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Advances in Teleophthalmology: Summarising Published Papers on Teleophthalmology Projects

Kambiz Bahaadinbeigy and Kanagasingam Yogesan
*Australian e-Health Research Centre – CSIRO,
Australia*

1. Introduction

Teleophthalmology is a branch of telemedicine that delivers eye care through digital medical equipment and telecommunications technology.¹ It does this through either a store and forward method or real-time communication, and so enables doctors to attend to patients in remote areas.²¹ It has been of increasing interest to researchers in the field of telemedicine over the last decade. This may have been due to the significance and prevalence of eye diseases, as well as a lack of specialists interested in working in remote areas.

A simple search for teleophthalmological research via the Medline database yielded hundreds of results with varying aims and objectives. There had been a significant increase in the research over the past decade, and this made summarising the papers challenging.

Although the studies possessed diverse aims and objectives, most focused on a particular eye problem, such as DR, glaucoma, adnexal disease etc. For instance, some of the projects questioned the feasibility of a particular type of teleophthalmological system for the screening of DR. Others concentrated on issues of cost and patient satisfaction. Whatever their main aims, each article took one or more eye diseases as its central theme.

The question of what eye problems had been of interest to date is important. Regardless of design or conclusions, each paper was proof of the field's increasing relevance. But what were the strengths and weaknesses of the teleophthalmological publications in terms of focusing on different type of eye problems? In other words, having considered the wide variety of eye disease which can be consulted through a telemedicine system, which area have been more of interest for researchers?

There were also other important questions. For example, the type of telemedicine used in teleophthalmological projects (pre-recorded or real-time) would have been of interest to eye care specialists.

Finally, the general conclusions made by the studies were also very significant. Were they positive, thus encouraging others to pursue the study, research and development of teleophthalmology?

This short report discusses the findings of a systematic literature review of published papers that have documented teleophthalmological projects and been indexed by major bibliographic databases. It will also attempt to classify them in order to answer the following questions:

1. What types of eye problems have been focused on?

2. Which type of telemedicine has been used, store and forward or real-time?
3. What proportion of papers has been conducted using a control group?
4. Are the papers' conclusions positive or negative?

2. Method

A comprehensive literature review was conducted.

2.1 Databases

Three bibliographic databases were searched: Medline, EMBASE and CINAHL. Medline was searched via Pubmed, while CINAHL (Ebsco) and EMBASE (Ovid) were searched through the library of University of Western Australia.

2.2 Dates

All published papers through the end of 2009.

2.3 Keywords

The databases were searched for the following keywords: telemedicine, e-health, telehealth, telemetry, tele ophthalmology, teleophthalmology, teleretiology, telediagnosis, teleconsultation, telemonitoring, tele screening, web-based, internet, remote or virtual. These keywords had to occur in conjunction with one of the following: ophthalmology, teleophthalmology, tele ophthalmology, eye, eye care, retina, retinal or tele ophthalmology. All three databases were asked to show only papers that had abstracts and were in English. A very broad range of keywords was chosen in order to ensure all relevant papers would be included.

2.4 Criteria for inclusion

Papers had to be about remote eye care delivered via digital devices or telecommunication technology, and had to be published in peer-reviewed journals. They also had to be in English and contain an abstract.

2.5 Criteria for exclusion

The first criterion for exclusion was that the material was presented in the format of a letter, editorial or review. The second criterion was that the paper was not about an actual teleophthalmological project. For example, articles that evaluated the potential of digital photo diagnosis for use in future teleophthalmological services were left out. Studies about research conducted on computerised models or on non-human models such as animal eyes (criterion three), were also eliminated from the review. Finally, double publications, i.e. a single project reported in two different formats (criterion four), were disqualified from this review.

2.6 Selection of papers

Papers retrieved from all three databases were entered in Endnote Reference Manager XI, and duplicates were removed. In total, 2,095 titles were retrieved. All papers were then reviewed and assessed for relevance to the topic at hand. In the second phase of the research, the abstracts of all shortlisted papers were analysed, with the full texts being evaluated when necessary. Paper selection steps are summarised in Table 1 below.

There were significant disparities between the selected papers in terms of their methodology and aims. They assessed the economy, feasibility, reliability and patient satisfaction of teleophthalmological projects on the screening or diagnosis of eye problems. Since the paper’s main aim was to discover what types of eye problems had been explored thus far, this heterogeneity was ignored.

All shortlisted papers were read, and for each paper, a simple questionnaire was filled out. The options for each question were based on the abstracts of the papers.

Question 1: Type of Eye Problem	Diabetic Retinopathy (DR)	<input type="checkbox"/>
	Premature Retinopathy (ROP)	<input type="checkbox"/>
	Glaucoma	<input type="checkbox"/>
	Strabismus	<input type="checkbox"/>
	General	<input type="checkbox"/>
	Other	<input type="checkbox"/>
Question 2: Type of Telemedicine	Store and Forward	<input type="checkbox"/>
	Real-Time	<input type="checkbox"/>
	Both	<input type="checkbox"/>
Question 3: Study Design	With Control Group	<input type="checkbox"/>
	Without Control Group	<input type="checkbox"/>
Question 4: Paper’s Final Conclusion	Positive	<input type="checkbox"/>
	Negative	<input type="checkbox"/>
	Unclear	<input type="checkbox"/>

Table 1. Questionnaire for the Classification of Papers

Number of papers retrieved from Medline	1573
Number of papers retrieved from CINAHL	169
Number of papers retrieved from EMBASE	1133
Final number of original papers	2095
Number of abstracts selected for further exploration after reading	351
Number of papers selected for in-depth reading	168
Number of papers excluded due to Criterion 1 (The paper was presented in the format of a letter, editorial or review)	183
Number of papers excluded due to Criterion 2a (The paper did not conduct an actual teleophthalmological project)	59
Number of papers excluded due to Criterion 2b (The paper conducted a teleophthalmological project using a computerised model)	11
Number of papers excluded due to Criterion 3 (The paper conducted a teleophthalmological project using a non-human model)	1
Number of papers excluded due to Criterion 4 (The teleophthalmological project was covered in more than one publication)	4
Final number of papers selected for the study	107

Table 2. Paper Selection Process

3. Results

3.1 Subspecialty

As Table 3 shows, 37 per cent of the research focused solely on DR and one or two other diseases. Twenty-three per cent concentrated on general ophthalmology (without a focus on a particular eye problem), fifteen per cent on ROP and ten per cent on glaucoma. In addition, two per cent focused on Strabismus.

Disease focused on in each paper	Number of papers(reference number)	Percentage
Diabetic Retinopathy	37(3-39)	34.58
General ophthalmology*	25(40-64)	23.36
(Retinopathy of Prematurity)ROP	16(65-80)	14.95
Glaucoma	11(81-91)	10.28
Strabismus	4(92-95)	3.74
Adnexal and Orbital disease	4(96-99)	3.74
DR and DME	2(100-101)	1.87
DR and AMD	1(102)	0.93
(Acute Macular Degenration) AMD	1(103)	0.93
DME	1(104)	0.93
SDME	1(105)	0.93
HTN (Hypertensive Retinopathy)	1(106)	0.93
Post-operative care	1(107)	0.93
Suspicion of abusive head trauma	1(108)	0.93
Retinoblastoma	1(109)	0.93
TOTAL	107	100

Table 3. Particular disease which each paper had focused on.

More than 37 per cent of all published projects on teleophthalmology studied only DR, while an additional three per cent also targeted macular degeneration.^{100, 101, 102} These studies evaluated either the feasibility of DR screening or diagnosis.

Twenty-five per cent of all papers were on general eye problems. This category covered projects that had been conducted in general practice clinics or that had not addressed any specific eye problem. These projects were merely targeted at confirming whether teleophthalmology had the potential to assist general practitioners in the treatment of patients with eye problems. Some of these projects focused on cost, patient satisfaction and other issues, rather than discussing a particular disease.

At sixteen per cent, ROP was the third main reason for the execution of teleophthalmological projects. The majority of papers on this eye disease aimed to evaluate the utility of teleophthalmology in its screening and diagnosis.

3.2 Type of telemedicine

Eighty-eight papers (83.02 per cent) focused on store and forward projects, eight (7.55 per cent) on real-time projects, and ten (9.43 per cent) used a mixed system.

3.3 Study design

Only two papers possessed a Randomised Controlled Trial (RCT) design,^{61, 98} and only four had used a control group.

3.4 Final conclusions of papers

Ninety-eight papers had a positive view of teleophthalmology. However, five papers did not arrive at a clear conclusion and four expressed a negative view towards teleophthalmology.^{5, 91, 98, 104}

4. Discussion

This chapter has attempted to locate all the teleophthalmological projects that have been published in peer-reviewed journals and indexed by the three popular bibliographic databases for biomedical research, Medline, EMBASE and CINAHL. It demonstrates that:

There is strong evidence that teleophthalmology is suitable for the treatment of retinal diseases, particularly DR and ROP;

Teleophthalmology has been successful when provided via the store and forward method;

Although the majority of studies to date have concluded on a positive note, only a few of these conclusions were based on high quality study designs involving controlled or randomised controlled trials.

The results show that most teleophthalmology projects to date have been focused on the treatment of DR. The health complications caused by diabetes and the importance of DR screening are likely major factors in the evaluation of teleophthalmology.¹¹⁰

However, other eye problems also require more attention. These include strabismus, cataracts and infectious diseases. Trachoma, for example, is a highly prevalent condition in developing countries.

Although the papers in the 'general eye problems' category were very diverse, it appears that the use of teleophthalmology to deliver eye care service to general practice clinics and optometrists has also been reasonably successful.

Teleophthalmology is still largely considered a store and forward application; this can be seen from the fact that less than seven per cent of the papers examined a real-time project. This might be explained by the requirement for high bandwidth. A considerable number of publications indicate that while store and forward teleophthalmology is both feasible and reliable, further evidence of the feasibility and reliability of real-time teleophthalmology is needed.

Approximately 90 per cent of the papers held positive views on teleophthalmology. However, ten per cent took a sceptical or negative view. This favourable statistic shows that teleophthalmology is a reliable method of eye care delivery. It was not possible to compare the feasibility and reliability of teleophthalmology across different subspecialties. Nevertheless, it is important to take into account the significant lack of papers using RCTs or comparable groups. This fact reveals that our evidence is undeniably inadequate and that we are not yet able to draw an informed conclusion.

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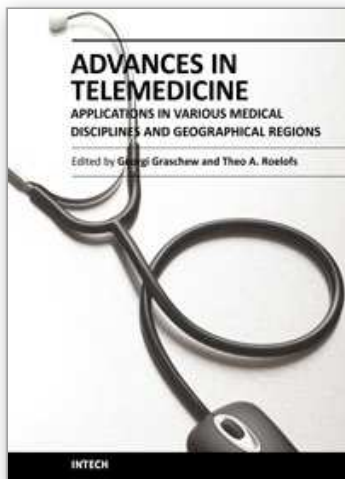
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中国上海市延安西路65号上海国际贵都大饭店办公楼405单元
Phone: +86-21-62489820
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