The ROYAL COLLEGE of OPHTHALMOLOGISTS

focus

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Telemedicine

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What is Telemedicine?

Telemedicine may be defined as the use of advanced communication and technology to deliver and improve healthcare, over the confining parameters of distance and time.[1] It is puzzling that despite being born over five decades ago and described in 2016 by Forbes Magazine as "the new online banking for health", telemedicine remains in its infancy. Advances in ocular imaging capabilities in conjunction with the ubiquity of internet connectivity surely must pave new paths for the delivery of eye care though teleophthalmology.

The History of Telemedicine

William Einthoven (1860-1927) is credited with the generation of the prefix "tele" in a medical context in his article in 1906 reporting on the use of a galvanometer with telephone technology to transmit heart sounds 0.9 miles, termed the "telecardiogram"[2]. The telemedicine as we know it today was first circulated in the early 1920s with the advent of radio communications enabling two-way communications between doctor and patient **(Figure 1)**. Relevant to the national health service (NHS) of today, telemedicine is most applicable in the form of the cost-savings model or access-to-market model, whereby cost-effective care can be delivered, within the confines of limited resources whilst defying the constraints of a reliance on health seeking behaviour.[3]

Figure 1. The April 1924 issue of Radio News Magazine.[20]

The Current Status of Teleophthalmology in the UK

The demand for ophthalmic services is outstripping supply. Although the number of ophthalmologists is rising, the UK has one of the lowest number of ophthalmologists per capita in the developed world, and numbers are increasing at only half the rate of the rise in population over age 60.[4] The challenge is to maintain the delivery of timely, high quality care in the face of diminishing resources. The impact of this imbalance of demand and supply is evidenced in the recently published figures of 22 patients per month facing severe vision loss whilst waiting to access ophthalmic services.[5]

In the UK, the store-and-forward model of teleophthalmology, whereby images are acquired at a separate time and place from their assessment by a trained grader, is best exemplified by the UK National Diabetic Eye Screening Programme (DESP). DESP has improved access for patients, with 76% of those eligible for screening (persons aged 12 years and over, with a diagnosis of diabetes mellitus) receiving retinal imaging yearly[6], and has allowed at-risk populations with diabetic retinopathy (approximately 4.5% of the screening population meeting threshold for referral) to be identified for early treatment at hospital based services.[7] First implemented in 2003, DESP achieved population coverage in 2008 and gradually evolved from a primarily hospital-based, consultant-delivered service, to an independent community-based, technician/optometry-delivered service. The benefits of this teleophthalmology programme was only realised over a decade later, when in 2009-2010, for the first time in five decades, diabetic retinopathy was no longer the leading cause of blindness in England and Wales.[8] The flip side, however, was an increase in hospital eye service attendances of more than 30% due to previously undetected retinopathy.[6] This was exaggerated by the low threshold for specialist referral, resulting in a false positive referral rate as high as 30%, within the national screening program.[9]

The growth in teleophthalmology has also been driven by the recent introduction of new imaging modalities including ultra-wide field imaging fundus cameras and optical coherence tomography. In diagnosing and monitoring treatment of retinal conditions, the new imaging modalities have shifted emphasis from the clinical gold standard of binocular fundus examination.[10] Although imaging devices have likely increased detection of potential ocular pathology, the availability of these devices in high street optometry practices has caused an increase in referrals to hospital based services.[11] As Thomas Kuhn (1922-1996), suggested in his publication The Structure of Scientific Revolutions, paradigm shifts (such as the move towards teleophthalmology and virtual clinics) tend to follow a "crisis" period where the normal state of play (routine face to face outpatient clinics) is unable to solve problems within the existing paradigm.[12] It can be argued that the new imaging modalities have led to a disruption, or "crisis" point due to their availability to the masses by economies of scale. They have however, also created the possibility of improved telemedicine.

The concept of the virtual clinic was born out of the need to provide additional capacity for unmet demand within the NHS. Proof of concept studies have shown that patients do not require a face to face interaction with a doctor at every hospital visit, and that a safe efficient service can be delivered in a "virtual clinic" pathway. [13] Furthermore, patients had a shorter "referral to treatment time" (RTT) compared to conventional outpatient clinics, and unnecessary appointments were avoided.[11] A study by Korteum et al. in 2018 demonstrated that the mean referral to appointment time was less than 7 weeks and therefore well within the challenging limit of 18 weeks claimed by the NHS for new referrals.[11] In this study, they further observed that the lack of an integrated telemedicine software solution resulted in the requirement of multiple parallel software programmes running alongside each other in order to complete a teleophthalmology assessment of the patient. This was not only time-consuming for the grader but prone to human error (wrong patient, wrong scan).

Virtual clinics have been piloted in several subspecialties, including medical retina, glaucoma and urgent care ophthalmology, with a number of programs developed over the past two decades.[10] Whilst it is clear that isolated programs have been successful, none have scaled to a national level. The King's Fund suggests that the difficulty in scaling innovation, lies in its inherent domino effect; triggering a series of changes such as methods of diagnosis, treatment pathways, staff roles, and revealing new patient needs.[14] They further suggest that even though an innovation may appear simple at face value, the spread of innovation within healthcare is costly and needs to be part of service improvement, rather than a mere "rolling-out" of a "proven approach". The King's Fund had previously identified in 2011 three key barriers to the utilization of telemedicine; a lack of access to data, commissioning services lacking the necessary tools and capabilities to drive change and the lack of the required infrastructure and leadership culture to support such changes.[15] Another important barrier is the lack of an integrated IT platform accessible for all (GPs, optometrists, ophthalmologists). This fragmentation of services is not only inefficient but can lead to duplication of work and may reduce the quality of care through loss of information. Despite evidence demonstrating a particularly high level of patient satisfaction with telemedicine compared conventional clinical care delivery, there remains a relatively poor uptake of teleophthalmology programs.[16] Finally, the paucity of published quality assurance processes and evidence is likely a further contributing factor and future developments of local protocols should be addressed with consideration to the patient perspective and emphasis on "patient-led care".

The Future of Teleophthalmology

Artificial intelligence (AI) and robotics have been forecast to transform healthcare by doing what humans do but more quickly and at a lower cost. In teleophthalmology this can be applied in two stages; stage one - where information is gathered from the patient in the form of a clinical history and when the eye is imaged; stage two - where this information is analysed, and a clinical decision made and communicated.

Stage one lends itself to the use of clinical decision trees, chatbots, machine learning, and automation. Current examples include the widespread use of autorefractors in areas of the world where there is a lack of optometrists, and the advent of chatbots as a symptom screening tool for self-administered triage, designed to improve access to care. Stage two has been an incredibly popular focus point for research. In 2018, the first deep learning algorithm to classify diabetic retinopathy was approved by the Federal Drug Administration in the United States of America[17]. This was closely followed by the publication of a deep-learning algorithm for OCT retinal images that was able to make referral recommendations for sight-threatening retinal diseases comparable to expert Ophthalmologists.[18]

Such developments have been a focal point in the recently published NHS 10-year long term plan, which aims to transform services and overcome the imbalance between demand and supply in healthcare. Digital technologies have been described as a critical part to achieve this goal and to provide care in the community where safe and possible.[19] Teleophthalmology serves this very purpose by allowing the gathering of structured clinical information and enabling the bidirectional flow of this information between patient, community, and hospital **(Figure 2)**. This builds an infrastructure for which AI algorithms and automation may be applied. With the NHS becoming ever more digital, it is likely that teleophthalmology will be integral to the future provision of 21st century eye care.

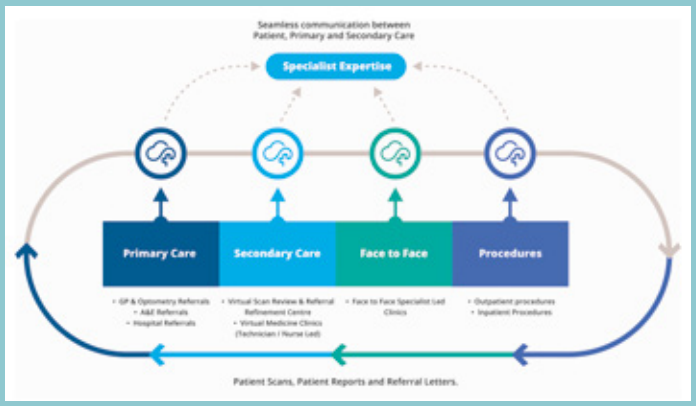

Figure 2: The Future of Teleophthalmology: A cloud-based Teleophthalmology platform will link all effects of patient care, from home monitoring, primary, secondary care, whilst maintaining a tertiary care level of specialist expertise by enabling efficient communication between healthcare professionals and the patient.

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