same glass used in the windshields of helicopters and high speed trains). It has 78% of the pixels of a larger tablet or pad in a far smaller screen size. The resolution is therefore optimised to the way the human eye sees things at the normal distance from the eyes.

We therefore explored the use of the smart phone to take photos of the digitally captured image and transfer these to the Consultant Ophthalmologist in charge of the Tywyn Eye Clinic in North Wales through MMS smart phone text.

Smart phone technology has already been used in emergencies in the Norway's Arctic Svalbard archipelago where British students were recently attacked by a polar bear (www.myfox8.com/

news/wghp-story-deadly-polar-bear-attack-norway). Images were sent through a phone to University Hospital Tromsoe for immediate advice on first aid to be obtained.

We used smart phone technology to transfer a digital image taken on a slit lamp of the anterior segment of the eye in rural North Wales to a Consultant Ophthalmologist in the local District General Hospital, over 1 hour away by ambulance transfer to gain an instant, rapid opinion on diagnosis. This reduced unnecessary travelling down to Swansea, over 3.5 hours away. Eye Emergencies have been shown to be treated in rural areas by Nurse Practitioners obtaining advice directly from a Consultant Ophthalmologist through high resolution images of the eye seen on a smart phone.

Larger pads and tablets may also be used to send macular Optical coherence tomography images to a Consultant Ophthalmologist wirelessly using appropriate apps to carry out Virtual Clinics, run by Nurse Practitioners or Opticians, so that treatment decisions may be made remotely if the ophthalmologist is working many miles away from the rural centre.

1.2. Smart phone images used for diagnosis and treatment of eye emergencies in rural North Wales

1.2.1. Brief outline of problem

Tywyn, Gywnedd, North Wales at the Tywyn War Memorial Cottage Hospital, is a rural outreach clinic in the Betsi Cadwaladr University Health board. One hundred and twenty four eye emergencies are seen at this unit by Nurse Practitioners in casualty per year. Twenty four of these emergencies have needed referral per year to a Consultant Ophthalmologist on call at Bronglais Hospital, Aberystwyth for assessment. Bronglais Hospital is in the neighbouring Hywel Dda Health Board.

Nurse Practitioners have already undergone training in use of the Topcon SL D7 slit lamp to take photos of the anterior segment of the eye and send these images to Bronglais casualty for assessment through a Polycom Telemedicine monitor

Last year, Consultant Ophthalmologists in Hywel Dda Health Board were taken out of the on call rota and no longer carried out on call duties. Nurse Practitioners in Tywyn would therefore have to send eye emergencies to Swansea for assessment, which is 3 hours away.

The Nurse Practitioner is well trained to take anterior segment photographs on the slit lamp. We therefore explored the use of the smart phone to take photos of the digitally captured image and transfer these to the Consultant Ophthalmologist in charge of the Tywyn Eye Clinic through MMS texting.

1.2.2. Assessment of problem and analysis of its causes

Twenty four patients with eye emergencies would need to be transferred to Swansea per year, involving 144 hours of travelling time per year or 1526 kg of CO_2 pollution per year, to gain a Consultant Ophthalmologist opinion.

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The Trust Telemedicine Board and the Caldicott Guardian were consulted to discuss in detail issues in regard to transfer of images through smart phones to a Consultant Ophthalmologist to obtain an expert opinion and avoid hospital transfer

1.2.3. Strategy for change

A pilot in the use of smart phone technology to transfer digital images was discussed in the Telemedicine Board. The Caldicott Guardian stated that in an emergency transfer of an image for an expert opinion could be justified on clinical need. None of the anterior segment photos would show an identifiable face, and no patient identifiable information would be on the image. After the emergency decision and treatment were carried out the images were to be deleted from the Smart phones by the Nurse Practitioner and the Consultant.

Patients presenting to casualty with an eye emergency which the Nurse Practitioner on call deemed to need a Consultant opinion were asked and given the option of transfer to Swansea or for an image of the anterior segment of the eye to be sent to the Consultant Ophthalmologist in charge of the Tywyn Eye Clinic.

The experience/success of the pilot was to be fed back to the Telemedicine group for further discussion/improvements.

1.2.4. Measurement of improvement

Over a 12 month period from September 2011– August 2012, there were 12 eye casualties who needed assessment by digital transfer of images through the smart phone to the Consultant. The Consultant gave help on history/investigation/diagnosis and treatment

These patients were then assessed in Tywyn clinic at an appropriate time interval, the diagnosis confirmed and the outcome on symptoms/visual acuities assessed.

1.2.5. Effects of changes

We used smart phone technology to transfer a digital image taken on a slit lamp of the anterior segment of the eye to a Consultant Ophthalmologist to gain an instant, rapid opinion on diagnosis. This reduced unnecessary travelling down to Swansea, with a total of 84 hours or 2800 miles saved over 12 months for patients and hospital transport. Twelve patients had their eye findings correctly diagnosed through the smart phone image by an expert and appropriate treatment was given rapidly with excellent visual outcomes in all cases

This had allowed eye emergencies to be seen in Tywyn, despite changes in the on call arrangements. Patients can still gain an expert opinion through use of digital photography, and gain rapid treatment by instruction to a trained Nurse Practitioner. This has been useful for patients who present with anterior segment disorders of the eye, but is not as useful for disorders of the posterior segment of the eye. These patients would need assessment of their symptoms and are referred for urgent assessment in the local clinic.

The main problem encountered in the change was the issue of confidentiality. The Caldicott Guardian deemed that the clinical need was greater in these instances, and once the decision was made, the images were to be deleted form both Smart phones

1.2.6. Lessons Learnt

Smart Phone technology has been shown to be useful in the assessment and treatment of eye emergencies. All patients showed improvements in visual acuity ranging from 1 line to 7 lines, and complete resolution of symptoms due to prompt diagnosis and therapy.

A Consultant opinion was gained quickly in all 12 cases. The costs of patient and hospital transport were saved. There is a role for the use of smart tablets in digital image transfer to provide a larger image, and these could also be used for transfer of retinal optical coherence tomography images in a macular clinic. There is the potential for use of smart phone images in dermatological emergencies

Eye Emergencies can be effectively treated in rural areas by Nurse Practitioners obtaining advice directly from a Consultant through high resolution images of the eye seen on a smart phone.

1.3. Smart phone adapters for slit lamps

It is possible to take slit lamp photos by placing the lens of a smart phone against the slit lamp lens; however, the use of an adapter will allows higher quality photographs. This may help to facilitate teleophthalmology for nurse practitioners and optometrists in the primary care setting.

The Keeler Portable Slit Lamp iPhone 4 image adapter has been reported to be compatible with the Haag-Streit 900 BM (older series) and Topcon SL-3F slit lamps. The adapter is not compatible with Topcon SL-D7, Mentor. When using the Keeler adapter, a moderate amount of force has to be applied to attach the adapter to most Haag-Streit slit lamp oculars (the diameter of my slit lamp's ocular is 30 mm and it requires a moderate amount of force to attach).

2. Eye care in the optometry setting using community based optical coherence tomography and virtual glaucoma clinics

Current treatment for age related macular disease requires patients to be monitored closely (usually on a monthly basis) for recurrence of the disease. This disease affects elderly people, who may be unable to drive due to loss of visual acuity below driving standards. In rural areas, where there is a greater travel burden (for example in rural Wales) there is a major challenge for people to keep up with their appointments. Elderly people are increasingly reliant on relatives, neighbours and carers to transport them to clinics, and in many cases ambulance transfer is needed for routine clinic appointments. This causes additional stress and inconvenience for these patients. It increases the chance of further health problems as for example

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increased rate of falls. This costs either the health authorities and/ or the patients for organising and supplying this transport. More CO2 gases are released in the atmosphere from the increased pollution.

The solution for all these issues is to deliver healthcare closer to the home in the community. This can be achieved with community based OCT machines, together with (non-) mydriatic fundus cameras. In areas with not very dense population or in countries, where the purchase of enough equipment is an issue, this equipment can be integrated into special mobile vans. Mobile vans can visit different areas with a pre- determined schedule, and are the topic of discussion of the next section in this chapter.

The information obtained with this equipment is sufficient for a trained ophthalmologist to assign appropriate treatment or follow up, using modern telemedicine equipment, even if he or she is thousands of miles away. This allows remote diagnosis and management of patients.

Glaucoma is a chronic disease, in which in the majority of cases lifetime follow up is required. This puts a large strain on the ophthalmology clinics. For most of the patients with stable glaucoma follow up in a virtual clinic is possible.

Trained opticians or nurses can check visual acuity, IOP (Goldman application), perform visual acuity test, nerve fibre layer scans (OCT, GDX, HRT) and record fundus photos with a (non)- mydriatic camera. All these tests can be done in the community and after that the information can be digitally transferred to a regional ophthalmology centre, where it can be interpreted by ophthalmologists. In this way patients are not going to have travel long distances. The ophthalmologists will be able to increase the capacity of their clinics. They will have all the required information for changing treatment and assigning follow up appointments. Prioritisation of patients who need to be seen for a face to face consultation can be made from the information.

2.1. Optometry and teleophthalmology

In the UK there are currently 2.3 ophthalmologists per 100 000 population, as described by Kulshrestha and Kelly (2011). This is the lowest pro rata than any other European Union country (www.uems.net). In the UK, optometrists play an important role in managing patients with eye complaints. Most of the patients seen in the Hospital Eye Service (HES) are referred by them either directly or through the patient's general practitioner (GP) (Bell and O'Brien 1997). For example more than 90 % of all suspected cases of primary open angle glaucoma are referred to the HES by optometrists according to Harrison and Wild et al (1988). The National Health Service (NHS) hospitals in the United Kingdom are a part of the public system. Optometry practices are private and have a dual role: they carry sight tests and dispense spectacles and contact lenses. The sight tests are reimbursed by the NHS.

The Hospital Eye Services (HES) in the UK are usually overloaded with patients and have waiting times of several months for new patients. There are also waiting times for follow up appointments. This means that for many patients allocated 6 months follow up appointments, the appointment may be delayed by a number of months. This is called slippage, and slippage has increased in recent years due to the introduction of new NICE guidance for glaucoma,

which has increased referrals into HES from primary care. In addition, increased workload from the Vasoactive Endothelial Growth Factor antagonist treatment of wet age related macular disease has overloaded the service due to the demands of monthly OCT scanning and injections. This service is now affecting appointments in general ophthalmology clinics where glaucoma patients are seen.

With an aging population (baby-boomers are currently retiring) and financial strain on the NHS hospital services, new technological and organizational solutions are in need of implementation to solve the capacity problems brought about by an increased demand on services. Involving optometrists as part of a team is one potential solution. To ensure that quality is guaranteed, this can be done under the direct supervision of the consultant ophthalmologist (or other trained HES trained staff) with the help of an IT teleophthalmology connection between them. In addition to assisting the Hospital Eye Service by using the human, technological and the space capacity available at the optometry practices in urban areas, teleophthalmology provides invaluable benefits in rural areas. The availability of ophthalmology services at the community reduces the need of transport (cost and carbon emissions) and reduces the inconvenience (need of accompanying relative/ absence from work).

For example in the Hywel Dda Health Board, patients from Wales have to travel sometimes more than 1 hour in each direction for a HES appointment. Ophthalmology patients are usually elderly, some with impaired eyesight and not fit to drive. Even if they are fit to drive they usually need somebody accompanying them, because of the need for pupillary dilation. Very often the general health of these patients is impaired as well which makes the journeys even more unpleasant and add to the psychological burden on the patient. Many of the ophthalmology conditions are chronic and need multiple follow up appointments (sometimes monthly visits) or on a lifelong basis (for example glaucoma). Waiting times for optometric appointments are usually a few days and these practices are situated in the community.

The teleophthalmology connection between HES and optometry practices can be significantly helpful in managing patients with 1) Glaucoma 2) Macular diseases 3) Emergency eye conditions.

2.2. Teleophthalmology in glaucoma patients

Management of patients with glaucoma and ocular hypertension is a significant part of the everyday workload in the glaucoma clinics. The North London Eye study and other population based surveys estimate that patients with ocular hypertension or primary open angle glaucoma (POAG) will increase by one third by 2021, as demonstrated by Morley and Murdoch (2006). According to Lockwood et al (2010) the positive predictive rate in the diagnosis of glaucoma and ocular hypertension was 0.37 before the National Institute of Clinical Excellence (NICE) guidelines published in April 2009 and has dropped to 0.2 after that. There are several glaucoma refinement schemes such as the Manchester, and Carmarthenshire Refinement Scheme, which rely on a specially trained optometrist to reduce the number of false positive glaucoma referrals and increase the positive predictive rate of HES referrals as described by Hensen et al (2003) and Devarajan et al (2011).In these schemes specially trained optometrists take the decision on which patients are to be referred to HES and which have to be discharged.

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Teleophthalmology provides us with the opportunity for these patients to be reviewed directly by the consultant and the HES staff who are already trained to do this by using virtual glaucoma clinics. At the Portsmouth-based glaucoma refinement scheme (Trickha et al 2012) designated refinement scheme optometrist examined the patients followed by a standard Humphrey 24-2 visual field (SITA fast) (Carl Zeiss Meditec,Dublin, CA, USA), applanation tonometry assessment of IOP (Goldmann model; Haag-Streit, Bern, Switzerland), and a digital disc photograph (Topcon, Tokyo, Japan). All the information is processed digitally to a named consultant, who takes the decision at a specially designated virtual glaucoma clinic, whether the patient needs an appointment at the HES or can be discharged and followed up in the community by a community optometrist. In this project only 11 % of the referrals to the virtual clinic needed an appointment in the HES and the other 89% did not need it. The positive predictive rate of the refinement scheme was 0.78 compared to 0.37 for the unrefined one.

In addition to refining patient referrals, teleophthalmology can be used for glaucoma patients follow up in the community. In a study performed by Bunduchi et al. (2010) in Scotland, stable glaucoma patients were followed up in the community by a designated optometrist.They had visual acuities, visual fields test, intraocular pressure measurement and fundus photograph of the eye done at a local optometrist sometimes many miles away from the HES. All the information was transferred via secure electronic information exchange system to the hospital where the information was assessed by the consultant or trained hospital staff at a virtual glaucoma clinic. In the virtual glaucoma clinic more patients can be assessed compared to a standard glaucoma clinic. In this way more slots were available for the unstable glaucoma patients. This can reduce the waiting time for follow up appointments and reduce the necessity for the patients to travel long distances usually every 6 months with all the associated drawbacks.

Teleophthalmology provides the opportunity of setting up an efficient glaucoma referral refinement and follow up system under the care of consultant ophthalmologist. In this way patients can receive quality specialised hospital services in their local community without the need for travel. This can lead to savings for the NHS and the patient, as it can increase the capacity of the existing glaucoma services.

2.3. Teleophthalmology and macular diseases

The optical coherence tomography (OCT) is the gold standard for diagnosis and follow up of many macular diseases. Many community optometry practices have OCT machines currently. In a study performed by Kelly at al. (2011) fundus photos and OCT scans were transferred by secure file transfer email (National Health Service or NHS mail) to the hospital ophthalmologist. The images transferred via email are with superior quality compared to the standard method of communication (faxing) and are much faster than posting of hard copies or using a CD. In 96 % of cases in this study analysis of the referrals and a working diagnosis/care pathway was provided by the ophthalmologist to the optometrist within the next calendar day. In the cases where ophthalmic examination was required patients were referred through the GP. In some cases on the basis of information provided by the optometrist urgent ophthalmology appointments were scheduled.

In the last few years wet age related macular degeneration (AMD) and the intravitreal anti-VEGF injection treatment has put unprecedented strain on the ophthalmology services worldwide. Even when the patients do not need treatment they have to be followed up on monthly basis, because of the possibility of recurrence. Stable wet AMD patients can be followed up locally with their community optometrist. Optometrists can examine the patients; take OCT scans and fundus photos and all this information can be transferred digitally via secure connection to the eye clinic. Consultants or other trained staff at the HES virtual AMD clinic can assess the information and manage the patients appropriately. In this way the current capacity of the eye clinics can be increased.

2.4. Teleophthalmology and urgent ophthalmology referrals

Many of the patients with eye complaints present initially at the optometrists practices. Sometimes the cases can be solved just with the advice of the ophthalmologist. The percentage of these cases can be increased significantly by using the opportunities of teleophthalmology. In this way unnecessary appointments at the HES and travel can be avoided. If emergency phone calls from the optometrists are accompanied by anterior segment photo or fundus photo the hospital ophthalmologist will receive much more information and can take immediate decision in most of the cases, whether to see the patient as an emergency or even to give appropriate management plan to the optometrist.

Most of the referral to the HES, even if they come from the GP are seen prior by their optometrists. If most of the referrals are accompanied by digital information received at the hospital the prioritisation consultant can more easily detect urgent cases, so they can receive sooner appointment.

Optometrists have the expertise to manage ophthalmology patients and with the help of teleophthalmology technology these skills can be expanded. The variety of patients managed in the community setting under the direct teleophthalmology supervision of a hospital consultant can be increased. In this way more resources at the hospitals can be spared for more challenging cases. On the other hand patients can receive high quality hospital service at their local community.

3. Eye care in mobile vans in urban and rural populations for macular disease and diabetic retinopathy

As the wet macular service continues to exponentially multiply the capacity issues in performing OCT scans (instrumental in the management of this condition) are becoming a limiting factor in this service. The use of transport mobile vans that perform these scans with technicians and nurses is now becoming a more viable option.

Mobile van units have been used successfully to deliver eye service in the community in York, Exeter and Wales. In Wales there is the National Diabetic Retinopathy Screening Service, where vans are used throughout the country to take fundus photos of diabetics. Images are then

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transferred to a grading centre in Cardiff. In Exeter there is a mobile glaucoma service which has been developed to provide additional clinic capacity, run by Glaucoma Nurse Practitioners. In York there is a Box Van where patients are seen to have OCT scanning and lucentis injections in the van.

3.1. Diabetic retinopathy screening service for Wales

In Wales all diabetic patients undergo annual screening in local community hospitals or GP surgeries depending on the rural location. Digital fundus imaging is carried out with dilated pupils. The photographs are saved onto laptops with strict security access codes. Images are stored in data centres in North Wales, (Canaervon), Mid and South West Wales (Carmarthen) and Trefforest near Cardiff at Fairway Court which is the main centre to which all images are sent for data backup. These centres are linked through a $DAWN_2$METRO VPN. Graders at Trefforest carry out primary and secondary retinal screening.

Any patients with sight threatening diabetic retinopathy are referred to their local eye clinic by a fax or letter referral depending on the urgency and the patients are seen appropriately in specialised diabetic eye clinics within the hospital eye service. Patients with background diabetic retinopathy or no retinopathy at all have annual follow up screening assessments. This has proved to be a world class, efficient and well coordinated screening service for all diabetics in Wales. Consultant Ophthalmologists throughout Wales have regular group meetings to discuss how the service is to be delivered and improved, and provide regular training for all the Graders at Trefforest. In addition, it has standardised ophthalmic care for diabetics throughout the whole country. Consultants may view images at the local Screening Centre. There are now developments in place to allow the images to be digitally transferred to individual clinics from the main centre, so Consultants can visualise them in the clinic setting

3.2. Exeter mobile glaucoma service

This service was set up to screening for new referrals and follow up care of stable patients according to NICE standards The Royal Devon & Exeter Hospital Wonford have a dedicated Mobile Eye Unit which goes out across the community which screens new referrals and provides follow up care of stable patients. It is Nurse led, the Specialist Glaucoma Nurses carrying out investigations in the mobile unit including:

- Visual field assessments,
- visual acuity,
- Goldman tonometry,
- gonioscopy,
- Pupil assessment,
- Pachymetry,
- Heidelberg Retinal Tomography,

- Digital fundus photography
- Optic nerve head assessments

The Specialist Nurses also drive the mobile units around the area

The Nurse Practitioners work closely with the consultants and other members of the health service such as Opticians and GPs to provide screening and follow-up care for glaucoma patients. Glaucoma Practitioners undergo MSc Glaucoma modules in assessment and management of Glaucoma and non medical independent prescribing qualifications.

Glaucoma Imaging Technicians provide technical support for Glaucoma Practitioners in carrying out Glaucoma screening and follow-up clinics. They record patients' visual acuities, carry out Humphrey visual field assessments, perform digital stereoscopic optic disc photography, retinal topography scans and optical coherence tomography images of the optic disc

3.3. York mobile service

AMD is the leading cause of blindness in the UK, and predominantly affects those aged 55 and over. It currently affects an estimated 500,000 people in the UK and approximately 26,000 new cases of the more severe wet form are reported each year. This includes over 10,000 people across the North and East of Yorkshire.

Eye patients based in East Yorkshire are now able to reap the benefits of a newly launched Mobile Community Eye Care Centre based at Bridlington and District Hospitals. Previously over 140, mostly elderly, patients from the Bridlington, Scarborough and Whitby area had to make a round trip of 80 miles or more to receive treatment at York Hospital once a month. This meant that a clinic visit which should not take longer than two hours could sometimes take a whole day.

Designed as a dedicated service for local people with wet Age-related Macular Degeneration (AMD), the new clinic has slashed patient travelling times by over half, also relieving local health services of some of the capacity issues currently being faced.

The York Mobile Unit is a large Box van in which there is a waiting area, visual acuity assessment, OCT scanning and injection facilities.

The mobile clinic has saved the local NHS money in transport costs, as patients will be able to receive treatment closer to home. On average, 50 patients required hospital transport to their AMD clinic appointments over a 3 month period previously.

Incorporation of" Iris software" into the van has enabled the development of an electronic patient record in the mobile unit and has the potential to transmit image data wirelessly to a smart phone or tablet, allowing remote teleophthalmology assessment of images to take place. The unique thing about iris is that it uses the cloud to store data so can be accessed more easily in peripheral locations than Stand alone systems. It's is connected via the National Health Service n3 secure network via a password that is sent to the users mobile phone on logging in. It is a paperless system that mails a summary to the General Practitioner direct.

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3.4. Setting up a mobile ophthalmology service: Rural Wales

The aim of the Project is to improve the quality and convenience of care for Ophthalmology patients by providing clinical reviews in the community by setting up a mobile assessment service with the capability of performing OCTs, automated visual fields, and slit-lamp based clinical examinations. This mobile assessment service will assist in overcoming current clinic capacity issues experienced by the general ophthalmology service (especially the wet AMD and glaucoma service) within the Hywel Dda Health Board Ophthalmology Department and reduce the requirement for extra out-of-hours / weekend clinics. The Mobile Ophthalmic Review Service (The Review Van) will be used in varying locations for patients to visit and receive their follow up wet AMD assessments (OCT scan and fundoscopy), and glaucoma assessments (optic disc imaging via the OCT machine, visual field analysis, and intraocular pressure check). Two possible models may be used. 1. Decisions can be made immediately in the van by an appropriate doctor or nurse practitioner. 2. The images can be transferred to the Department of Ophthalmology to be reviewed by clinicians at Hywel Dda Health Board. The mobile unit could be used to monitor other ophthalmic conditions such as pre-op and post-op cataracts, diabetic macular oedema (DMO), retinal vein occlusion (RVO) etc.

In West Wales, there are a number of community hospitals in rural areas, where elderly people find it difficult to access care. We are in the process of piloting an OCT Scan Van which will provide local OCT scanning for macular patients undergoing lucentis therapy. This will reduce the travel burden for these elderly patients who would otherwise have to access this care at District General Hospitals which are more than 1 hour away. It will also provide OCT scanning of the Optic Disc for Glaucoma patients. Some of the local community hospitals have injection facilities/theatres which could be used at a later stage to provide a one stop service. There will also be the option of providing an Injection van for carrying out Lucentis injections at certain community locations at a later stage.

Hywel Dda Health Board is the operational name of Hywel Dda Local Health Board.

Hywel Dda Local Health Board provides healthcare services to a total population of around 372,320 throughout Carmarthenshire (178,119), Pembrokeshire (116,001), and Ceredigion (78,200). It provides Acute, Primary, Community, Mental Health and Learning Disabilities services via General and Community Hospitals, Health Centres, GP's, Dentists, Pharmacists, Optometrists and other sites. The Headquarters is at Merlin's Court, Winch Lane, Haverfordwest.

The map below provides a visual overview of the wide area covered by Hywel Dda Health Board.

The map shows the site of the 4 general hospitals (white circles 1-4) within Hywel Dda Health Board. For geographic reasons the ophthalmology service for Hywel Dda has historically developed as 2 separate departments each with its own separate group of staff. The wet AMD and glaucoma services that the Hywel Dda Health Board Mobile Outreach Joint Working Project Group applies to are delivered by the department serving Carmarthenshire and Pembrokeshire (and some patients from Ceredigion) serving a total population of approxi-

Figure 1. Map of Wales with locations of Hospitals served by Hywel Dda Health Board

mately 300,000. The intravitreal service for this area currently operates out of Amman Valley Hospital (yellow circle 2). The day surgery unit at this community hospital accepts patients for its intravitreal service from the catchment areas of 3 general hospitals: Withybush Hospital (WBH) in Haverfordwest (white circle 3), West Wales General Hospital (WWGH) in Carmarthen (white circle 2), Prince Phillip Hospital (PPH) in Llanelli (white circle 4). Thus Amman Valley Hospital provides a wet AMD service for Carmarthenshire, Pembrokeshire and parts of Ceredigion which covers a population of approximately 300,000 drawing patients from a wide geographical area.

The AA route finder shows that a return journey from Haverfordwest to Amman Valley Hospital is 110 miles taking 2 hours and 50 minutes, from Fishguard it is 140 miles with an estimated return travel time of 3.5 hours. Only a proportion of this journey has a dual carriageway, patients often have longer travel times than this, especially when using hospital

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transport. A public transport journey is complicated, exceptionally long, and not practical for patients, and is never undertaken. The above example (the catchment area for Withybush Hospital in Haverfordwest) applies to approximately one third of the departmental catchment area (serving 116,000 people). There are currently 460 wet AMD patients in this service for regular follow up and treatment, approximately 1/3 of this population each lives in the catchment area of PPH (Llanelli), WWGH (Carmarthen), Withybush (Haverfordwest, Pembrokeshire). This represents a significant travel burden on patients and their relatives, especially for the patients from Pembrokeshire. Costs of travel are met by patients and family (75% of journeys), and Hywel Dda Health Board via the Welsh Ambulance Service (25% of journeys).

An audit of 26 recent clinics (June, July 2011) has shown that the number of patients injected per clinic has fallen from 75-80% in 2009, to 50% currently (due to the increased proportion of stable wet age related macular disease patients as the macular service service has matured). This has resulted in an inefficient use of the injection facilities available, and unnecessary travel for the 50% of patients who do not receive injections. Not all 'non-injection' decisions can be predicted, but many can, especially those patients who have been recently dry for 4 months or more.

The Ophthalmology service is currently operating beyond capacity and the expected increase in patient numbers would mean the service would be further stretched. An increased time interval between intravitreal treatments has been proven to reduce visual outcomes. The service currently requires a combination of extra Saturday clinics or volunteers to cross-cover for colleagues when they take annual leave from the service. The current guidelines from the Royal College of Ophthalmologists on the standard of care for the management of wet AMD is that initial treatment be given within two weeks of presentation and that patients be followed up four weekly. The current average follow up time at Hywel Dda Health Board is 5 weeks for patients with active wet AMD, longer for those patients who have been 'dry' for successive visits, as long as extra clinics and cross-cover can be arranged. The extra out-of-hours clinics and volunteer based cross-cover is no longer sustainable.

New treatment modalities have recently been approved for Diabetic Macular Oedema (DMO)and Retinal Vein Occlusion (RVO). These developments will increase the burden on theintravitreal service over and above the burden from the wet AMD service. The wet AMDservice continues to accumulate patients at a rate of 11-14 new patients per month, thiscontinues to far exceed the number of discharges from the service despite now entering its 4th year. Experience from around the UK is showing only a 5% discharge at year one, only 25% at year two, the predicted service plateau at end of year three has not materialised.

Within the Department of Ophthalmology, the medical retina service has been a priority due its immediate capacity needs. However, the service cannot keep up with the demand, and the new treatment modalities now available for DMO and RVO will impact this service further. This growth in demand for intravitreal treatments has had a major impact on the ability and capacity to deliver the general ophthalmic service, especially the glaucoma and cataract services.

The glaucoma service for this department currently operates out of the 3 main district general hospitals described above (WBH, WWGH and PPH – white circles 3, 2 and 4 respectively). The extra capacity demands placed on the Ophthalmology department following the development of the new wet age related macular disease service in 2008 has resulted in a lack of building space and staff to cope with the increased demands placed on the glaucoma service via recent NICE guidelines and the new National (NHS Wales) Glaucoma pathway. The glaucoma service cannot currently meet these guidelines predominantly due to capacity issues, created by recent intravitreal service development

Delivering a health system focused on care closer to home will require support from the population of Carmarthenshire, Ceredigion and Pembrokeshire, as well as stakeholders. The key driver for change is the opportunity to improve the quality and the safety of health services. This project fits perfectly with the stated aims of the Health Board by moving wet age related macular disease consultations from a day surgery unit hospital environment into the community, and nearer to the home of the patient. As stated above there is a considerable travel burden for one third of the intravitreal population, and in comparison to a non-rural region there is still a significant travel burden for the other two thirds of the population. The costs for 25% of journeys are met by the Health Board; costs for 75% of journeys are met by patients and their families. The table below provides a snapshot of the travel burden.

Catchment area	Approx proportion of population (Total 300,000)	Minimum return journey time*	Frequently quoted return journey time	Return mileage from district general hospital to intravitreal centre (AVH, Glanamman)
WBH, Pembrokeshire	33%	2 hrs 50mins	4 hrs WBH 5 hrs Fishguard	110 miles
WWGH, Carmarthen	33%	80 mins	80 mins	52 miles
PPH, Llanelli	33%	60 mins	60 mins	31 miles

*AA route finder quote

NB: Carmarthen to AVH is the only journey which is predominantly dual carriageway, the other 2

Table 1. journeys are predominantly single carriageway roads

- The Health Board has limited buildings and infrastructure to grow and develop the Ophthalmology service. This has significant implications for the intravitreal service (wet age related macular disease, Diabetic macular oedema and retinal vein occlusion), and the Glaucoma service, both of which have NICE guidelines and new NHS Wales pathways to adhere to. The Glaucoma service does not have the required buildings / space to expand

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into in any of the above 3 district general hospitals (WBH, WWGH, PPH – white circles 3, 2, 4 above).

- There are demands on the Ophthalmology service to follow up patients at regular intervals which cannot be achieved with current staff / service logistics / capacity.
- Adherence to National Institute of Clinical Excellence guidelines (for both wet age related macular disease and glaucoma) and the new NHS Wales 'Focus on Ophthalmology' Pathways (for both wet age related macular diseases and glaucoma) cannot be guaranteed with current demands and activities

The proposed project is to set up a mobile assessment unit (review van) complete with an OCT machine, visual field machine and slit-lamp to follow-up recently 'dry' macular disease patients nearer to their home rather than in Amman Valley Hospital; plus follow-up glaucoma patients at an approved interval near to or at their local district general hospital thereby:

- Reducing the number of unused injection slots in the Amman Valley Hospital (AVH) theatre
- Reducing considerably the travel time burden on patients and their family to AVH
- Reducing considerably the travel cost burden on the Health Board, patients and their families
- Reducing the time interval between reviews in wet age related macular disease, thus facilitating improved visual outcomes due prompt recognition of the requirement for further intravitreal therapy.
- Reduce the time interval between glaucoma follow-up reviews to that required by NICE guidelines and NHS Wales 'Focus on Ophthalmology' Pathways, thus facilitating enhanced visual outcomes.

The 'Review Van' will be used in varying locations for patients to visit and receive their follow up macular and glaucoma assessments. 2 models are available:

- Data (intraocular pressure and images for glaucoma, images for macular assessment) can be transferred to the Department of Ophthalmology at Hywel Dda Health Board to be reviewed by clinicians, or
- The assessments can be reviewed in real-time by a doctor or nurse practitioner present within the van

For macular disease, the first locations for the mobile unit to provide follow up appointments have been identified in Pembrokeshire. There is an aspiration to achieve further locations within twelve months in/near Carmarthen and Llanelli.

For glaucoma, WWGH Carmarthen has been identified as the primary area of interest due to acute constraints of available building space and staff. There is an aspiration to pilot the review van for glaucoma reviews in WBH and PPH (both also have constraints on available building space and staff).

There is also the potential for the review and monitoring of other patients that require OCT scanning and slit-lamp review as part of their regular monitoring eg diabetic macular oedema, retinal vein occlusion, pre and post-op cataract assessments.

By moving a proportion of the wet AMD service and glaucoma service out of the main unit it is proposed that there will be more capacity to meet the current and immediate future demands for intravitreal therapies. It is proposed that after 3-4 months of 'dry' status patients could be seen in the review van for follow up.

The lucentis service at Aberystwyth caters for the population of Ceredigion (90,000), South Gwynedd (50,000 of a total of 130,000 for Gwynedd county and Powys (120,000). Some patients in Powys are managed by the medical retina teams of Shrewsbury and Hereford.

All patients undergo OCT scanning at North Road Eye Clinic, and lucentis injection at Bronglais Hospital at a separate booked appointment. Currently up to 20-25 patients are booked for lucentis injection from North Road onto one injection list at Bronglais Hospital as a two stop service.

Patients are seen at local community clinics of Tywyn (South Gywnedd), Machynlleth (North Powys), Llanidloes (North Powys), Newtown (Mid Powys), Aberaeron (South Ceredigion) and Cardigan (South Ceredigion). All patients from these community clinics therefore have to travel twice per month when undergoing review of lucentis therapy for OCT scanning at North Road and subsequent injection at Bronglais. Provision of local Optical Coherence Tomography scanning in the van in the community will allow this travel burden to be halved.

Patients from Aberaeron, Machynlleth are within 30 minutes of Aberystwyth and can therefore continue to have their injections in Bronglais. Patients from South Gwynedd and Mid Powys may have to travel in excess of 1 hour to access the theatre facilities in Aberystwyth. This travelling time can be up to 1.5 or 2 hours in snowy winter conditions, where the roads are full of traffic from holiday makers from the Midlands in the summer or in rare instances where there has been a road traffic accident

This group of patients can potentially have injections in theatre facilities within Tywyn for South Gwynedd patients and Llandrindod Wells Hospital for Mid Powys patients. Cardigan patients are over 1 hour from Aberystwyth, and they may have the travel burden reduced by having both the OCT scan and injection facilities to be made available in two separate vans. It would be possible therefore, for certain sited to have a one stop service (Tywyn, Llandrindod Wells, Cardigan) and some to remain as a two stop (Aberaeron, Machynlleth) depending on the facilities available on each site.

There remains scope to reduce the travel burden on patients from Powys who currently are scanned in Shrewsbury or Hereford to have local OCT scanning and/or injections in the community at Welsh Community Hospitals in the future to reduce their travel burden. This may be incorporated into the project once the project has been established within Hywel Dda Health Board.

In order to set this develop this project, an Ophthalmic Mobile Unit team was set up to discuss development of a business case with regular meetings monthly for a year. The Project is now

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about to hit the road, and has had a successful demonstration using the Mobile van for optical coherence tomography scanning

4. Eye care to the paediatric population

4.1. Medico legal issues

The diagnosis of non-accidental injuries in children and babies frequently requires the presence of retinal haemorrhages. Court conviction depends on the testimony of the ophthalmologist who has to rely only on clinical notes as evidence. Having retcam video and photographs carry huge weight age in such proceedings.

4.2. Retinopathy of prematurity

Babies born prematurely or underweight are at risk of developing a devastating proliferative retinopathy of prematurity (RoP) that can be blinding. It remains a major cause of visual loss worldwide and there is approximately 50 000 babies annual rate of global blindness from RoP. This is potentially a treatable condition and therefore requires thorough and extensive screening. Unfortunately screening is dependant on the presence of highly skilled paediatric ophthalmologists. Most babies with RoP are in developing countries where there is a lack of properly trained paediatric ophthalmologists. Having a device that can photograph the fundus appearance and then either email or share these pictures with a central resource where trained ophthalmologists can grade them will obviously save sights. The answer has been in the use of the retcam, which can photograph and even video the fundi of such babies. The retcam images are now increasingly replacing the indentation indirect approach of fundoscopy.

Another source of problems is intra and inter grader variability. To overcome this issue software are in the process of development for "Automated Quantification of Retinal Vessel Morphology". Human input is still required, but the aim of development is to make screening entirely computerized.

4.3. Retcam images

Retcam images are similarly used for screening of premature or low birth weight babies for Retinopathy of Prematurity (ROP) using ophthalmoscopy and image-based telemedicine examinations. The number of premature infants is increasing throughout the world, and a larger percentage of them are surviving. A Telemedicine examination from images obtained from a Retcam may be more reproducible than if you see an infant's retina only briefly during ophthalmoscopy. These are manufactured by Spectrum and Clarity Medical systems. There is a rationale that image-based examination may be better because findings are documented photographically, rather than an indirect ophthalmoscopic examination, which may also be more uncomfortable for the baby. In many other ophthalmic diseases, definitions are based on standard images, so this has implications for the way we might deliver the best care to patients in the future.

The Retcam does require contact with the cornea and will therefore require training. It uses pupillary illumination to take digital photos of the fundus and skilled screeners may grade these images in a central location that can be remote from the neonatal unit. Where a shortage of trained paediatric ophthalmologists is stretching the services of ROP screening, this mode of teleophthalmology is not only valuable, but is in fact the only solution to maintaining a credible service. Other paediatric ophthalmic pathology can also be excluded via the retcam. An example is the presence of retinoblastomas[4] in an eye with a white reflex, allowing decisions to be made on urgency of referrals. Photographs of shaken babies for diagnostic and medico legal purposes can also be taken via a Retcam and the images subsequently transferred for opinion.

Advantages of the Retcam include its portability and manoeuvrability in constrained areas such as on the Neonatal Intensive Unit and outpatients. It is easily transportable between hospitals and clinics, and allows transfer of images to any networked system. It allows timely remote evaluation of patient images and provides advanced image analysis and comparison capability of previous images with retcam review software.

In 2008 at Nayayana Nethralaya Postgraduate Institute of Ophthalmology, Bangalore, India, a tele ROP service was initiated using a nonphysician screening model as described by Vinekar A (2008). This was entitled KIDROP (Karanataka Internet Assisted Diagnosis of ROP). The Retcam Shuttle (clarity MSI) and a portable laser indirect ophthalmoscope were transported by a clinical team to 23 Neonatal Intensive Care Units in 7 districts around Bangalore city.

The images are exported from a laptop using a portable wireless data card which allows internet access. The images are uploaded onto a secure server using an n indigenously designed software (i2i Telesolutions;Bangalore, India), which are backed up at 2 geographic sites. A remotely situated expert will login read and report the image live.

Since 2009, images have been visualised on a smart phone remotely using a specially designed application for the device. The reports created on the smart phone are in PDF, and on submission to the expert, they enter the server through the GSM cellular network and are accessible to the technician in any remote rural area.

5. Conclusion

Governments are now focusing on delivering care closer to the patient's home. With the ever increasing number of patients we need to see in our clinics, these clinically driven IT solutions may allow patients to have investigations carried out either in their local community hospitals, primary care setting or in mobile ophthalmic units. The various solutions discussed in this chapter using wireless technology to set up virtual clinics will:

- Increase productivity of healthcare professionals
- Strengthen referral patterns
- Effectively educate hospital staff, clinicians and the community

- Extend patient care and expertise to remote areas
- Improve patient care with mobility solutions

We would envisage that this will help to reduce slippage on patient appointments, distribute the workload to the community staff and help to increase capacity. This will help to reduce also the travel burden on patients traveling to the main centre every month for some patients. This becomes increasingly more difficult for elderly patients with time, and saves them many hours of a long trip, with reduced need for hospital transport, or patients own transport costs in many instances. There is also reduced pollution directly arising from reduced travel needs.

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