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Original Research

Real-time teleophthalmology in rural Western Australia

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Abstract

***Objective*:** *This study aims to assess the current utilisation of a real-time teleophthalmology service for rural Western Australia (WA).*
***Design*:** *Service evaluation by prospective audit.*
***Setting*:** *Includes general practices, optometrists, hospitals in rural WA and the Lions Eye Institute in Perth.*
***Participants*:** *Eighty-five patients from rural WA participating.*
***Interventions*:** *Video consultation (VC) with a general ophthalmologist.*
***Main outcome measures*:** *Number of referring practitioners and their locations, software and imaging equipment used as well as the presentation, working diagnosis and follow-up plan for each consultation.*
***Results*:** *Eighty-five participants took part in a total of 100 VCs in the 5-month data collection period. There were 49 men (58%); age range 7–92 years; 31 identified as Indigenous Australian (37%). Participants were referred by optometrists (59%), hospital district medical officers (23%) and GPs (18%). Karratha (41%), Albany (20%) and Broome (14%) were the main VC locations. There were 31 different eye conditions managed; red eye, acute vision loss, known glaucoma and abnormal retinal photographs were the main presentations. Skype was the commonly used software (71%). Images were provided in 63% of all VCs. The main equipment used included digital retinal cameras (56%), smartphones (25%) and digital slit lamps (13%). An outpatient appointment with the ophthalmologist was recommended following 35 VCs.*
***Conclusions*:** *Optometrists used this service most frequently, despite a lack of financial incentive. Digital retinal cameras and smartphones were the most commonly used imaging modalities. Overall, real-time teleophthalmology was used in the management of a broad range of eye conditions and was a useful supplement to outreach ophthalmology services.*

KEY WORDS: *general practice, ophthalmology, optometry, service evaluation, telemedicine.*

Introduction

Telemedicine offers a number of benefits to rural patients and health care practitioners, including improved access to specialist care, reduced travel and associated expenses, more prompt clinical assessment and improved continuity of care.[1] Many of these benefits of telemedicine have been reported in the context of ophthalmology.[2–7] This is particularly relevant to eye care in Australia, with previous studies suggesting rural Australians have higher rates of glaucoma, cataract, pterygia and ocular trauma compared to urban residents.[8] It has also been found that those living in rural areas are less likely to have ever seen an eye care provider.[9] This difference is partly explained by the lack of medical services by specialists and the travel distances in rural areas. Telemedicine offers an approach that provides a means of addressing this issue.

There are two broad categories of telemedicine depending on the technology used: store-and-forward and real time. Published literature reporting real-time telemedicine, particularly within the field of ophthalmology, is scant. Articles relating to studies which did use this technology evaluated a mobile unit connected to a base hospital[10] and ophthalmologists between developing and developed countries.[7] One other service linked ophthalmologists with hospital district medical officers (DMOs) in remote Australia,[11] and two services in Scandinavia connected ophthalmologists to GPs.[12,13] The teleophthalmology service evaluated in this study,

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***What is already known on this subject*:**
- *Medicare rebates for telehealth were introduced in order to improve access to specialist care for patients in remote, rural and outer metropolitan areas.*
- *In the field of ophthalmology, evaluations of services using this technology are scant.*

***What this study adds*:**
- *Real-time teleophthalmology can be used with a number of health practitioners, including optometrists.*
- *This technology can be used in the management of a broad range of eye conditions for patients in rural areas.*

however, uses a real-time system to link a general ophthalmologist with GPs, hospital DMOs and optometrists across multiple sites in rural Western Australia (WA).

We aimed to evaluate the current utilisation of this teleophthalmology service in order to identify its limitations and provide recommendations for improvement. The specific objectives were to determine the service utilisation by different primary health care professionals, to ascertain the clinical reasons for use as well as determine the main technologies used. This study was conducted as a pragmatic prospective audit of real-time clinical teleophthalmology, and is the first comprehensive evaluation of a real-time teleophthalmology service involving a range of health care professionals. Recommendations provided from this evaluation might thus be relevant to the improvement of other existing real-time services and could aid the development of future teleophthalmology services.

Methods

Ethics

This study was granted exemption from formal ethics approval by the Human Research and Ethics Committee at the University of Western Australia and the Kimberley Aboriginal Health Planning Forum on the basis that it was a clinical audit.

Service description

In 2012, a general ophthalmologist based at the Lions Eye Institute in Perth conducted outreach visits to 12 locations across rural WA. The ophthalmologist provided real-time and store-and-forward consultations to patients and health care practitioners to supplement these outreach clinical visits. Referring practitioners were directly informed about the availability of this option. Generally, for real-time consultations, the referring health practitioner contacted the specialist directly to organise a video consultation time. A referral letter and any relevant images captured by the referring health practitioner or other trained staff member were transferred electronically to the specialist for review. A video consultation was then conducted with the patient, referring health practitioner and specialist at the organised time. This prospective evaluation includes all patients who were involved in a video consultation with the ophthalmologist from April to August 2012.

Data collection

Data were collated on clinical log sheets completed by the specialist following a consultation. Information regarding patient demographics, referring practitioner details, as well as the technical, logistical and clinical aspects of the consultations was collected. The use of clinical log sheets has been recommended as a simple evaluation tool and used previously to evaluate telehealth consultations in WA.[14,15] The information collected was then recorded into a secure password-protected database (MS Access 2007, Microsoft Corporation, Redmond, Washington, USA). The participants' electronic medical records (MMEx, UWA Centre for Software Practice, WA, Australia) held by the specialist were reviewed to verify the validity of the information collected. Any forms not completed immediately following a video consultation were completed retrospectively using the participants' electronic medical record and referral information.

Data analysis

Only real-time consultations were evaluated in this analysis. To determine differences between referring health practitioners in the utilisation of this service, comparisons were made between the type of rural health practitioner and their location, the reasons for referral and the technology used. The recorded presentations and diagnoses were categorised and subgrouped for analysis. Data were analysed using Stata 10.0 (StataCorp, College Station, Texas, USA) and XLSTAT 2012.6.2 (Addinsoft, New York, USA). Categorical data were analysed using either the χ^2 or Fisher's exact test.

Results

Patient demographics

During the five-month study period, a total of 85 participants had a video consultation. The mean age of the participants was 49.8 years (range: 7 to 92 years). There were 49 men (58%), and 31 participants (37%) identified as Indigenous Australians. The majority of patients were residents in the Kimberley (33%) and the Pilbara (37%) regions of Western Australia. Just over 5% of people usually resided in urban, interstate or overseas locations, but were present in a rural location at the time of the video consultation. There were a total of 100 video consultations over the study period.

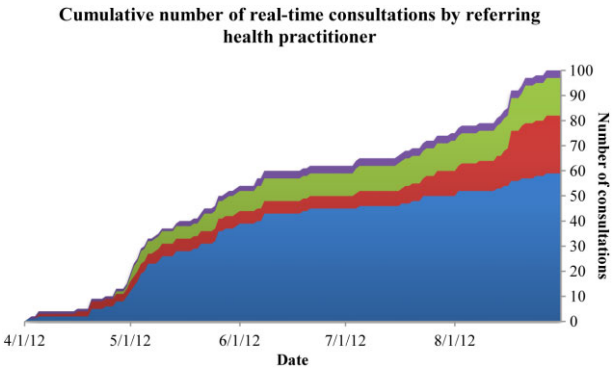

FIGURE 1: *The cumulative number of real-time teleophthalmology consultations by referring health practitioner. 'GP – PP' is a general practitioner in a private practice. 'GP – AMS' is a general practitioner in an Aboriginal Medical Service. Hospital DMO is a hospital district medical officer. ((■) GP – PP; (■) GP – AMS; (■) Hospital DMO; (■) Optometrist)*

Referring health care practitioners and locations

Three broad categories of health practitioner referred participants to the ophthalmologist: optometrists, hospital DMOs and GPs. Participants were referred by an optometrist in 59 video consultations, a hospital DMO in 23 consultations and a GP in 18 consultations (Fig. 1). The rural health practitioners were from nine locations across rural WA (Table 1, Fig. 2). It was found that 92% of all video consultations occurred with referring practitioners from locations that the specialist visits.

Reasons for consultation

There were 31 different eye conditions managed by video consultations (Table 2). Main reasons for a consultation were for a red eye, diabetic retinopathy (DR) screening and glaucoma follow-up (Table 3). In two consultations, the diagnosis could not be determined and required a face-to-face consultation. One was a case of sudden vision loss and this patient was transferred to Perth, the other was a case of DR screening where the image provided was of inadequate quality to accurately assess the retina. In 14 consultations there were no abnormalities detected.

Follow-up plan

Follow-up with the ophthalmologist was recommended in 35 consultations; 28 were for a face-to-face consultation in a visiting outpatient appointment and seven

TABLE 1: *The number of real-time consultations according to the referring rural health practitioner and their locations (*n = *100)*

	ASGC† remoteness area	Optometrist (*n*)	Hospital DMO (*n*)	GP – AMS (*n*)	GP – PP (*n*)	Total
Albany	RA3	11	0	8	1	20
Broome	RA4	6	4	2	2	14
Derby	RA5	0	12	0	0	12
Karratha	RA4	41	0	0	0	41
Kununurra	RA5	0	6	0	0	6
Roebourne	RA5	0	0	4	0	4
Other	–	1	1	1	0	3
Total		59	23	15	3	

†ASGC, Australian Standard Geographical Classification used by the Australian Bureau of Statistics; RA3, outer regional; RA4, remote; RA5, very remote. Hospital DMO, hospital district medical officer; GP – AMS, general practitioner in an Aboriginal Medical Service; GP – PP, general practitioner in private practice.

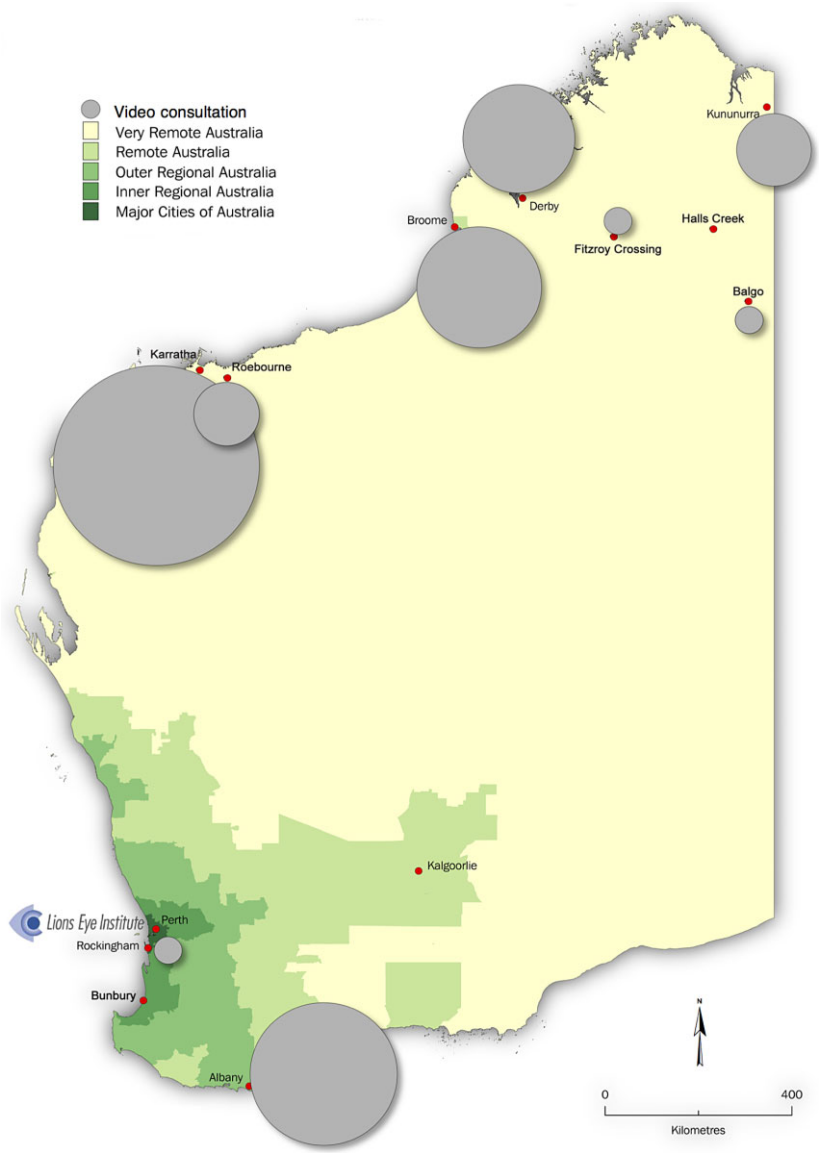

FIGURE 2: *The number of real-time teleophthalmology consultations by rural health practitioner location. The size of the bubble is proportional to the number of consultations from that location. Map adapted from Western Australia Remoteness Area ASCG Edition 2006. Available from: http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/1216.0.15.0032006?OpenDocument*

were for another telehealth consultation. In three cases it was recommended that the patient be immediately transferred to Perth. These included a case of sudden vision loss of unknown cause, a possible retinal tear and a known case of benign intracranial hypertension requiring neurosurgical assessment.

Technology used

Imaging equipment

Images of the eye using peripheral imaging equipment were provided in 63 consultations (Fig. 3). Types of imaging equipment used included fundus camera, digital slit lamp, smartphone with and without a slit lamp, ocular coherence tomography, visual field perimeter and a digital camera. Six consultations had images provided from more than one type of imaging equipment. GPs and hospital DMOs were more likely than optometrists to provide images for a video consultation ($P < 0.001$), and these practitioners were more likely to provide images from retinal cameras than optometrists ($P < 0.001$). However, optometrists were more likely to use smartphones with the slit lamp ($P = 0.044$) and were the only practitioners to provide images with optical coherence tomography or a perimeter. Participants were more likely to require follow-up by an eye care provider (ophthalmologist or optometrist) if images were not provided ($P = 0.002$).

TABLE 2: *The working diagnoses for first real-time teleophthalmology consultations (*n = *85)*

Diagnostic category	Diagnosis	Number of patients
External eye	Blepharitis	2
	BCC (Basal cell carcinoma) eyelid	1
	Chalazion	1
Conjunctiva	Pterygium	3
	Allergic conjunctivitis	2
	Bacterial conjunctivitis	1
	Episcleritis	1
	Subconjunctival haemorrhage	1
Cornea	Foreign body	2
	HSV (Herpes simplex virus) keratitis	2
	Marginal keratitis	1
	Adenoviral corneal infiltrates	1
	Corneal oedema	1
Anterior chamber		
	Idiopathic anterior uveitis	7
	Anterior uveitis secondary to VZV	3
	Hyphaema	1
Lens		
	Age related cataract	3
	Traumatic cataract	1
	Congenital cataract	1
	Posterior capsular opacification	1
Retina		
	Diabetic retinopathy only	4
	Diabetic maculopathy	4
	Posterior vitreous detachment	3
	Retinal tear	1
	Age-related macular degeneration	1
	Branch retinal vein occlusion	1
	RPE (Retinal pigment epithelium) detachment	1
	Retinal naevus	1
Optic disc	Primary open angle glaucoma	9
	Myelinated nerve fibre layer	1
Other	Ocular migraine	2
	Benign intracranial hypertension	2
	Crouzon syndrome	1
	Simple anisocoria	1
	Fourth nerve palsy	1
Normal/Unknown	Normal	14
	Unknown	2

Software

Two software applications were used for video-conferences, Skype (Microsoft Corporation, USA) and Scopia Desktop (Radvision, Tel Aviv, Israel). Skype is a proprietary voice-over Internet Protocol (voIP) service commonly used for communication with peers but also has a videoconferencing function. Scopia Desktop is used by the Western Australian Department of Health for telehealth consultations. Skype was used in 71 of the 100 consultations and Scopia Desktop was used in the remainder.

Logistics

Video consultations were classified as either 'unscheduled' or 'scheduled' based on whether an appointment time was made before the consultation occurred.

TABLE 3: *The presentations for real-time teleophthalmology consultations when the diagnosis was not known prior to the consultation* (n = *56)*

Reason for consultation	Frequency
Red eye	16
Diabetic retinopathy screening	16
Vision loss	
Painless	5
Painful	2
Flashes and/or floaters	5
Painful eye	3
Abnormal image	
Retinal photo	2
Optical coherence tomography	1
Other	
Glaucoma suspect	2
Eyelid pathology	2
Diplopia	1
Headache	1

Eighty-six consultations were unscheduled and optometrists were more likely to organise a scheduled consultation than medical practitioners ($P = 0.039$).

Discussion

This real-time teleophthalmology service provided continuous access to specialist ophthalmic care and support for rural patients and providers in Western Australia. Optometrists initiated the majority of video consultations, despite a lack of reimbursement through the Medicare Telehealth Initiative.[16] GPs used this service less frequently. Potential reasons for this finding include a lack of awareness of the service, a lack of familiarity with the ophthalmologist in locations where outreach visits are not provided, reduced frequency of eye presentations, logistical difficulties in organising a consultation and poor connectivity in very remote sites.[17,18] Other potential barriers include concerns regarding the diagnostic accuracy of this means of delivering health care, as well as technical and privacy issues associated with the technology used.[17,19] Recommendations for improvement include directly contacting optometrists and GPs in these locations to raise awareness of the service availability and developing a user-friendly booking system.

Diagnostic and management advice were provided for a broad range of ophthalmic conditions, as well as reassurance to patients and referring health practitioners for several presentations. The most common reasons for referral were red eye, DR screening and follow-up of known glaucoma patients. The presentation of red eye is a broad category that can be an indication of multiple, potentially serious conditions. Given the frequency of these presentations, further research is warranted to assess the clinical efficacy of diagnosing conditions presenting with a red eye via telemedicine, as well as the reliability of managing known glaucoma patients. Despite a lack of research in this area, it is felt that this approach was more beneficial than a telephone call in which there is generally no interaction with the patient and no provision of clinical images, nor any formal medical record keeping. Importantly, in this evaluation there were a number of cases where follow-up was organised with the ophthalmologist as an outpatient, supporting the use of telemedicine as a supplement to rather than a replacement for outreach visits.

Fundus cameras were the most common peripheral imaging equipment used and their use by optometrists, GPs and hospital DMOs for capturing images of the posterior segment has the potential to become more widespread.[20,21] The use of smartphone and a slit lamp adapter provides a simple means of obtaining images of the anterior segment, and offers a less costly alternative to the digital slit lamp (Fig. 4).[22] Skype was found to be the most commonly used video conferencing software, and smartphones the second most commonly used peripheral imaging equipment, supporting the notion that familiarity and ease of use are important factors in the use of technology.[23] Smartphones used were practitioners' personal devices; the practicality of using such devices needs to be balanced against the possible ethical implications on patient confidentiality. Interestingly, patients who had a video consultation without images provided were more likely to be followed up by an eye care professional, suggesting the provision of images is important to adequate clinical assessment via teleophthalmology, thus it is recommended that the use of peripheral imaging equipment should be encouraged.

Due to the descriptive design of this study, an evaluation of diagnostic accuracy and clinical efficacy was not possible. The conditions described were the working diagnoses of the specialist and not compared to a face-to-face assessment. Furthermore, when comparing the patterns of use by different health care practitioners, we included the frequency of consultations as the base unit of analysis and did not take into account the number of individual optometrists, GPs and hospital DMOs. However, the findings in this study do provide preliminary indications in the differences of the utilisation of the service by different health practitioners.

A number of important aspects of evaluation were considered beyond the scope of this study and warrant further research. Generally telemedicine in ophthalmology has been well received by patients and providers, however, this was not formally assessed in this study and importantly, Indigenous Australian perspectives of

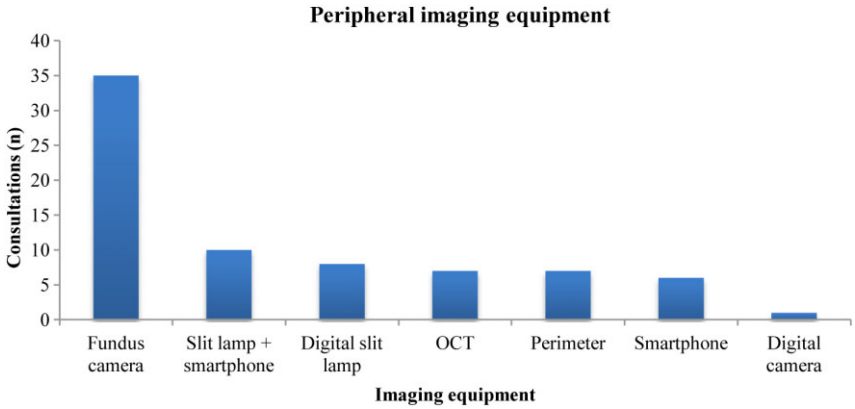

FIGURE 3: *The number of consultations in which peripheral imaging equipment was used* (n = 63). *Note some consultations used more than one type of imaging equipment. OCT, optical coherence tomography.*

FIGURE 4: *The iPhone 4S combined with a slit lamp adapter at Derby Hospital, WA. Assoc/Prof Angus Turner (right), Dr John Stace (centre), local Aboriginal Health Worker (left).*

telemedicine are currently unknown. In addition, a qualitative study that assesses GP perspectives on the use of telemedicine is required to identify which of the potential barriers identified in this study are most relevant.

Conclusion

Optometrists used this telemedicine service more frequently. Telemedicine for shared eye health care between optometrists and ophthalmologists in rural areas requires further investigation to establish models of care and funding. Digital retinal cameras were the main imaging technology used, with smartphones also being a popular means of image capture and transmission. Ultimately, teleophthalmology was useful in the delivery of eye care for patients across rural Western Australia; however, it should be considered a supplement rather than a replacement for outreach ophthalmology services.

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