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Prospective Comparative study on Tele-Ophthalmology and Face-to-face Consultations in Patients with Chronic Visual loss

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Background

- The recent COVID-19 pandemic has generated significant interest in tele-ophthalmology as a viable consultation modality.

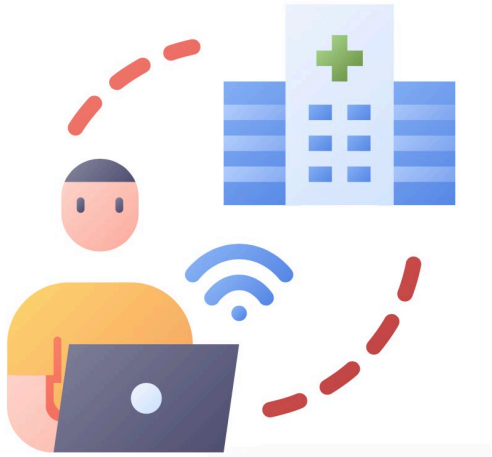
- Telemedicine services have clear benefits in ophthalmology beyond the pandemic. As a specialty that relies on image-based diagnostics and investigations, ophthalmology is a perfect fit for store-and-forward telehealth solutions.

- The accuracy and effectiveness of tele-ophthalmology platforms across multiple diseases, and especially for consultation purposes, have not been established in the published literature

Purpose

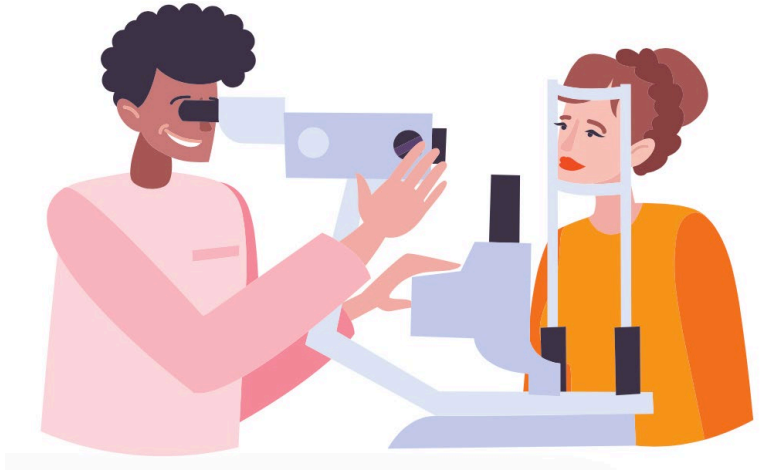
The aim of this study was to:

1) Determine the diagnostic accuracy of store-and-forward tele-ophthalmology for cataracts, glaucoma and age-related macular degeneration
2) Compare store-and-forward tele-ophthalmology agreement levels with face-to-face consultation in terms of diagnosis and severity
3) Compare the downstream costs generated by the consultation modalities.



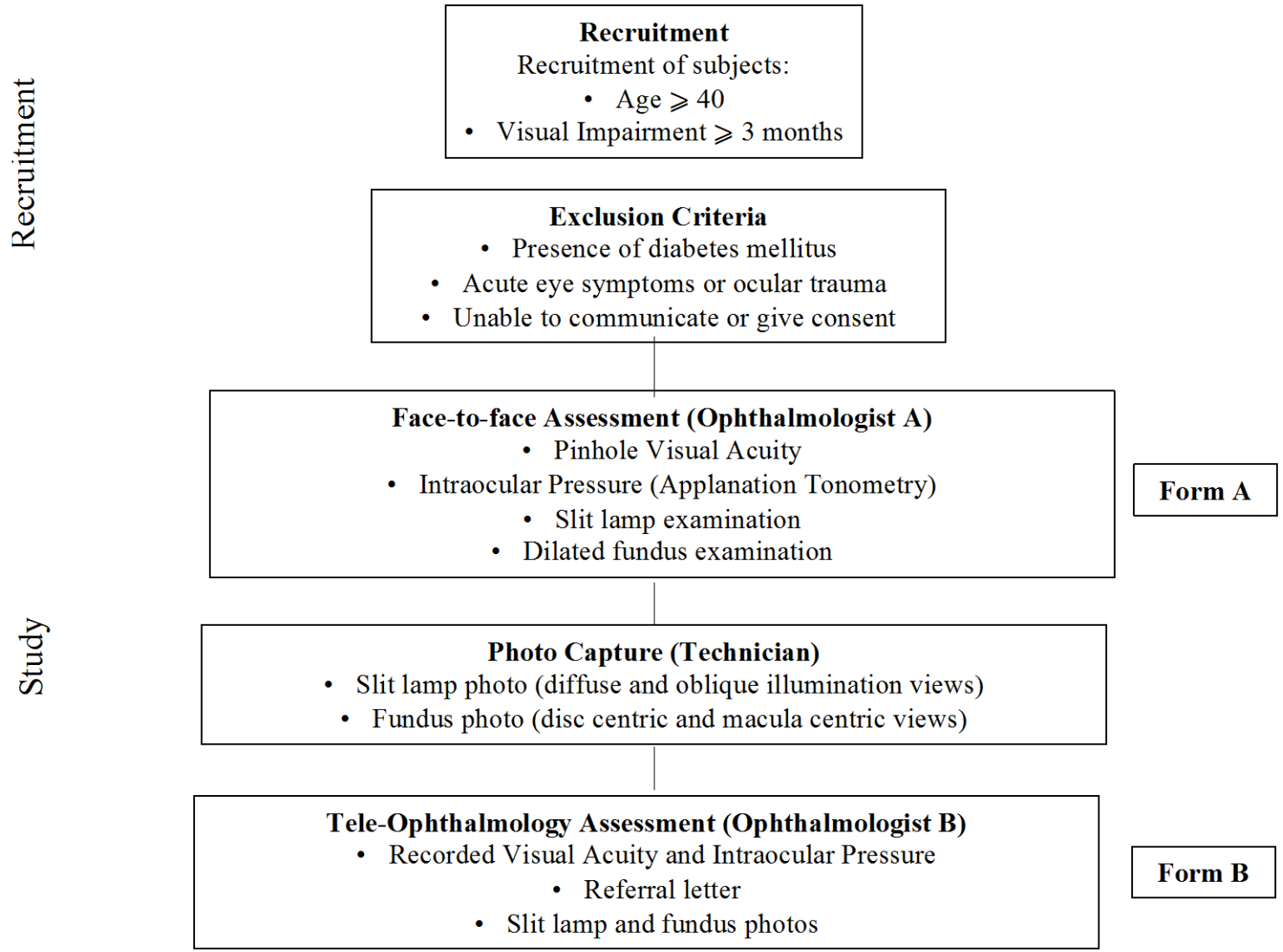
Tele-ophthalmology

VS



Face-to-face consultation

Patients/Study Design



Input Form

- Presence or absence of pathology
- Severity grading
- Management derived from severity grading

Subject no. _____ Face-to-face examination by_____ Date:_____

	Right eye	Left eye
Cataract (Severity)	Present / Absent	Present / Absent
	□ Early □ Moderate □ Severe □ Complicated	□ Early □ Moderate □ Severe □ Complicated
Glaucoma	Present / Absent	Present / Absent
	□ CD < 0.5 (normal) □ 0.5- 0.7 (suspicious) □ > 0.7 (need early intervention)	□ CD < 0.5 (normal) □ 0.5- 0.7 (suspicious) □ > 0.7 (need early intervention)
AMD	Present / Absent	Present / Absent
	□ Drusen only (observe) □ Dry (observe with follow up) □ Wet (need treatment) □ Dry AMD with scarring (observe with follow up) □ Wet AMD with scarring (may need treatment)	□ Drusen only (observe) □ Dry (observe with follow up) □ Wet (need treatment) □ Dry AMD with scarring (observe with follow up) □ Wet AMD with scarring (may need treatment)
Others		
Diagnosis		
Mx plan		
SOPD Follow-up	Yes	No

Methodology

- A prospective comparative study [study period: 1 Aug 2019 - 31 July 2021]
- Patients were independently assessed by both tele-ophthalmology and face-to-face assessment.
- Diagnostic accuracy of tele-ophthalmology was determined by sensitivity and specificity using the face-to-face consultation serving as the gold standard.
- Agreement level between the two modalities for diagnosis and severity were compared using kappa statistic[1].

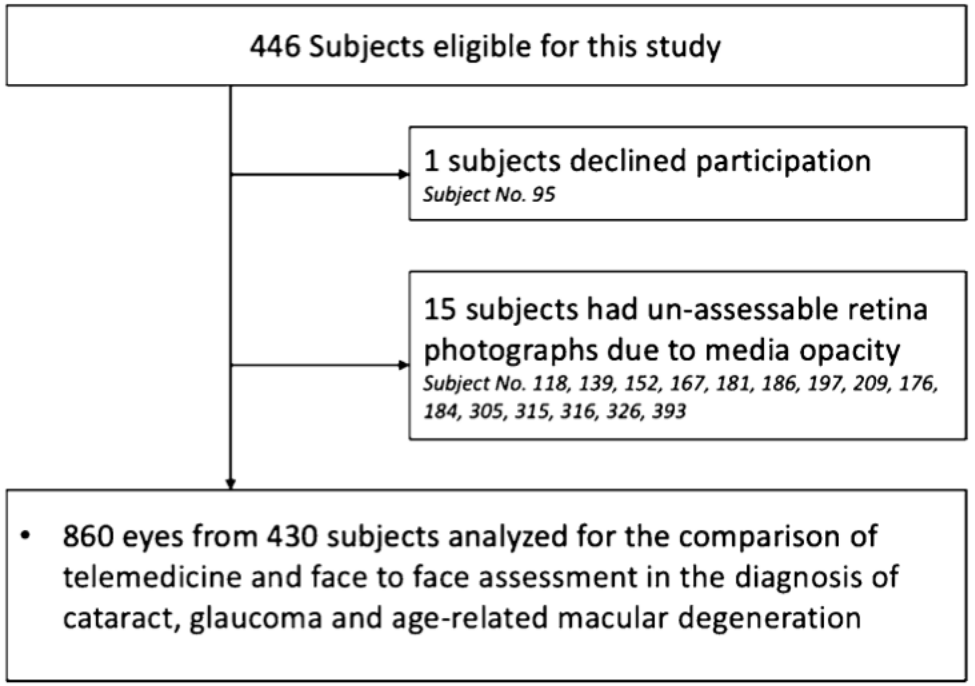
1. Landis JR, Koch GG. The measurement of observer agreement for categorical data. Biometrics. 1977;33(1):159-74.

Outcome Measures

- The primary outcome of the study was agreement level between tele-ophthalmology and face-to-face consultations in diagnosis and severity for cataracts, glaucoma and AMD, and the diagnostic accuracy of tele-ophthalmology with face-to-face consultation as the reference gold standard

- Secondary outcome includes comparison of downstream costs generated by the two consultation methods

Results – Patient Enrolment



Results

- 860 eyes from 430 subjects were assessed for the comparison study.
- The mean age of subjects at enrolment was 67 years (±11).
- 57.6% of recruited subjects were female, compared to 42.3% being male.
- The two ophthalmologists took turns serving as the face-to-face and tele-ophthalmology physician 44.9% and 55.1% of the time respectively.

Results - Disease prevalence between Techniques

	Prevalence from face-to-face consultation	Prevalence from tele-ophthalmology consultation	χ^2 statistic	*p* value
Cataracts	671/860 (75.3%)	690 (80.2%)	1.8	0.400
Early	432/671 (64.4%)	444/690 (64.4%)		
Moderate	213/671 (31.7%)	224/690 (32.5%)		
Severe	24/671 (3.6%)	22/690 (3.19%)		
Possible glaucoma	272/860 (31.6%)	216 (25.12%)	12.6	0.002
Glaucoma suspect	230/272 (84.6%)	193/216 (90.2%)		
Definite glaucoma	48/272 (17.6%)	23/216 (10.7%)		
Age-related macular degeneration	107/860 (12.4%)	106 (12.3%)	0.1	1.000
Drusen only	57/107 (53.3%)	62/106 (58.5%)		
Dry AMD	24/107 (22.4%)	15/106 (14.2%)		
Dry AMD with GA	23/107 (21.5%)	25/106 (23.6%)		
Wet AMD	3/107 (2.80%)	4/106 (3.70%)		

VA visual acuity, *IOP* intraocular pressure, *AMD* age-related macular degeneration, *GA* geographical atrophy

Results - Agreement between Tele-ophthalmology and Face-to-face Consultation in Diagnosis and Grading

Overall, agreement levels for both modalities were high across all three diseases.

Tele-ophthalmology had "almost perfect" agreement with F2F consultation in diagnosis and grading of cataract and AMD, and "substantial" agreement in diagnosis and grading of glaucoma

	Agreement *N* (%)	Kappa value (95% CI)	Agreement level	*p* value
Cataract present				
FTF vs. telemedicine	833/860 (96.9%)	0.91 (0.87–0.94)	Almost perfect	0.000
AMD present				
FTF vs. telemedicine	853/860 (99.2%)	0.96 (0.93–0.99)	Almost perfect	0.000
Glaucoma present				
FTF vs. telemedicine	790/860 (91.9%)	0.80 (0.75–0.84)	Substantial	0.000
Cataract severity				
FTF vs. telemedicine	800/860 (93.2%)	0.89 (0.86–0.92)	Almost perfect	0.000
AMD severity				
FTF vs. telemedicine	837/860 (97.3%)	0.88 (0.84–0.93)	Almost perfect	0.000
Glaucoma severity				
FTF vs. telemedicine	765/860 (88.9%)	0.74 (0.69–0.78)	Substantial	0.000

VA visual acuity, *IOP* intraocular pressure

Results - Diagnosis accuracy of telemedicine in the diagnosis of cataract, AMD, and glaucoma

	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
Cataract	87.8	99.4	97.6	96.7
AMD	99.7	99.5	99.3	98.1
Glaucoma	98.7	76.5	90.5	96.3

AMD age-related macular degeneration, *PPV* positive predictive value, *NPV* negative predictive value, *VA* visual acuity, *IOP* intraocular pressure

- Among the three ocular diseases, the accuracy for diagnosing AMD was highest with greater than 99% sensitivity and specificity achieved through tele-ophthalmology
- Tele-ophthalmology achieved a high specificity when diagnosing cataracts, but had a lower sensitivity at 87.8%
- Conversely, tele-ophthalmology had high sensitivity for diagnosing glaucoma, but had a lower specificity at 76.5%

Results - Estimated 6-month downstream costs

Overall, the estimated cost, per patient, per 6 months, was higher for tele-ophthalmology consultations and compared to face-to-face consultations

	Generated investigations and treatment in next 6 months	Downstream costs of face-to-face consultation	Downstream costs of tele-ophthalmology consultation (with VA, IOP)
Cataracts			
Early	None	–	–
Moderate	Phacoemulsification and IOL implantation (HKD 15,100)	HK$3,216,300.00	HK$3,382,400.00
Severe	Phacoemulsification and IOL implantation (HKD 15,100)	HK$362,400.00	HK$332,200.00
Possible glaucoma			
Glaucoma Suspect	HVF 24-2 (HKD 600) and OCT NFL Assessment (HKD 600)	HK$138,000.00	HK$115,800.00
Definite glaucoma	HVF 24-2 (HKD 600) and OCT NFL Assessment (HKD 600) and 6 months of topical Latanoprost (HKD 180 per bottle)	HK$109,440.00	HK$52,440.00
Age-related macular degeneration			
Drusen only	None	–	–
Dry AMD	None	–	–
Dry AMD with GA	None	–	–
Wet AMD	FFA and ICG, 2 × OCT macula (HKD 600) and 3 × intravitreal ranibizumab injection and drug fee (HKD 2190 + HKD 6350)	HK$87,540.00	HK$116,720.00
Total added costs for 860 patients/ 6 months		HK$3,913,680.00	HK$3,999,560.00
Average added cost per patient/ 6 months		HK$4550.79	HK$4650.65

Limitations

- Study limited to the diagnosis and management of cataracts, glaucoma and age-related macula degeneration

- The store-and-forward methodology for teleconsultations did not allow the ophthalmologist to converse with the study subject or to examine the subject directly

- The lack of use of ophthalmic investigations, such as optical coherence tomography in the study meant that investigations were still required for disease confirmation.

Conclusion

- In summary, tele-ophthalmology is a highly accurate and viable consultation method in the context of chronic visual loss

- However, there are still diagnostic and grading limitations, particularly for cataracts and glaucoma, that prevent it fully from being an alternative to face-to-face consultation with current technology.

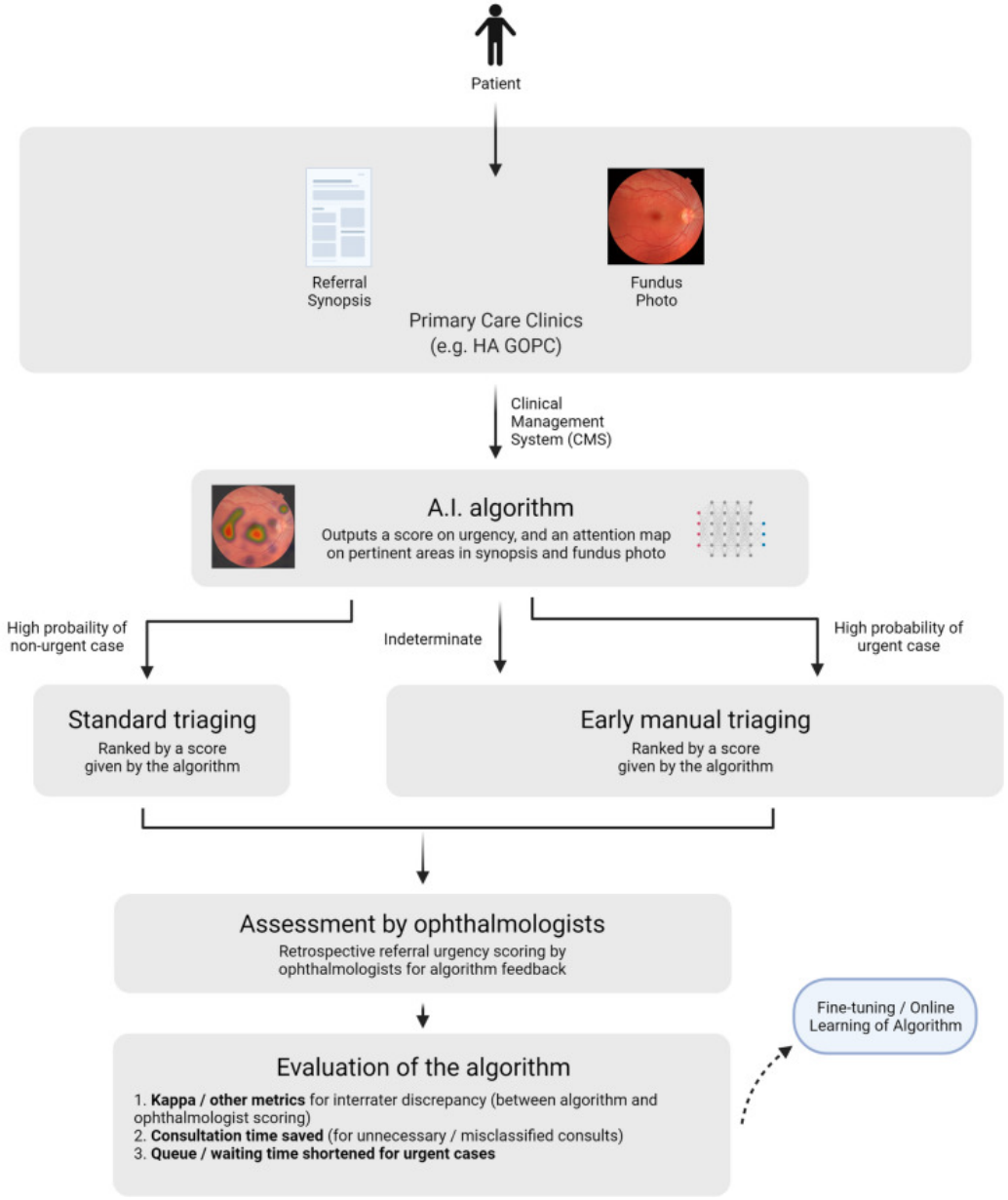
- The accuracy of tele-ophthalmology consultations can be greatly improved through the availability of high-resolution cameras in primary care.

- *Another viable alternative is to introduce machine learning, as an aid to diagnosis and management.*

Further Directions

HMRF #19201871 Ongoing Study

- Deep Learning Colour Fundus Image Analysis for Triage of Chinese Elderly Patients with Progressive Vision Loss for More than 3 Months



Acknowledgements

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Publications

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- Wong JK, Zhu MM, Lam JC, Leung KM, Lian JX, Lam CL, Shih KC, Lai JS. *Prospective Comparative Study Investigating Agreement between Tele-Ophthalmology and Face-to-face Consultations in Patients Presenting with Chronic Visual Loss.* Ophthalmol Ther. 2022 Jun;11(3):1199-1213.

Thank You

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