DEVELOPMENT AND EVALUATION OF TELEGLAUCOMA PROGRAMME IN A TEACHING HOSPITAL IN KUALA LUMPUR FOR THE PREVENTION OF FUTURE BLINDNESS IN MALAYSIA

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UNIVERSITI KEBANGSAAN MALAYSIA

THESIS SUBMITTED IN FULFILMENT FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

FACULTY OF MEDICINE
UNIVERSITI KEBANGSAAN MALAYSIA
KUALA LUMPUR

2026

PEMBENTUKAN DAN EVALUASI PROGRAM TELEGLAUKOMA DI HOSPITAL PENGAJAR DI KUALA LUMPUR UNTUK PENCEGAHAN KEBUTAAN MASA DEPAN DI MALAYSIA

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DECLARATION

I hereby declare that the work in this thesis is my own except for quotations and summaries which have been duly acknowledged.

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ACKNOWLEDGEMENT

First and foremost, I would like to express my deepest gratitude to Assoc. Prof. Dr. Jemaima Che Hamzah, for her guidance and support throughout this research project. I would also like to thank my co-supervisors, Prof Dr. Sharanjeet Kaur, Assoc. Prof. Dr. Mohd Izzuddin Hairol, Dr. Harimi Abd Rahman, and Dr. Rona Asnida Nasaruddin for their supervision and guidance during my research project. I sincerely appreciate Prof. Dr Zaleha Isa's assistance with statistical analysis. I would also like to thank Dr. Afzan Adam at the Centre of Artificial Intelligence, Faculty of Information Science and Technology, for her helpful assistance with the teleglaucoma system.

I would also like to thank Assoc. Prof Dr. Aznida Firzah Binti Abdul Aziz from Klinik Primer Hospital Canselor Tuanku Muhriz (HCTM), Dr. Rohayah Ismail from Klinik Kesihatan Sentul, and staffs at Ophthalmology Clinic HCTM for their help in my data collection. My deepest gratitude to the staff at these clinics for their help in my data collection. I would also like to thank Dr Cheng Teck Chee and Our Optometris for their support. I would also like to thank the Ministry of Health Malaysia for allowing me to collect data at Klinik Kesihatan Sentul. Finally, I acknowledge Universiti Kebangsaan Malaysia's financial support through the Research University Grant [GUP-2020-027] and Fundamental Grant Faculty of Medicine [FF-2020-098]. Lastly, I would like to thank my family for their unwavering support throughout my PhD journey.

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ABSTRAK

Glaukoma merupakan penyebab utama kebutaan yang tidak dapat dipulihkan. Ia memerlukan diagnosis tepat pada masanya kerana penyakit ini tanpa simptom. Glaukoma tidak dapat dikesan awal kekal sebagai isu yang mencabar walaupun di negara maju menunjukkan batas dalam pengesanan kes secara oportunistik di klinik. Kerugian ekonomi dan kehilangan produktiviti yang signifikan akibat kebutaan yang disebabkan oleh glaukoma memerlukan pengesanan kes glaukoma yang lebih baik. Teleglaukoma iaitu teleperubatan untuk glaukoma, menawarkan penyelesaian yang baik untuk mengatasi cabaran ini. Matlamat kajian ini adalah untuk meneroka peranan program teleglaukoma dalam meningkatkan kadar pengesanan kes individu dengan glaukoma dan berkemungkinan glaukoma dalam populasi Malaysia. Kajian ini terdiri daripada lima fasa kajian iaitu (1) mengenal pasti strategi untuk pelaksanaan program teleglaukoma dan (2) komponen program latihan saringan glaukoma menggunakan kajian sistematik dan temu bual kualitatif, (3) pembangunan, pengesahan dan penilaian program latihan untuk penyaring glaukoma, (4) kebolehgunaan dan kefungsian sistem teleglaukoma dan (5) perbandingan kadar pengesanan individu dengan glaukoma dan berkemungkinan glaukoma di antara program teleglaukoma di Klinik Primer Hospital Canselor Tuanku Muhriz (HCTM) dan pengesanan kes secara oportunistik di Klinik Kesihatan Sentul. Komponen untuk pelaksanaan program teleglaukoma termasuk individu yang berisiko tinggi untuk penyakit glaukoma, pemeriksaan saringan glaukoma termasuk pengambilan sejarah, ujian visual akuiti, tonometri, fotografi fundus, perimetri, lokasi saringan yang mudah diakses, perhubungan sistem teleglaukoma yang baik, kakitangan terlatih yang mahir, dan garis panduan rujukan pesakit yang jelas. Modul latihan dibangunkan dalam bahasa Melayu dan Inggeris di mana ia mempunyai kesahan kandungan dan muka yang baik oleh pakar dan peserta sasaran. Modul latihan meningkatkan pengetahuan ($p=0.02$) dan kemahiran (lulus 100%) penyaring glaukoma dalam saringan glaukoma. Sistem teleglaukoma didapati mesra pengguna dan boleh berfungsi. Kadar pengesanan individu dengan glaukoma dan berkemungkinan glaukoma menggunakan sistem teleglaukoma (6%) adalah lebih tinggi berbanding dengan penemuan kes secara oportunistik (1.4%). Kajian ini adalah yang pertama di Malaysia yang meneroka kemungkinan melaksanakan program saringan teleglaukoma menggunakan sistem tempatan. Program teleglaukoma boleh mengubah amalan piawai dalam glaukoma yang membawa kepada pengesahan awal dan mencegah kebutaan. Kajian masa depan harus merangkumi penilaian keberkesanan kos dalam pelaksanaan teleglaukoma di Malaysia.

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ABSTRACT

Glaucoma, a leading cause of irreversible blindness, necessitates timely diagnosis as disease is asymptomatic. Undetected glaucoma remains a challenging issue even in developed countries, revealing limitations in current case detection. Significant economic and productivity losses due to blindness caused by glaucoma demand a better detection of glaucoma cases. Teleglaucoma, a telemedicine for glaucoma, offers a promising solution to overcome these challenges. The aim of this study was to explore the role of a teleglaucoma programme in improving the detection rate of cases with glaucoma and probable glaucoma in the Malaysian population. This study comprised of five study phases which were (1) identify strategies for implementation of teleglaucoma programme and (2) components of its training programme using systematic reviews and qualitative interviews, (3) development, validation and evaluation of training programme for glaucoma screeners, (4) usability and functionality of a local teleglaucoma system and (5) comparison of detection rate of glaucoma or probable glaucoma between teleglaucoma pathway at Primer Clinic and opportunistic case finding pathway at Sentul Health Clinic. Components for implementation of teleglaucoma programme include high-risk individuals of glaucoma, glaucoma screening examinations including history taking, visual acuity test, tonometry, fundus photography and perimetry, accessible screening locations, well-connected teleglaucoma system, skilled personnel, and a clear referral guideline. The training module were developed in Malay and English languages with good content and face validity by both experts and targeted participants. The training module increased the glaucoma screeners' knowledge (p=0.02) and skills (100% pass) in glaucoma screening. The local teleglaucoma system was found to be user-friendly and functionable. The detection rate of glaucoma and probable glaucoma using teleglaucoma system (6%) was higher compared to the opportunistic case finding (1.4%). This study is the first in Malaysia that explored the feasibility of implementing a teleglaucoma screening programme using a local system. Teleglaucoma programme can transform the standard glaucoma practice, leading to early identification and prevent blindness. Future study should include evaluation of cost- effectiveness in implementation of teleglaucoma in Malaysia.

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LIST OF ABBREVIATIONS

AIDS	Acquired Immunodeficiency Syndrome
AMO	Association of Malaysian Optometrists
ARMD	Age related macular degeneration
AI	Artificial intelligence
CCT	Central cornea thickness
CDR	Cup-to-disc ratio
C-EYE-C	Community Eye Care
C-HEtS	Caring Hospital Enterprise System
CI	Confidence Interval
CKD	Chronic kidney disease
COPD	Chronic obstructive pulmonary disease
COVID-19	Coronavirus disease of 2019
CSUQ	Computer System Usability Questionnaire
CVI	Content Validity Index
dB	decibel
DOPS	Direct observation of procedural skills
DR	Diabetic retinopathy
EMR	Electronic medical record
EyePACS	Eye Picture Archive Communication System
FDT	Frequency doubling technology
GAT	Goldmann applanation tonometer
GCP	Good Clinical Practice
GONE	Glaucomatous optic neuropathy evaluation
HCTM	Hospital Canselor Tuanku Muhriz
HFA	Humphrey Field Analyser
HIV	Human Immunodeficiency Virus
HOD	Head of department

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HRT	Heidelberg Retina tomography
IBM	International Business Machines Corporation
ICC	Intraclass correlation coefficient
ICT	Information and communication technology
I-CVI	Item-level Content Validity Index
INFOQUAL	Information Quality
INTERQUAL	Interface Quality
IOP	Intraocular pressure
IQR	Interquartile range
KR-21	Kuder-Richardson Formula 21
MCQs	Multiple-choice questions
MD	Mean deviation
MMAT	Mixed Methods Appraisal Tool
MRF	Melbourne Rapid Fields
NA	Non applicable
NICE	National Institute for Health and Care Excellence
NGO	Non-profit organizations
NTG	Normal-tension glaucoma
OCT	Ocular coherence tomography
OR	Odds ratio
ORA	Ocular response analyser
OSA	Obstructive sleep apnoea
OSCE	Objective Structured Clinical Examination
PAAO	Pan-American Association of Ophthalmology
PACG	Primary angle-closure glaucoma
PACGS	Primary angle-closure glaucoma suspect
PD	Pattern deviation
POAG	Primary open-angle glaucoma
POAGS	Primary open-angle glaucoma suspect

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PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
PSD	Pattern Standard Deviation
QUADAS-2	Quality Assessment of Diagnostic Accuracy Studies-2
REDCaps	Research Electronic Data Capture
S-CVI/Ave	Scale Content Validity Index/Average
SDI	Secure Digital Imaging
SIGHT	Screening and Intervention for Glaucoma and Eye Health through Telemedicine
SIGN	Scottish Intercollegiate Guidelines Network
SPSS	Statistical Package for the Social Sciences
SYSUSE	System Usefulness
TECS	Technology-based Eye Care Services
Tele-DR	Tele-Diabetic Retinopathy
UK	United Kingdom
UKM	Universiti Kebangsaan Malaysia
USA	United States of America
USPSTF	US Preventive Services Task Force (USPSTF)
VA	Visual acuity
VC	Visual capacity
VCDR	Vertical cup-to-disc ratio
VR	Virtual reality

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CHAPTER I

INTRODUCTION

1.1 INTRODUCTION

Glaucoma is a progressive optic neuropathy that leads to optic nerve damage, leading to blindness if not treated (Odayappan et al. 2021; Stein et al. 2021; Sunija et al. 2022). It is widely known as the second leading cause of global blindness after cataract (Flaxman et al. 2017; Steinmetz et al. 2021; Tham et al. 2014) and the major cause of irreversible blindness (Flaxman et al. 2017; Joshi et al. 2022; Sun et al. 2022). In 2020, glaucoma affected 7.75 million people globally, of which 4.14 million had visual impairment, while 3.61 million people were blind (Steinmetz et al. 2021; Vision Loss Expert Group of the Global Burden of Disease Study 2024). In Malaysia, the prevalence of blindness in those aged 50 and above was 1.2%, of which 6.6% was caused by glaucoma, representing the third cause of blindness after cataracts and diabetic retinopathy (Chew et al. 2018). The number of individuals affected by glaucoma is predicted to increase as the population ages. This issue is a significant public health problem.

Glaucoma is classified into two types: primary and secondary glaucoma (Allison et al. 2020; Wagner et al. 2022). It is further categorized into open-angle glaucoma and angle-closure glaucoma (Allison et al. 2020; Wang et al. 2024). Primary open-angle glaucoma (POAG) is the most common type of glaucoma (Buonfiglio et al. 2024; Munteanu et al. 2021; Zhang et al. 2021). Globally, the prevalence of POAG was 2.4% for adults aged 40 years and above (Zhang et al. 2021). It is called the "silent thief of sight", as patients are unaware of the disease due to its asymptomatic nature at the beginning stage (Lee & Mackey 2022; Nilsson & Peters 2021). The incidence of angle-closure glaucoma (ACG) was lower than open-angle glaucoma, as demonstrated in a

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study that the prevalence of ACG was 10.4% compared to 45.3% for OAG in Palestine (Banayot 2024). ACG is more likely to cause blindness than OAG according to a recent meta-analysis (George et al. 2022) as they present acutely and cause severe damage.

Glaucoma has a devastating impact on the individuals who have it. As the visual impairment progresses, glaucoma patients face challenges with daily tasks such as reading, mobility and driving (Huang et al. 2020; Mwale et al. 2024; Pryandhini et al. 2024). This visual impairment also causes an increased risk of falls which can lead to fracture or death (Bhorade et al. 2021; Dagi et al. 2025; Ouyang et al. 2023; Ouyang et al. 2022; Tsang et al. 2024), which in turn caused higher hospitalization fees (Purola et al. 2023). Studies reported a higher rate of anxiety and depression among glaucoma patients than the normal population (Ajith et al. 2022; Ambrósio et al. 2025; Giacometti et al. 2024; Holló et al. 2021; Wu et al. 2022). This psychological problems may reduce social interaction (Klauke et al. 2023; Shah et al. 2020).

Vision loss from glaucoma often leads to a significant economic burden to glaucoma patients, families, and the country (Allison et al. 2020; Inayat et al. 2024). The cost of treatment of glaucoma is high in the long-term causing financial strain in 58.11% glaucoma patients in India (Usgaonkar et al. 2023). Some glaucoma patients were unemployed due to visual impairment (Huang et al. 2020; Inayat et al. 2024; Madheswaran et al. 2025). Glaucoma can also affects caregivers of glaucoma patients in term of psychological, physical, and financial burdens (Pur et al. 2023). Caring for visually impaired patients often demands a significant time commitment from caregivers (Varadaraj et al. 2021). This time commitment can lead caregivers to reduce their working hours, change jobs, or even lose their jobs. Reducing working hours or unemployment among visually impaired patients and caregivers will affect the country's productivity (Inayat et al. 2024). Therefore, early glaucoma detection is crucial to prevent blindness from glaucoma, which can significantly impact the patients.

Diagnosis of glaucoma and management require specialised instruments for measuring intraocular pressure, optic disc evaluation and visual field examination (Hasan et al. 2025; Schuster et al. 2020). However, these instruments are expensive and limited to hospitals and eye clinics, which are in the urban areas. It is a challenge to

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patients who live in rural areas to get glaucoma care. In addition, regular follow-ups to monitor the progression of glaucoma are restricted by long travel distances to the healthcare facilities with eye care services. Patients referred for glaucoma experienced a long waiting time for a hospital appointment, as long as a year in Australia (Ford et al. 2020). In Malaysia, the current waiting time to get an appointment for glaucoma follow-up in public hospitals may take four to six months (Sidhu et al. 2023). This delay in the appointment for eye examination raises concern as it could result in more undetected glaucoma cases, especially given that more than half of all glaucoma cases go undiagnosed in developed countries (Allison et al. 2021; Soh et al. 2021; Vaajanen et al. 2022). An efficient approach is to have a system which connect between primary health care providers and ophthalmologists to detect glaucoma earlier to reduce the visual impairment caused by glaucoma.

Several systems are being implemented in glaucoma care, such as glaucoma referral refinement schemes and shared care models in the United Kingdom. Glaucoma referral refinement schemes reduce inappropriate hospital referrals by having accredited community optometrists conduct further tests to determine whether a definitive referral to hospital eye services is warranted, while shared care models enable these optometrists to manage stable glaucoma patients. However, the current trend shows a growing adoption of telemedicine. Telemedicine is defined as practicing medicine over a spatial or temporal distance by using electronic communications for the diagnosis, treatment, and prevention of disease to improve health (Akbar et al. 2020; Haleem et al. 2021; Su et al. 2024). Teleglaucoma is the application of telemedicine in glaucoma care services (Brandão-De-Resende et al. 2023; Ertel et al. 2021). The study by Tuulonen et al. (1999) in Finland was among the earliest studies to explore the application of telemedicine for glaucoma care, evaluating its access, efficiency, and cost-effectiveness. This marked the emergence of what is now commonly called 'teleglaucoma". Many glaucoma patients are elderly and have physical limitations such as reduced stamina, arthritis, or other comorbidities, making travel to the hospital difficult for them. Teleglaucoma can overcome the lack of access to glaucoma care and is ideal for screening, diagnosis, and monitoring.

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1.2 PROBLEM STATEMENT

Glaucoma is the leading cause of irreversible blindness (Lee & Mackey 2022; Stein et al. 2021; Sun et al. 2022; Wagner et al. 2022). Most patients present late to the healthcare system, as glaucoma is usually asymptomatic. It was reported that about 50% of patients with glaucoma were undetected, even in developed countries (Allison et al. 2021; Vaajanen et al. 2022). This shows that the current case-finding is inadequate at detecting new glaucoma cases. However, active screening could increase the eye clinics' workload, especially in public hospitals, which are already struggling with high numbers of patients leading to longer waiting times for appointments. These delays can lead to undiagnosed glaucoma, resulting in irreversible vision loss.

1.3 JUSTIFICATION OF THE STUDY

Teleglaucoma can connect primary healthcare with tertiary eye services, allowing for efficient case finding of potential glaucoma patients and ongoing monitoring of those already diagnosed. It enables the remote use of diagnostic instruments for patient screening and monitoring, eliminating the need for an ophthalmologist to be present at the remote site. Therefore, it enables early detection of glaucoma and the prevention of blindness. Currently, there is no teleglaucoma programme in Malaysia. Thus, there is a need to explore the role of teleglaucoma as an efficient system to improve access to glaucoma care within the Malaysian population. If proven effective, the teleglaucoma system can be adapted for screening and managing other eye diseases such as diabetic retinopathy and retinopathy of prematurity

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1.4 RESEARCH QUESTIONS

i) What are the essential components and referral pathways for screening glaucoma via teleglaucoma in the Malaysian population?

ii) What are the appropriate contents for a training programme for glaucoma screeners in a teleglaucoma screening programme?

iii) Is the newly developed training module for glaucoma screeners valid?

iv) Is the newly developed training module effective in training the glaucoma screeners to detect cases with glaucoma and probable glaucoma in the population?

v) Is the teleglaucoma system user-friendly and functional?

vi) Is the newly developed teleglaucoma programme effective at detecting cases with glaucoma and probable glaucoma in the population compared to opportunistic case finding?

1.5 RESEARCH OBJECTIVES

1.5.1 General Objective

To develop and evaluate a teleglaucoma programme in improving the detection rate of cases with glaucoma and probable glaucoma in the Malaysian population.

1.5.2 Specific Objectives

i) To identify components of the teleglaucoma screening programme and referral pathway

ii) To identify the content of the training programme for glaucoma screeners

iii) To develop and determine the validity of the newly developed training modules to be used in the teleglaucoma screening programme

iv) To determine the effectiveness of the training modules for glaucoma screeners in the teleglaucoma screening programme

v) To determine the usability and functionality of teleglaucoma system

vi) To compare the detection rate of cases with glaucoma and probable glaucoma between opportunistic case finding and the newly developed teleglaucoma screening programme

1.6 HYPOTHESIS

Teleglaucoma can detect glaucoma and probable glaucoma and prevent future blindness in Malaysia

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1.7 OUTLINE OF THE THESIS

This thesis is divided into eight chapters as illustrated in Figure 1.1. Chapter II describes the literature review of teleglaucoma. Chapter III describes identifying telemedicine strategies in glaucoma using systematic review and semi-structured interviews. Chapter IV used the same methodology in Chapter III, a systematic review and semi-structured interviews to identify the components of training programmes for glaucoma screeners. Chapter V describes a training programme's development, implementation, and evaluation using a newly developed training module for glaucoma screeners. Chapter VI presents the results of a functionality and usability study of the adapted teleglaucoma system. Chapter VII presents the results of the teleglaucoma screening programme, which consisted of the detection rate of cases with glaucoma and probable glaucoma in opportunistic case finding and teleglaucoma screening programme. Chapter VIII consisted of conclusions and recommendations for future research.

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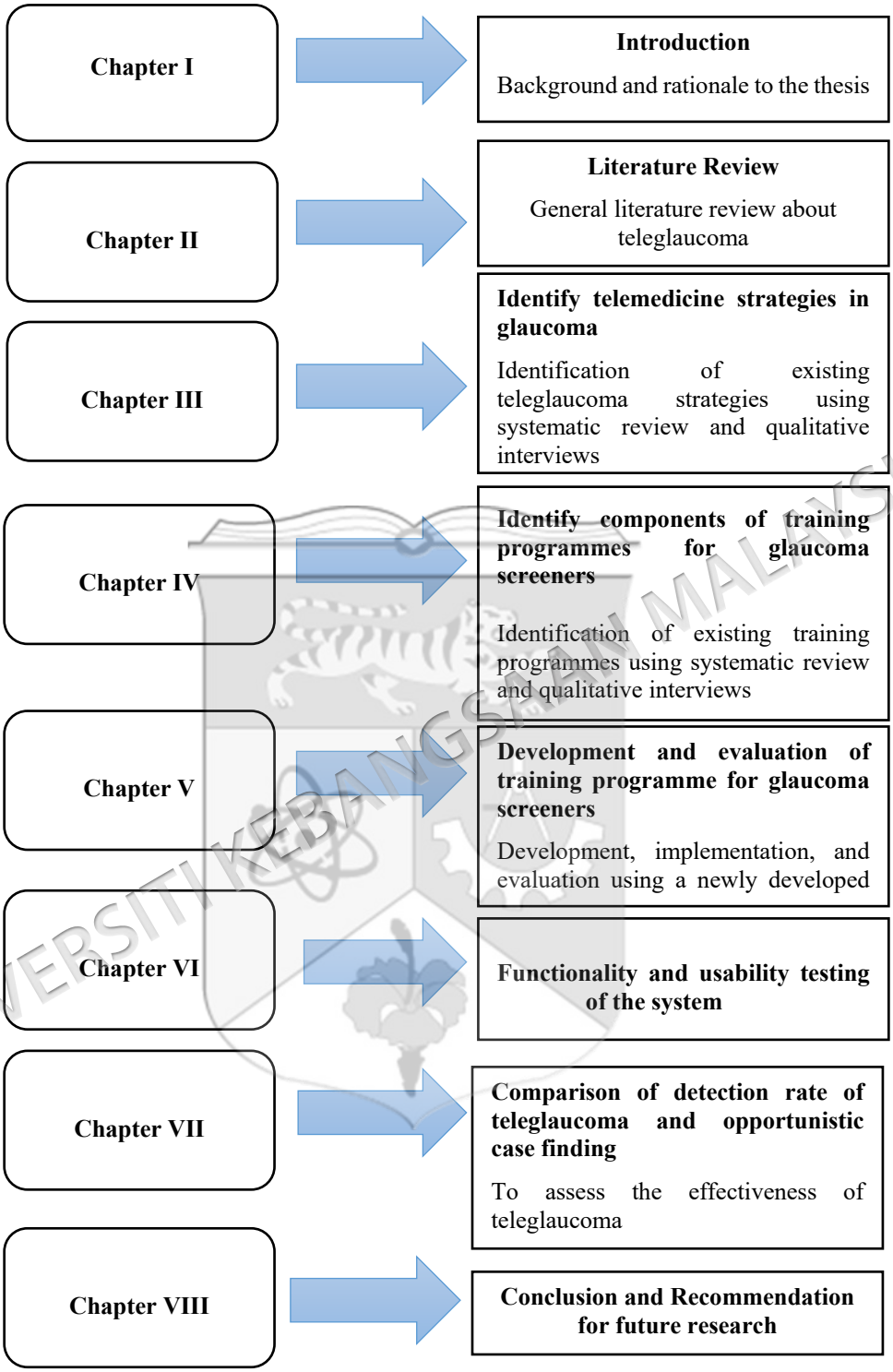

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Figure 1.1 Outline of the thesis

CHAPTER II

LITERATURE REVIEW

2.1 INTRODUCTION

This literature review offers an overview of glaucoma and the emerging role of teleglaucoma in glaucoma care. The initial sections will establish an understanding of glaucoma, detailing its types, epidemiology, clinical examinations, and risk factors. This is critical to appreciating the clinical challenges posed by glaucoma. Subsequently, the review will transition to current glaucoma case detection, the concept of teleglaucoma, its current practice, its effectiveness, advantages, disadvantages, and barriers to its implementation.

2.2 OVERVIEW OF GLAUCOMA

2.2.1 Definition of Glaucoma

Glaucoma is a progressive optic neuropathy (Dorairaj et al. 2025; Zawadzka & Konopińska 2024). It is characterised by a gradual loss of retinal ganglion cells, glaucomatous optic nerve changes, and peripheral visual field defects (Dorairaj et al. 2025; Zawadzka & Konopińska 2024). The most common signs of glaucomatous optic nerve changes are optic disc cupping, thinning of nerve fibre layers, neuroretinal rim thinning, disc haemorrhages and notching (Senthil et al. 2021).

2.2.2 Classification of Glaucoma

Glaucoma can be classified using various criteria such as aetiology, the anatomy of the anterior chamber angle, and the onset duration (Güven & Fahrettin 2024; Wagner et al. 2022). Based on aetiology, glaucoma falls into two main categories: primary glaucoma,

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which develops without any identifiable underlying cause, and secondary glaucoma, which results from other conditions such as trauma, ocular diseases, or medical co-morbidities (Güven & Fahrettin 2024; Wagner et al. 2022). This primary or secondary glaucoma can be further divided based on the anatomy of the anterior chamber angle into open-angle glaucoma with open drainage, and angle-closure glaucoma, where the drainage is obstructed (Kaushik et al. 2024; Schuster et al. 2020; Sharif et al. 2024; Wagner et al. 2022; Wang et al. 2024). Glaucoma is also classified as chronic or acute based on the duration (Güven & Fahrettin 2024; Wagner et al. 2022).

Primary open-angle glaucoma (POAG) is the most common type of glaucoma (Buonfiglio et al. 2024; Munteanu et al. 2021; Zhang et al. 2021). An open anterior chamber angle is characteristic of POAG. However, despite this open angle, increased resistance to the outflow of aqueous humour gradually elevates intraocular pressure (IOP) (El-Safy et al. 2024; Joshi et al. 2022; Schuster et al. 2020; Stamer et al. 2024), eventually leading to optic nerve damage and peripheral visual field loss (Yadav et al. 2023). POAG is asymptomatic, which causes most patients to be unaware that they have it until they have severe damage (Tan et al. 2020; Vats et al. 2024). There is a variant of POAG, which is normal-tension glaucoma (NTG) (Jiang et al. 2021; Wei et al. 2021). NTG is defined as glaucoma that has the characteristic of normal IOP below 21mm Hg with glaucomatous optic nerve changes and corresponding visual field defect (Lu et al. 2021; Stoskuviene et al. 2023; Wei et al. 2021; Wu et al. 2023).

Primary angle-closure glaucoma (PACG) is a type of glaucoma that poses a significant risk to eyesight as it is associated with a greater threat of blindness than POAG (George et al. 2022). It occurs due to an increase in intraocular pressure (IOP), caused by the peripheral iris physically blocking the trabecular meshwork and thereby obstructing aqueous humour outflow (Elsaka 2021; George et al. 2022; Kymbat et al. 2025; Zhang et al. 2024). There are two types of PACG: acute angle-closure and chronic angle-closure glaucoma (Elsaka 2021; Wang et al. 2024). Acute angle-closure glaucoma causes a sudden increase in IOP due to the sudden blockage of the trabecular meshwork by the iris, which requires immediate medical treatment (Ciobanu et al. 2021; Lubis et al. 2020; Nüßle et al. 2021; Shi & Wang 2021). In chronic angle closure, IOP

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gradually increases over time as the iris gradually blocks the trabecular meshwork (George et al. 2022; Nüßle et al. 2021; Zhang et al. 2024).

Probable glaucoma, also known as glaucoma suspect, is a condition with either of the following criteria: elevated IOP more than 21mmHg, suspicious optic nerve head, and abnormal visual field defect (Phu et al. 2022).

2.2.3 Pathophysiology of Glaucoma

Pathogenesis of glaucoma involves the degeneration of retinal ganglion cells and their axons (Fernández-Albarral et al. 2024). The exact mechanisms behind glaucoma are complex, leading to several theories. The most widely accepted theory suggests that elevated intraocular pressure (IOP) contributes to the degeneration of retinal ganglion cells by exerting mechanical stress on the optic nerve head (Joshi et al. 2022; Sahu 2024; Stein et al. 2021). Elevated IOP is currently the only risk factor that can be modified through treatment (Ahmed et al. 2023; Asrani et al. 2024; Sahu 2024). However, glaucoma can develop and progress among some individuals with normal IOP. Therefore, another theory which is vascular theory which suggests that a lack of blood supply can lead to insufficient oxygen and nutrient to the optic nerve causes damage to the retina (Cui et al. 2022; Feng et al. 2023; Hsu & Desai 2023). There are other theories which may contribute to glaucomatous damage, such as oxidative stress, excitotoxicity, inflammation and neurotrophic factor deprivation theories (Ekici & Moghimi 2023; Feng et al. 2023; Fernández-Albarral et al. 2024).

2.2.4 Epidemiology of Glaucoma

The prevalence of glaucoma globally among individuals aged 40 years and above was estimated at 2.8% in 2024 (Wang et al. 2026). It accounts for a significant global burden, resulting in 4.14 million people with visual impairment and 3.61 million experiencing blindness (Steinmetz et al. 2021; Vision Loss Expert Group of the Global Burden of Disease Study 2024). The global prevalence of glaucoma is substantial and on an upward trajectory, primarily due to an aging global population. According to Tham et al. (2014), the number of estimated individuals with glaucoma will rise to over 111 million by 2040.

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The distribution of glaucoma is based on geography and demographics such as age, ethnicity, and gender (Allison et al. 2020; Khachatryan et al. 2019). For instance, POAG is the predominant type of glaucoma worldwide, especially affecting people of African ethnicity (Vision Loss Expert Group of the Global Burden of Disease Study 2024; Zukerman et al. 2020). Global prevalence of POAG is 2.4% which affects 68.56 million adults aged 40 years and above with higher rates in Africa (4%) (Zhang et al. 2021). Zhang et al. (2021) also reported the second highest prevalence of POAG in North America (3.4%) and the lowest in Oceania (1.8%). In Europe, the prevalence of POAG is estimated to be 2.60% (Afflitto et al. 2022).

PACG is more commonly found in Asia (Kondkar 2021; Zhang et al. 2021). Global prevalence of PACG is less than POAG, which is 0.6% (Zhang et al. 2021). Additionally, it is estimated that approximately 12 million people in Asia were affected by PACG, which accounts for over 70% of the total 17.14 million global cases (Zhang et al. 2021).

The risk of developing glaucoma increases after the age of 40 (Grzybowski et al. 2020). Therefore, there is a higher prevalence of glaucoma due to an aging population, especially in Western countries (Afflitto et al. 2022; Grzybowski et al. 2020). According to a meta-analysis, the prevalence of glaucoma was 2.56% among adults aged 40 years and above in the USA with 0.9% suffering from glaucoma-related visual impairment in 2022 (Ehrlich et al. 2024).

Glaucoma prevalence also varies significantly by gender (Allison et al. 2020). Previous meta-analyses indicated that the prevalence of POAG is higher in males (Afflitto et al. 2022; Banik et al. 2025; Zhang et al. 2021) while the prevalence of PACG is higher in females than in males (Zhang et al. 2021). This is supported by a study in India, which reported that females accounted for 60.29% of PACG cases, compared to 39.71% in males (Deshmukh et al. 2022). In contrast, a meta-analysis found no significant difference in PACG prevalence between genders (Banik et al. 2025).

In Malaysia, glaucoma is the third leading cause of blindness (6.6%) after cataract and diabetes, according to the National Eye Survey (Chew et al. 2018).

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According to the 12th National Eye Database 2018 Report, 3.6% of patients had glaucoma as a comorbidity (Salowi et al. 2020). Another recent study conducted at the University of Malaya Medical Centre found that glaucoma affected approximately 12.28% of patients attending the eye clinic (Kevin-Tang et al. 2024). It was the leading cause of blindness in 33.33% of the nine blind patients (Kevin-Tang et al. 2024).

2.2.5 Risk Factors of Glaucoma

Understanding glaucoma risk factors is fundamental in early diagnosis and effective management. There are many risk factors in the development of glaucoma, such as increased IOP, older age, family history of glaucoma, race (Lee & Mackey 2022; Stein et al. 2021), central corneal thickness (Lee & Mackey 2022), gender (Angriani et al. 2022; Zhang et al. 2021), refractive errors (Jenchitr & Jaradaroonchay 2021; Yao et al. 2023), obstructive sleep apnoea syndrome (Cheong et al. 2023; Zoh & Yun 2024) and reduced ocular perfusion pressure (Ch'ng et al. 2021; Mudhol et al. 2021) due to vascular factors such as hypertension, hypotension, diabetes mellitus, migraine headache, Raynaud syndrome, and anaemia (Funk et al. 2022).

a. Intraocular pressure (IOP)

IOP remains the most significant risk factor (Di Pierdomenico et al. 2022; Omodaka et al. 2022; Tribble et al. 2023). It is because it is a risk factor that can be modified to treat glaucoma (Dada et al. 2022; Omodaka et al. 2022; Stein et al. 2021). Normal IOP typically ranges from 10 to 21 mmHg (Fan et al. 2024; Mohapatra et al. 2023; Stamer et al. 2024; Uwah et al. 2021). Increased resistance to aqueous humour outflow due to impaired trabecular meshwork (El-Safy et al. 2024; Fan et al. 2021; Shen et al. 2025) or closure of the anterior chamber angle (El-Safy et al. 2024; Murgoitio-Esandi et al. 2023; Wilensky & Mehta 2022) will lead to increased intraocular pressure (IOP) beyond the normal range. This elevated IOP is associated with a higher risk of developing glaucoma (Hsu & Desai 2023; Sato et al. 2025). However, not all individuals with high IOP will develop glaucoma (Wagner et al. 2022). This condition is called ocular hypertension (Wagner et al. 2022). Nevertheless, lowering IOP has been shown to slow glaucoma progression (Naik et al. 2025).

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b. Age

Age is a significant risk factor for glaucoma (Angriani et al. 2022; Di Pierdomenico et al. 2022; Tribble et al. 2023). As individuals age, oxidative stress and structural changes in ocular structures, such as reduced trabecular meshwork function and changes in the optic nerve, may contribute to optic nerve damage, increasing the likelihood of developing glaucoma (Goodman & Ness 2023; Guo et al. 2025; Reinehr et al. 2024). Therefore, the risk of glaucoma increases significantly after the age of 40. Studies have reported that the prevalence of glaucoma increases significantly with age (Ahmad et al. 2020; Bikbov et al. 2020; Fujiwara et al. 2022; Liu et al. 2023).

c. Race

Race is one of the risk factors for glaucoma (Zhang et al. 2021). Individuals of African (Cole et al. 2021) and Latino descent have a higher risk of POAG (Wurster et al. 2020), while those of Asian descent have a higher risk for PACG and NTG (Belamkar et al. 2022). Several studies reported a larger cup-disc ratio in African individuals than in other races, such as Asian and Caucasian (Bonnemaijer et al. 2021; Zhao et al. 2022). Moreover, previous studies reported that a South African descent population was found to have thinner corneal thickness (Bonnemaijer et al. 2021; Van Der Lecq 2021). A study by Grant et al. (2024) reported that African individuals had a higher mean IOP than individuals of other races. The findings from these studies showed that these factors may contribute to the development of POAG among Africans. A recent review reported that risk factors of glaucoma among Latinos were age, genetics, increased intraocular pressure, structural differences (e.g., thin corneas, longer axial length), and systemic conditions such as diabetes mellitus and hypertension (Wurster et al. 2020). Asians are more likely to have PACG due to differences in the anatomy of the eye, such as a narrower anterior chamber angle and shallower anterior chamber depth (Zhang et al. 2021). NTG is more commonly found in Asian populations. The higher prevalence of NTG in Asians may involve risk factors such as impaired intracranial pressure, insufficient blood supply, and vascular dysregulation (Chen 2020).

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d. Gender

Gender is also one of the risk factors of glaucoma. According to a meta-analysis, males are more likely than females to develop POAG with a risk ratio of 0.71 (Zhang et al. 2021). Females are more likely to develop angle-closure glaucoma (Zhang et al. 2021). Zhang et al. (2021) suggested that anatomical differences in male eyes, such as their elongated axial length and increased anterior chamber depth, have been proposed as a potential reason for their increased incidence of POAG.

e. Family history of glaucoma

Another risk factor of glaucoma is a family history of glaucoma (Lee & Mackey 2022). The risk of developing glaucoma is significantly increased for individuals with a first-degree family history of glaucoma, reaching 22% compared to 2.3% in a control group (Stein et al. 2021). Previous studies identified numerous genes associated with glaucoma, such as MYOC (myocilin), which is associated with juvenile-onset and adult POAG (Kader et al. 2024), OPTN (optineurin), and TBK1, which is associated with NTG (Fox & Fingert 2023) and CYP1B1 for congenital glaucoma (Alsubait et al. 2020).

f. Thin central corneal thickness

A thin central corneal thickness increases the risk of development and progression of glaucoma, especially POAG (Agbato et al. 2025; Waimir et al. 2022). In the Ocular Hypertension Treatment Study, they reported that eyes with a central cornea thickness (CCT) of 555 μm or less have a three times higher risk of developing glaucoma compared to eyes with a CCT above 588 μm among ocular hypertension patients (Gordon et al. 2002). Thin corneas are associated with increased progression especially visual field loss among glaucoma patients (Agbato et al. 2025). The higher prevalence among individuals of African descent may be attributed to this risk factor, as past studies have shown thin corneas in this population (Bonnemaijer et al. 2021; Van Der Lecq 2021).

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g. Refractive errors

There is an association between refractive errors, such as myopia and hyperopia, in the development of glaucoma. Refractive errors such as myopia and hyperopia are associated with glaucoma (Jenchitr & Jaradaroonchay 2021). Myopia is one of the risk factors for POAG (Choquet et al. 2022; Wu et al. 2022). In a myopic eye, the axial elongation may cause optic nerve head changes, which will cause it to be more susceptible to glaucomatous damage (Jonas et al. 2020; Kim et al. 2024). A meta-analysis indicated a 20% increase in glaucoma risk for every 1.0 D increment in myopia, with this risk increasing more sharply in individuals with high myopia (Ha et al. 2022). Hyperopia is also a risk factor for PACG (Muthusamy et al. 2023; Zhou et al. 2023). It is reported that high hyperopia was associated with an increased risk of PACG (Zhou et al. 2023). This increased risk observed in hyperopic individuals may be attributed to anatomical differences such as a shallow anterior chamber and a short axial length, which may increase their risk of PACG development (Marinescu et al. 2023; Muthusamy et al. 2023).

h. Anatomical factors

Other anatomical factors, such as a large cup-to-disc ratio (Choe et al. 2023; Kim et al. 2023; Soh et al. 2020) and asymmetry of the cup-to-disc ratio between both eyes (Soh et al. 2020) are risk factors for glaucoma. Large cup-to-disc ratio and asymmetry of cup-to-disc ratio between both eyes of 0.2 or more may need further glaucoma examination, as they may indicate glaucomatous damage (Bragança et al. 2024; Soh et al. 2020; Yum et al. 2021). However, large cupping can be physiological in some individuals (Bragança et al. 2024).

i. Systemic conditions

Certain systemic conditions such as hypertension, hypotension, diabetes mellitus, obstructive sleep apnoea (OSA), migraine, Raynaud's syndrome (Funk et al. 2022; Hsu & Desai 2023), chronic obstructive pulmonary disease (COPD), chronic kidney disease (CKD), thyroid diseases, and neurodegenerative diseases may contribute to glaucomatous damage (Hsu & Desai 2023). Systemic hypertension and hypotension

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may impair ocular blood flow, causing glaucomatous damage (Cui et al. 2022; Nislawati et al. 2021). Diabetes is associated with glaucoma due to vascular and optic nerve damage (Li et al. 2021). Oxidative stress and hemodynamic abnormalities play a role in the increased risk of glaucoma among individuals with COPD (Hsu & Desai 2023). CKD is linked to glaucoma, possibly due to shared vascular, genetic, and hormonal pathways (Liu et al. 2023). While OSA is associated with glaucoma, which may be caused by hypoxia, which causes changes to the optic nerve (Cesareo et al. 2020). Migraine is more commonly associated with NTG (Funk et al. 2022). Both hyperthyroidism (Betzler et al. 2022; Ghenciu et al. 2024; Nasreen & Puttiboyina 2022) and hypothyroidism are associated with glaucoma, potentially through higher IOP (Castro et al. 2021). Glaucoma shares exact pathophysiological mechanisms of Alzheimer's disease, such as neurodegeneration, mitochondrial dysfunction, neuroinflammation, and vascular dysregulation (Ho et al. 2024; Sen et al. 2020; Zheng et al. 2022). Raynaud syndrome, also known as Raynaud's phenomenon, is associated with glaucoma, as the vasospasm may cause impaired blood flow to the optic nerve (Dada et al. 2022).

j. Long term use of steroids

Long-term use of steroids, especially topical ocular steroids, is a risk factor for glaucoma, as it can elevate IOP (Hsu & Desai 2023; Musleh et al. 2020; Price et al. 2022). Previous eye injury or surgery can lead to secondary glaucoma (Gurung et al. 2021) by damaging the trabecular meshwork (Kolipaka & Rao 2023).

k. Lifestyle factors

Lifestyle factors such as smoking (Kulkarni & Banait 2023), and alcohol consumption (Meller et al. 2025; Stuart et al. 2022) are risk factors that contribute to glaucoma development (Mahmoudinezhad et al. 2023). Heavier smoking is linked to a thinner retinal nerve fibre layer (Elhusseiny & Aref 2025; Nishida et al. 2023) and a faster rate of visual field loss (Elhusseiny & Aref 2025).

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2.2.6 Clinical Examinations for Glaucoma Diagnosis

The diagnosis of glaucoma involves a combination of clinical examinations, such as a visual acuity test (Wagner et al. 2022), tonometry, evaluation of the optic nerve head, visual field test, retinal nerve fibre imaging (Scott 2023; Wagner et al. 2022), pachymetry (Wagner et al. 2022) and gonioscopy (Scott 2023).

a. Visual acuity (VA) test

A visual acuity (VA) test should be conducted as one of the tests for the diagnosis of glaucoma (Murthy et al. 2022). The VA test helps to evaluate the central vision (Fazeenah 2021) and detecting vision impairment (Masthi et al. 2025). This test is important because it provides an assessment of ocular structures, such as clarity of the cornea and crystalline lens, macular and optic nerve function (Fazeenah 2021).

b. Tonometry

Tonometry was usually conducted to measure intraocular pressure (IOP), as high IOP is a risk factor for glaucoma (Di Pierdomenico et al. 2022; Omodaka et al. 2022; Tribble et al. 2023). The Goldmann applanation tonometer was usually used in tonometry as it was the gold standard instrument (Brusini et al. 2021; Choritz et al. 2020; Porwal et al. 2023). Newer tonometers have been developed, such as the Air Puff tonometer, iCare tonometer, or Diaton transpalpebral tonometer (Kratz et al. 2025). Recent advancements in technology, such as contact lens-based sensors and intraocular telemetry sensors, enable continuous monitoring of IOP (Yang et al. 2021).

c. Evaluation of the optic nerve head

Evaluation of the optic nerve head is an important assessment in glaucoma diagnosis. It can detect glaucomatous changes of the optic disc, as the optic nerve head is the anatomical site where glaucomatous damage occurs (Sihota et al. 2021). These glaucomatous damages include increased vertical cup-to-disc ratio (VCDR), thinning of the neuroretinal rim, retinal nerve fibre layer defect and the presence of optic disc haemorrhages or parapapillary atrophy (Bourne & Khatib 2021; Gedde et al. 2021). These structural changes can occur before visual field defects (Bourne & Khatib 2021).

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d. Visual field test

The visual field test is used to assess a patient's visual field as a visual field defect is one of the signs of glaucomatous damage (Gedde et al. 2021). Automated perimetry, such as the Humphrey Visual Field Analyzer (HFA) remains the gold standard for visual field tests (Lee et al. 2023). Frequency doubling technology (FDT) can also be used for testing the visual field, as it is portable and has shown good diagnostic accuracy for detecting severe glaucoma, with an Area under the Receiver Operating Characteristic Curve of 0.93 (95% CI [0.88, 0.97]) for the mean deviation of FDT (Richardson et al. 2023). Another recent technology, such as virtual reality perimetry (VRP) and tablet perimetry such as Melbourne Rapid Field test, has been introduced for visual field tests. VRP and tablet perimetry showed good diagnostic accuracy compared to the standard automated perimeter, with VRP showing a high intraclass correlation coefficient (ICC = 0.956) for mean deviation and (ICC = 0.825), for pattern standard deviation (PSD), while tablet perimetry showed moderate to high agreement (Mean Deviation ICC = 0.832; PSD ICC = 0.566) (Schrittenlocher et al. 2025).

e. Retinal nerve fibre layer imaging

Retinal nerve fibre layer imaging was one of the clinical examinations for glaucoma diagnosis, as retinal nerve fibre layer thinning is one of the signs of glaucoma (Bourne & Khatib 2021; Gedde et al. 2021). Instruments used in retinal nerve fibre layer imaging are Optical Coherence Tomography (OCT) and the Heidelberg Retina Tomograph (HRT) (Leung 2024; Lommatzsch & Van Oterendorp 2024). Measurement of the thickness of the retinal nerve fibre by these instruments allows for early detection and monitoring of glaucoma progression (Camara et al. 2022; Geevarghese et al. 2021).

f. Pachymetry

Pachymetry is the measurement of corneal thickness (Pateras & Kouroupaki 2020; Ucak et al. 2021). This test is important in glaucoma diagnosis because corneal thickness affects the accuracy of IOP measurements (Agbato et al. 2025). Thin corneas can cause a falsely low IOP and thick corneas can result in a falsely high reading (Kanski & Bowling 2011).

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g. Gonioscopy

Gonioscopy is the gold standard test for assessing the anterior chamber angle (Esporcatte et al. 2022; Yaisiri et al. 2025). Diagnosis of angle closure glaucoma is based on the assessment of the anterior chamber angle (Desmond et al. 2022). Therefore, gonioscopy is used in glaucoma diagnosis to differentiate between angle closure and open-angle glaucoma.

2.3 SCREENING OF GLAUCOMA

There are two methods of glaucoma screening, which are opportunistic case finding and population screening (Hamid et al. 2022; Tan et al. 2020). Opportunistic case finding refers to identifying individuals with glaucoma when they present for complaints or other reasons during a routine eye examination (Doozandeh et al. 2022; Founti et al. 2024). Population screening is a screening programme that identifies individuals at risk of glaucoma in the general population (Tan et al. 2020).

In many countries, particularly developing countries, glaucoma detection relies primarily on opportunistic case finding (Karvonen et al. 2020; Thapa et al. 2021). This approach was utilised due to its cost-effectiveness compared to population screening (Chan & Bourne 2023; Thapa et al. 2021). It is cost-effective due to the availability of infrastructure and trained personnel (Tan et al. 2020). However, a recent study demonstrated the lack of effectiveness of opportunistic case finding in detecting glaucoma, where 55.3% of patients with primary open-angle glaucoma (POAG) were undiagnosed despite having undergone prior eye examinations (Doozandeh et al. 2022).

Population screening for glaucoma remains a topic of controversy. Most organisations, such as the UK National Screening Committee and the Ministry of Health Malaysia, do not recommend population screening due to the lack of a single accurate diagnostic test or improved outcomes compared to opportunistic case finding (Hamid et al. 2022; Ministry of Health Malaysia 2017). The low prevalence of glaucoma also makes population screening impractical in high-income countries (Hamid et al. 2022). Similarly, the US Preventive Services Task Force (USPSTF) concludes that there is insufficient data to determine if the benefits of screening asymptomatic adults for

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POAG outweigh the risks (Mangione et al. 2022). However, some studies have reported that population screening for glaucoma can be cost-effective in countries such as India, China, and Spain (Anton et al. 2023; John & Parikh 2018; Liu et al. 2023; Tang et al. 2019). A more recent study has reported that population screening is not cost-effective in low and middle-income countries (Purohit et al. 2025).

According to the International Council of Ophthalmology and the American Academy of Ophthalmology, screening high-risk populations is recommended instead of general population screening (Gunzenhauser & Coleman 2024). Screening programmes for high-risk populations have been reported to successfully detect glaucoma early (Gajwani et al. 2020; Hark et al. 2023; Varadaraj et al. 2022; Xie et al. 2023).

In conclusion, the conflicting findings from the literature review underscore the need for a strategy to prevent glaucoma-related blindness. The asymptomatic nature of glaucoma necessitates more proactive and systematic approaches, such as targeted screening programmes or teleophthalmology in glaucoma to reduce the burden of glaucoma-related blindness significantly.

2.4 TELEOPHTHALMOLOGY IN MALAYSIA

Telemedicine can be applied in various fields, especially in ophthalmology. Teleophthalmology is the application of telemedicine to the delivery of eye care services such as screening, diagnosis, and monitoring (Yuen et al. 2022). Within the Malaysian public health sector, teleophthalmology was mainly implemented in tele diabetic retinopathy screening programmes such as the Tele-Diabetic Retinopathy and Retinal Disease Awareness Programme (RDAP), where fundus images were captured at primary care clinics and remotely graded by trained optometrists or ophthalmologists (Ngah et al. 2020; Omar et al. 2018). Tele-Diabetic Retinopathy (Tele-DR) was the first tele-diabetic retinopathy programme launched in Terengganu in 2008 (Omar et al. 2018), while the Retinal Disease Awareness Programme (RDAP) was launched in Selangor (Ngah et al. 2020). In 2025, the Ministry of Health Malaysia introduced DR.MATA, which is an artificial intelligence (AI) software to help in grading diabetic retinopathy (DR) (Gomes 2025). Despite the growing adoption of teleophthalmology in

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Malaysia, there was no teleglaucoma programme. Since glaucoma is often overlooked or only found by accident, developing a teleglaucoma programme is essential to prevent vision loss.

2.5 TELEGLAUCOMA

2.5.1 Modalities of Teleglaucoma

Teleglaucoma is defined as the application of telemedicine in diagnosing, managing, and monitoring glaucoma (Ertel et al. 2021). There are three types of modality in teleglaucoma, such as asynchronous, synchronous, and hybrid (Ertel et al. 2021).

The most common modality used in teleglaucoma is the asynchronous, store-and-forward mode (Azzopardi et al. 2023; Ertel et al. 2021). Store-and-forward modality allows the transmission of clinical data, such as images and documents, via email or web-based software for the ophthalmologist to review at a time convenient to them (Bisorca-Gassendorf et al. 2022; Huang et al. 2021; Kalavar et al. 2020). One advantage of the store-and-forward is that it does not need higher bandwidth than real-time (Alenoghena et al. 2023). Therefore, it offers patients living in rural areas with limited internet connectivity access to glaucoma care services (Culmer et al. 2023).

Synchronous modality in teleglaucoma is a real-time mode, which allows a patient and an eye specialist living at different locations to have a live video consultation (Bisorca-Gassendorf et al. 2022; Huang et al. 2021; Kalavar et al. 2020). The advantage of the synchronous modality is that the ophthalmologist can immediately consult with the patient, similar to an in-person examination (Wang et al. 2022). However, this requires a higher bandwidth and good video conferencing equipment (Hwei & Octavius 2021), which may incur a higher cost than store-and-forward mode.

The hybrid modality is a combination of both synchronous (real-time mode) and asynchronous models (store-and-forward) (Ertel et al. 2021). Clinical examination data, such as fundus images, visual field examinations, intraocular pressure measurements, and others, are transmitted to the consultant (Vinod & Sidoti 2021). The

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ophthalmologist will review the data and consult the patient via video conference if needed (Vinod & Sidoti 2021).

2.5.2 Teleglaucoma Practice

Early pilot studies for teleglaucoma emerged since 1999 (Li et al. 1999; Tuulonen et al. 1999; Yogesan et al. 1999). Teleglaucoma has been conducted in many countries such as the United States of America (USA), the United Kingdom, Australia, India, and China. It is used in many applications, such as screening and disease monitoring (Brandão-De-Resende et al. 2023; Gan et al. 2020; Lam et al. 2021). These applications have transformed the delivery of glaucoma care, particularly in developing countries with limited access to specialist care.

Teleglaucoma screening enables healthcare providers to identify individuals at high risk of developing glaucoma. These screening programmes vary by clinical setting and examination methods. A teleglaucoma programme, known as Screening and Intervention for Glaucoma and Eye Health through Telemedicine (SIGHT), was implemented at community clinics in Michigan and Alabama (Newman-Casey et al. 2021; Newman-Casey et al. 2023; Rhodes et al. 2021). This model used ophthalmic technicians to collect clinical data, such as optical coherence tomography and fundus photography, for remote review by specialists (Newman-Casey et al. 2023). Another similar teleglaucoma screening programme in New York used a mobile van equipped with a GlobeCheck kiosk, where patients underwent clinical examinations, including visual acuity testing, intraocular pressure measurement, pachymetry, optical coherence tomography, and non-mydriatic fundus photography (Kapoor et al. 2020). Bilong et al. (2020) used a smartphone to capture fundus photographs to screen 395 diabetic patients at the National Obesity Centre, Cameroon, which was later transferred virtually to an ophthalmologist for review. This study discovered that 39 patients were diagnosed with suspect glaucoma (Bilong et al. 2020).

Teleglaucoma screening programmes have been successfully conducted in developing countries such as Kenya (Marco et al. 2021) and Ethiopia (Giorgis et al. 2019). In Kenya, a teleglaucoma programme at Nyamira District Hospital recruited 1187 patients aged 35 and above (Marco et al. 2021). They reported a glaucoma

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prevalence of 3.46% and 4.12% of participants were diagnosed as glaucoma suspects (Marco et al. 2021). Similarly, a hospital-based teleglaucoma programme in Ethiopia identified glaucoma in 7.9% and probable glaucoma in 13.8% of high-risk participants (Giorgis et al. 2019).

Teleglaucoma is also employed to monitor the patient's glaucomatous progression (Lee et al. 2023). This approach is more efficient because it reduces patient waiting time by scheduling in-person examinations only when needed (Lee et al. 2023). It also allows the eye specialist in the conventional glaucoma clinic to treat patients with more severe conditions, reducing the number of patients who do not need to be seen in the glaucoma clinic (Huang et al. 2021). An example of teleglaucoma's application in managing glaucoma is the use of virtual glaucoma clinics for long-term monitoring of glaucoma patients in the United Kingdom and Singapore (Clarke et al. 2017; Huang et al. 2021; Lee et al. 2023; Nikita et al. 2023). Stable glaucoma patients undergo tests such as tonometry, visual field testing, and digital fundus imaging, which are sent to a glaucoma specialist virtually for diagnosis and management. In Canada, a recent teleglaucoma management programme called Care1 involved glaucoma or glaucoma-suspect patients undergoing clinical examinations at optometry clinics by optometrists, who uploaded the clinical data to the Care1 database for virtual review by ophthalmologists (Elson et al. 2022). It was reported that about 1.9% of the 4070 patients were referred to the ophthalmologist through this teleglaucoma programme (Elson et al. 2022). In Singapore, a virtual glaucoma clinic found that, among 377 low-risk glaucoma patients, 29 (7.7%) were referred for an eye examination (Huang et al. 2021).

Home-based monitoring was also one of the newer approaches in teleglaucoma management. A pilot study comparing home glaucoma testing using virtual reality perimetry and rebound tonometry with in-clinic measurements found a strong correlation between virtual reality perimetry and Humphrey Field Analyser ($r^2 = 0.8793$, $p < 0.001$) (Berneshawi et al. 2024). Similarly, another teleglaucoma monitoring programme using the Melbourne Rapid Fields application successfully detected clinical progression in two eyes during the study (Prea et al. 2022). These studies showed that home-based monitoring can monitor glaucoma progression among glaucoma patients.

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2.6 COMPONENTS OF A TELEGLAUCOMA PROGRAMME

The components of a teleglaucoma programme are patient history, instruments, teleglaucoma platform, and skilled personnel (Gan et al. 2020).

2.6.1 Patient's History

One of the components of the teleglaucoma programme is the patient's history (Gan et al. 2020). Patient's history, such as demographic information, such as age, race, and address, chief complaint, ocular history, medical history, and family history of glaucoma, needs to be recorded by primary eyecare providers (Gan et al. 2020; Wong & Tsai 2021).

2.6.2 Instruments

Teleglaucoma requires more instruments than a tele-retinal screening programme. These instruments are necessary to measure intraocular pressure (IOP), visual field, corneal thickness, and retinal nerve fibres for more accurate glaucoma diagnosis (Moyer et al. 2013; Elson et al. 2021). Therefore, the instruments in the teleglaucoma programme may include advanced imaging devices such as fundus cameras, perimetry, and optical coherence tomography (OCT).

A visual acuity test should be conducted as one of the tests for teleglaucoma (Gan et al. 2020; Wong & Tsai 2021). A visual acuity test was used to assess the distance and near vision. The instruments used are a Snellen Chart or a smartphone application (Wong & Tsai 2021).

Intraocular pressure measurement is required in a teleglaucoma programme, as high intraocular pressure is a risk factor for glaucoma (Stein et al. 2021). According to Wong and Tsai (2021), knowing intraocular pressure is essential, as it is one of the indicators needed to diagnose and manage glaucoma. Several instruments are available to measure intraocular pressure. The Goldmann applanation tonometer is the gold standard instrument for measuring intraocular pressure (Brusini et al. 2021; Choritz et al. 2020; Porwal et al. 2023). However, it requires topical anaesthesia, needs to be

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mounted on a slit lamp, and requires high expertise to use (Wong & Tsai 2021). A portable tonometer is preferable for use in a screening program at a remote location, such as an Air Puff tonometer, iCare tonometer, or Diaton transpalpebral tonometer (Wong & Tsai 2021). These tonometers can be used easily by healthcare providers such as nurses and technicians, as they need minimal training and screening at remote locations (Wong & Tsai 2021). Furthermore, some tonometers can be used at home, such as the iCare HOME tonometer (Icare Ltd, Vantaa, Finland) (Liu et al. 2020). It is a handheld rebound tonometer (Liu et al. 2020) and does not require topical anaesthesia (Hu et al. 2023; Liu et al. 2020). Recent research showed a good agreement (Kuo & Rahimy 2024; Susanna et al. 2025) and repeatability (Amatu et al. 2025; Romano et al. 2025) between the iCare HOME tonometer and Goldmann Applanation tonometry (Kuo & Rahimy 2024; Susanna et al. 2025). However, it underestimates low IOP readings and overestimates high readings (Lauwers et al. 2024; Liu et al. 2020). Despite these fluctuations, the device is usually used by glaucoma patients to self-monitor their intraocular pressure (Jayaram et al. 2023; Liu et al. 2020).

In most of the teleglaucoma screening programmes, the most frequently used instrument is a fundus camera (Thomas et al. 2014). The assessment of the optic nerve can be determined from fundus images (Gan et al. 2020). It was reported that 80% of images taken by a non-mydriatic fundus camera are satisfactory and can be used to diagnose retinal diseases (Lin et al. 2020). Moreover, a study found that a portable, non-mydriatic fundus camera is a highly accurate tool for glaucoma screening, with two different graders demonstrating high sensitivity (over 94%) and specificity (over 97%) when compared to the gold standard of a dilated fundus exam (Upadhyaya et al. 2022).

The most common equipment used for visual field test in teleglaucoma was the Humphrey Field Analyser (HFA) or the Octopus Perimeter, as they were the gold-standard automated perimeters for detection and monitoring of glaucoma (Zeppieri et al. 2025). Other equipment, such as frequency-doubling technology (FDT) perimetry, was also used for visual field testing. Terauchi et al. (2020) reported that the glaucoma detection rate was significantly higher in the FDT group compared to the control group (0.97% versus 0.47%, $p = 0.041$). Currently, portable perimetry systems are available, such as the tablet-based application Melbourne Rapid Fields (MRF). MRF applications

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can test the visual field up to 30 degrees horizontally and 24 degrees vertically (Jemaima et al. 2020). According to Kumar and Thulasidas (2020), the MRF and HFA showed excellent correlation across all perimetric metrics, with Intraclass Correlation Coefficients (ICC) ranging from 0.889 for Pattern Standard Deviation to 0.978 for Visual Capacity. A recent study demonstrated a significant correlation between MRF web-based perimetry and HFA for Mean Deviation (ICC=0.91, 95% CI [0.82,0.95]) and pattern standard deviation (ICC=0.88, 95% CI [0.82,0.92]) (Chen et al. 2025).

Recent advancements in visual field testing have led to the emergence of virtual reality (VR) perimetry, which uses virtual reality headsets and specialized software. Several virtual reality perimetry software solutions are currently available, including Vivid Vision Perimetry (Vivid Vision, San Francisco, CA, USA), C3 Field Analyzer (Remidio, Glen Allen, VA, USA), VisuALL (OllEyes Inc., Summit, NJ, USA), and others. Several studies have demonstrated the potential of virtual reality perimetry. Griffin et al. (2024) compared VisuALL perimeter with HFA in adults with glaucoma and found that it showed a good correlation with HFA ($r= 0.871$, $p < 0.001$). Mees et al. (2020) reported that the C3 Field Analyser effectively identified individuals with glaucoma. Virtual reality perimetry offers several advantages, such as portability and reducing fixation loss (Montelongo et al. 2021; Slagle et al. 2025).

Ocular coherence tomography (OCT) provides high-resolution imaging of the retina, especially the retinal nerve fibre layer, macula, and optic disc, which enables the detection of glaucomatous changes (Shiga et al. 2023; Sreedharan et al. 2023; Yang et al. 2025). It can detect changes associated with glaucomatous changes before visual field loss occurs in the visual field test (Swaminathan et al. 2021). Heidelberg Retinal Tomography (HRT) is another imaging tool for glaucoma screening. It creates 3D topographic images of the optic nerve head and is widely used to evaluate changes in the optic disc in glaucoma (Camara et al. 2022).

2.6.3 Teleglaucoma Software

The teleglaucoma programme requires a teleglaucoma software that can be web-based or cloud-based software (Gan et al. 2020; Kassam et al. 2013). The teleglaucoma system can also be integrated with an Electronic medical record (EMR), allowing healthcare

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providers and glaucoma specialists to access the patient's medical history during remote consultations (Tupsakhare 2020). The integration of Artificial Intelligence (AI) into teleglaucoma system for image analysis is expected to be a vital component in the diagnostic workflow of teleglaucoma in the future (Tonti et al. 2024).

2.6.4 Skilled Personnel

Another important component of the teleglaucoma programme is a team of skilled eye healthcare professionals (Gan et al. 2020). Eye healthcare professionals, including ophthalmologists, optometrists, primary care doctors, assistant medical officers, and ophthalmic technicians, play an essential role in teleglaucoma programmes. Eye care providers at the screening site are responsible for taking patient history and operating the screening equipment to collect the necessary data for remote analysis (Elson et al. 2022). Therefore, they must be trained to operate the instruments before being employed in the teleglaucoma programme (Elson et al. 2022). The efficiency of the teleglaucoma programme will increase if providers are well-trained to capture high-quality images, thereby reducing the likelihood that patients will need repeat examinations (Ertel et al. 2021). This was demonstrated in a study by Elson et al. (2022) which showed that training optometrists in eye examinations such as gonioscopy using a combination of lectures and practical sessions led to a successful programme.

2.7 EFFECTIVENESS OF TELEGLAUCOMA

The teleglaucoma screening programme has shown its effectiveness in detecting glaucoma among high-risk participants. In New York, this model effectively identified glaucoma in 21.47% of the 326 high-risk participants (Kapoor et al. 2020). Similarly, the Philadelphia Telemedicine Glaucoma Detection and Follow-up Study, which used fundus photography and iCare tonometry to screen 902 individuals at primary care sites, diagnosed 10.9% with glaucoma and 7.2% with ocular hypertension (Hark et al. 2019). The efficacy of the teleglaucoma screening programme also extends to resource-limited settings. A pilot teleglaucoma programme in Ethiopia, which screened 1,002 high-risk patients aged 35 years or older, successfully identified 7.9% with glaucoma and 13.8% as probable glaucoma (Giorgis et al. 2019). While another teleglaucoma screening programme in Kenya reported that 3.46% of 1187 participants had glaucoma, and

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4.12% were diagnosed as probable glaucoma (Marco et al. 2021). These findings showed that the teleglaucoma screening programme can effectively detect glaucoma or probable glaucoma.

Many studies have compared diagnostic agreement between teleglaucoma and in-person examinations. A recent study found high agreement between store-and-forward teleophthalmology and in-person examination for glaucoma diagnosis and grading, with kappa values ranging from 0.61 to 0.8 (Wong et al. 2022). While this teleophthalmology demonstrated high sensitivity (98.7%) for glaucoma diagnosis, its specificity was lower (76.5%) (Wong et al. 2022). Another simulated teleglaucoma programme found moderate agreement between the programme and the ophthalmologist (kappa value of 0.49 and 0.44 for the two teleglaucoma graders, respectively) (Balakrishnan et al. 2024). In Atlanta, a teleophthalmology programme called Technology-Based Eye Care Services, conducted in a primary care clinic, reported that graders exhibited sensitivity of 47% to 72% in detecting glaucoma or glaucoma-suspect cases, relative to ophthalmologist assessments (Maa et al. 2020). The Philadelphia Telemedicine Glaucoma Detection and Follow-up Study reported that 78.1% of probable glaucoma (n=183) identified during teleglaucoma were confirmed as glaucoma or probable glaucoma during subsequent in-person examination (Hark et al. 2019). Chandrasekaran et al. (2019) found a strong correlation between teleglaucoma and in-person examination results, concluding that teleglaucoma's diagnostic capability is comparable to that of in-person examination. A meta-analysis by Thomas et al. (2014) also found that teleglaucoma can be used for glaucoma screening, with a sensitivity of 0.832 and a specificity of 0.79 compared to in-person examination. These findings indicated that teleglaucoma could accurately detect glaucoma or probable glaucoma.

2.8 ADVANTAGES OF TELEGLAUCOMA

Teleglaucoma provides several benefits to the community. One advantage of teleglaucoma is that it allows access to eye care services, especially for people living in rural areas. This was demonstrated by teleglaucoma screening programmes in rural areas of Philadelphia, USA, Ethiopia, and Kenya (Giorgis et al. 2019; Hark et al. 2019; Marco et al. 2021). The Philadelphia Telemedicine Glaucoma Detection and Follow-up

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Study successfully identified 78.1% (n=143) of 183 glaucoma cases in populations with limited access to eye care services (Hark et al. 2019). Pilot teleglaucoma programmes in Ethiopia and Kenya have demonstrated feasibility in resource-limited settings, identifying a glaucoma prevalence of 7.9% (Giorgis et al. 2019) and 3.46% (Marco et al. 2021) respectively.

Teleglaucoma can help in saving time for both patients and healthcare providers (Brandão-De-Resende et al. 2023). A study reported that a virtual glaucoma clinic in Singapore reduced patient journey time by 50% (59.3 minutes versus 132 minutes) and specialist review time from 19.5 minutes in face-to-face consultation to 5.8 minutes (Huang et al. 2021). Lee et al. (2023) also reported that the time ophthalmologists spent reviewing patients in a virtual glaucoma clinic was shorter (5.75 minutes versus 13.7 minutes) than in a standard clinic consultation. Polat et al. (2021) also reported that teleglaucoma reduced the time for a specialist consultation from 31 minutes for an in-person examination to 19 minutes. The Australian Community Eye Care (C-EYE-C) teleglaucoma programme in community optometry practice demonstrated shorter appointment waiting times (Ford et al. 2019).

Teleglaucoma not only saves patients time but also reduces costs, as patients do not need to travel long distances for consultation (Sharma et al. 2020). Many studies have reported significant cost savings associated with teleglaucoma. A systematic review reported that teleglaucoma screening was cost-effective with savings of $27460 per quality-adjusted life year (Thomas et al. 2015). Another economic review of teleophthalmology also concluded that teleophthalmology for glaucoma was more cost-effective compared with in-person examination (Sharafeldin et al. 2018). The virtual clinic in Singapore demonstrated a 50% reduction in per capita manpower costs compared with conventional care ($36.77 versus $65.62), translating into $280.65 in savings per patient (Lee et al. 2023). In Australia, the C-EYE-C model demonstrated a 22% reduction in health system costs compared with standard hospital care (Ford et al. 2019).

Another advantage of teleglaucoma is the reduction of unnecessary referrals to the eye clinic (Ertel et al. 2021). Teleglaucoma demonstrated moderate agreement with

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in-person diagnosis (Balakrishnan et al. 2020; Balakrishnan et al. 2024). Therefore, teleglaucoma can reduce the burden of false-positive cases in clinical settings through remote ophthalmologist review.

Teleglaucoma also provides protection against contagious diseases such as COVID-19 for patients and health care providers, especially ophthalmologists (Vinod & Sidoti 2021). It helps reduce the chance of transmission by minimizing in-person visits (Lam et al. 2021). This was demonstrated by a study that found use of teleophthalmology increased significantly during the pandemic (Faes et al. 2021).

2.9 DISADVANTAGES OF TELEGLAUCOMA

Teleglaucoma needs high-quality images for a consultant ophthalmologist to detect glaucoma properly (Kalavar et al. 2020). Poor quality of fundus images is usually caused by media opacity due to cataract and small pupil size (Sharma et al. 2020). This will affect the ophthalmologist's ability to detect glaucoma. This poor quality of fundus images was usually found in tele-ophthalmology programmes with a non-mydriatic fundus camera (Mazzuca et al. 2022). A teleophthalmology study in Taiwan reported 70% of fundus images were of good quality (Chan et al. 2024). They mostly cited poor image quality as the reason, which led to different diagnoses in 18 (22.2%) fundus images (Chan et al. 2024).

Teleglaucoma also raises privacy and security concerns, especially regarding patient data storage, due to its vulnerability to cyberattacks (Kalavar et al. 2020; Mazzuca et al. 2022). This will affect patients' and healthcare providers' perceptions of the use of teleglaucoma (Sharma et al. 2020). Therefore, safety measures to protect the patient's privacy and confidentiality must be implemented to increase trust in the adoption of teleglaucoma (Kalavar et al. 2020).

2.10 BARRIERS IN THE IMPLEMENTATION OF TELEGLAUCOMA

Teleglaucoma is still not widely practised compared to other tele retinal programmes, even though it was started over two decades ago. There were barriers to the widespread adoption of teleglaucoma programmes.

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One of the barriers is the high startup cost and teleglaucoma maintenance (Gan et al. 2020). Teleglaucoma requires specialized software, extensive imaging equipment, and highly trained personnel (Gan et al. 2020). Thomas et al. (2014) reported that implementing glaucoma screening requires an initial instrument investment of $89,703 to $123,164.28. A survey of European glaucoma specialists found that a lack of suitable staff (34%) and insufficient time or money (34%) were barriers to implementing a virtual glaucoma clinic (Azzopardi et al. 2023). Thus, teleglaucoma incurs a higher investment cost than other tele retinal programmes which primarily require only a fundus camera.

Another barrier in the implementation of teleglaucoma is insufficient information and communication technology (ICT) infrastructure, including computers and Internet access, especially in rural areas. Video consultation and transmission of clinical data, such as fundus images, videos, and pictures, can only be implemented when a high-speed internet connection is available (Car et al. 2020; Das 2022). Inadequate ICT infrastructure, such as poor internet access and insufficient power supply, remains the primary barrier to telemedicine implementation in developing countries (Lestari et al. 2024; Sagaro et al. 2020).

Lack of acceptance among eye care professionals and patients is another barrier to the implementation of teleglaucoma. A recent qualitative interview with glaucoma specialists in the USA found that all participants perceived teleglaucoma as not comparable to an in-person examination, leading to its discontinuation (Liu et al. 2023). Some patients prefer a face-to-face consultation with their consultant ophthalmologist, as demonstrated in a survey in Iran, which found that most participants (n=865, 71%) out of 1226 preferred an in-person examination over telemedicine (Moulaei et al. 2023). This preference is largely driven by the perception that in-person examinations offer more accurate diagnoses than telemedicine (Moulaei et al. 2023). Lack of awareness or familiarity with the technology used in teleglaucoma among patients and healthcare professionals may cause them not willing to use the teleglaucoma service (Mazzuca et al. 2022; Vinod & Sidoti 2021). Data security is also a barrier to the acceptability of teleophthalmology among patients, as teleglaucoma is vulnerable to cyberattacks (Kalavar et al. 2020)

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Reimbursement for teleglaucoma services is a barrier to the adoption of teleglaucoma (Rathi et al. 2017). This is because an insurance claim may not cover telemedicine services. In the United States of America, Medicare only provides reimbursement for telemedicine if the following conditions are met: the patient stays in a rural area, the telemedicine setting is at a health clinic or hospital, the consultation must involve live video or audio consultation, and the doctor must stay in the United States (Kalavar et al. 2020). A survey conducted among 146 medical doctors in Malaysia reported that 62.5% of participants cited insurance reimbursement as one of the barriers to the implementation of telemedicine (Thong et al. 2021).

Unclear regulatory frameworks pose a significant barrier to the teleglaucoma (Mazzuca et al. 2022). In the USA, clinicians can only provide remote consultations in the states where they are licensed (Mazzuca et al. 2022). In Malaysia, the Telemedicine Act 1997 (Act 564) was enacted to regulate telemedicine (Muuti 2019). However, it has been proposed for abolition, as it was never enforced (Muuti 2019). Currently, the 2025 MOH Online Healthcare Services guideline governs telemedicine practice (Ministry of Health Malaysia 2025). This guideline emphasizes registered practitioners, data security, and informed consent (Ministry of Health Malaysia 2025). However, practitioner concerns persist as reported by a survey by Thong et al. (2021) which reported that 80.6% of 146 medical doctors cited medico-legal issues and consent as barriers to the implementation of telemedicine in Malaysia.

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2.11 RESEARCH GAP

Teleglaucoma has proven its effectiveness for screening. However, there is no teleglaucoma programme in Malaysia. Existing national teleophthalmology initiatives include Tele-Diabetic Retinopathy (Omar et al. 2018) and DR.MATA AI tool specifically designed for grading diabetic retinopathy (DR) (Gomes 2025). These programmes occasionally yield incidental glaucoma findings. However, they lack systematic protocols, standardised referral pathways, and diagnostic validation for glaucoma, as they are optimised for DR. Therefore, there is currently a significant research gap, as no studies in Malaysia have been conducted on the development and effectiveness of the teleglaucoma screening programme for glaucoma detection.

2.12 CONCEPTUAL FRAMEWORK

Figure 2.1 shows the conceptual framework of this study.

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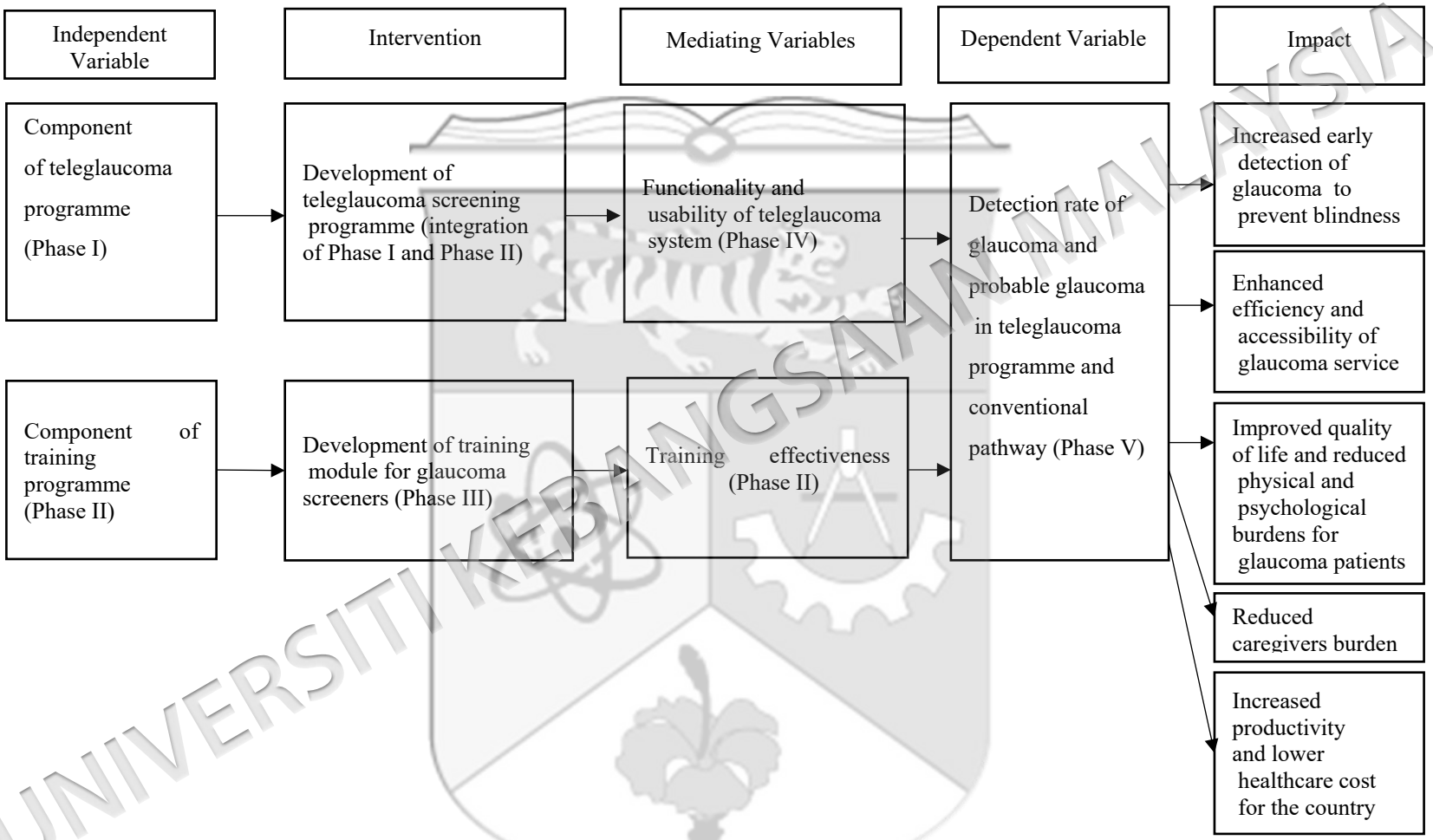

Figure 2.1 Conceptual framework

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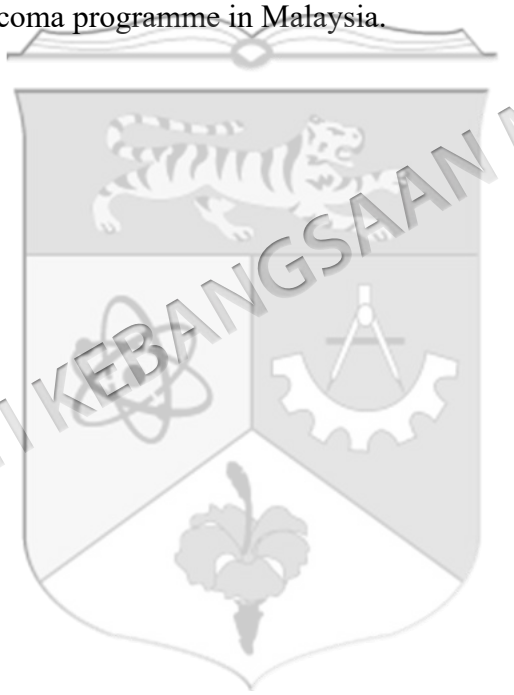
2.13 CONCLUSION

In conclusion, this literature review has provided the foundations for understanding glaucoma and teleglaucoma programmes. While key components of teleglaucoma programs (e.g., instruments, software, personnel) are well-defined in existing literature reviews, there is a lack of literature explaining how these components are most effectively synthesized to create a standardized and effective teleglaucoma programme in practice, especially in middle-income countries such as Malaysia. The next chapter will bridge this gap by detailing the specific components of teleglaucoma programmes in a real-world scenario. This aims to provide a guideline for developing and implementing teleglaucoma programme in Malaysia.



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CHAPTER III

PHASE I: IDENTIFY COMPONENTS OF TELEGLAUCOMA SCREENING PROGRAMME

3.1 INTRODUCTION

Identifying the most suitable components to conduct a successful teleglaucoma screening programme is crucial. This includes identifying the teleglaucoma system, the instruments needed, the personnel involved, and referral pathways to ophthalmologists. While Chapter II provided a broad overview of the key components of teleglaucoma programmes, this chapter offers a more detailed review of how these components can be effectively integrated. Furthermore, most existing literature focuses on high-income settings, creating a critical gap in understanding how such models apply in middle-income contexts such as Malaysia. Therefore, there is a need to identify and determine the essential components of a teleglaucoma programme that are suitable for the local healthcare context. This chapter addresses this gap through a mixed-method study to identify and determine the components required for an effective teleglaucoma programme in Malaysia.

3.2 OBJECTIVE

This study aimed to identify and determine the appropriate components for the teleglaucoma screening programme and referral pathway for glaucoma or probable glaucoma patients in the Malaysian population.

3.3 ETHICAL APPROVAL

Ethics approval was obtained from the Research Ethics Committee Universiti Kebangsaan Malaysia (UKM PP1/111/8/JEP-2020-127) (Appendix A) and the Medical

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Research and Ethics Committee under the Ministry of Health Malaysia (NMRR-20-2418-56993) (Appendix B).

3.4 STUDY DESIGN

The study design was a mixed method study which were systematic review (Section I) to identify the components of the teleglaucoma screening programme and their referral pathway from previous studies worldwide, while semi-structured interviews (Section II) explored themes from a local perspective that may not be fully addressed in the literature.

3.5 SECTION I: SYSTEMATIC REVIEW

3.5.1 Methodology

The systematic review was performed from 1 January 2010 to 31 December 2020 in the following databases: PubMed, Scopus, and Web of Science. Search strategy for systematic review included keywords for glaucoma, teleglaucoma, screening, and referral pathway (Appendix C). We also manually searched articles based on the reference lists in the included studies and previous systematic reviews.

Full-text articles were included if they were in English and focused on teleglaucoma screening and human subjects. The exclusion criteria were articles published before 2010 and studies on telemonitoring and teleophthalmology other than glaucoma. Reviews, case reports, duplicate studies, commentaries, letters, books, and abstracts were excluded.

The results of the search were imported into EndNote 20, and duplicates were removed. Title and abstracts of the articles were screened independently by two reviewers (WXH and JCH). Then, the full-text articles were reviewed for eligibility by two reviewers (WXH and JCH). If there were any disagreements, it was solved by discussion and mutual agreement.

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The quality of the studies was assessed using Mixed Methods Appraisal Tool (MMAT) version 2018 (Appendix D) and Quality Assessment of Diagnostic Accuracy Studies-2 (QUADAS-2) (Appendix E) by two investigators independently (WXH and JCH) and any disagreements was resolved by discussion and mutual agreement. MMAT tool was used in our study because it can appraise the quality of different types of studies such as quantitative, qualitative and mixed methods studies (Hong et al. 2018). The MMAT tool consists of two screening questions and five questions in each of the category of the type of studies to be scored (Hong et al. 2018). They suggested to report MMAT score as stars (*) or percentage (%), which were 1* or 20% quality criteria met, 2 ** or 40% quality criteria met, 3 *** or 60% quality criteria met, 4 **** or 80% quality criteria met and 5***** or 100% quality criteria met (Hong et al. 2018).

QUADAS-2 was used because MMAT is unsuitable for diagnostic accuracy studies (Hong et al. 2018). It has four domains: patient selection, the index test, the reference standard test, the flow of patients and timing of tests (Appendix E). Quality assessment was based on the risk of bias and applicability concerns (Whiting et al. 2011). However, applicability concerns were assessed only in three domains: patient selection, the index test and the reference standard test. The risk of bias consists of signalling questions which identify aspect of study designs that exposed to risk of bias. The risk of bias was classified as low, high, or unclear (Whiting et al. 2011). If the answers to signalling questions for a domain were "yes," then the risk of bias was rated as "low" (Whiting et al. 2011). If the answers to signalling question was "no" or "unclear", it was rated as "high" or "unclear" (Whiting et al. 2011). Applicability concerns were also rated as low, high or unclear (Whiting et al. 2011).

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3.5.2 Data Synthesis

Microsoft Excel 2020 (Microsoft Corp., Redmond, Washington, USA) was used for data synthesis. The quantitative analysis was not performed due to the heterogeneity of the articles such as variations in the types of instruments used in the studies. Therefore, only qualitative synthesis was performed. Data were extracted from the full-text articles and transferred into an Excel sheet. Name of authors, the year of publication, country, modality of teleglaucoma, study participants, location, tests, instruments, personnel,

teleglaucoma system and referral pathway were presented in the descriptive table (Table 3.1).

3.5.3 Results

Figure 3.1 shows the results of the study selection procedure according to PRISMA (Preferred Reporting Items for Systematic reviews and Meta-Analyses) 2020 flowchart. The data search resulted in seventeen articles included for data analysis from 681 articles (Figure 3.1). Of the seventeen studies, 12 (70.6%) were classified as quantitative descriptive studies (Ahmed et al. 2013; Chandrasekaran et al. 2019; Grau et al. 2019; Hark et al. 2018; Hark et al. 2019; Kapoor et al. 2020; Keenan et al. 2015; Kotecha et al. 2017; Shahid et al. 2012; Staffieri et al. 2011; Trikha et al. 2012; Verma et al. 2014). Two studies (11.8%) were mixed-method studies (Giorgis et al. 2019; Sapru et al. 2017), and a study (5.9%) was a quantitative non-randomized study (Arora et al. 2014). Two studies (11.8%) were a diagnostic accuracy studies (Kiage et al. 2013; Maa et al. 2020). Most studies were conducted in the United States (8, 47%), the United Kingdom (3, 17.6%), and Canada (2, 11.8%). The remaining studies were from Tasmania (1, 5.9%), Germany (1, 5.9%), Africa (1, 5.9%), and Ethiopia (1, 5.9%).

Table 3.1 shows detailed characteristics of the studies from the systematic review. Table 3.2 shows the summary of the characteristics of the studies from the systematic review.

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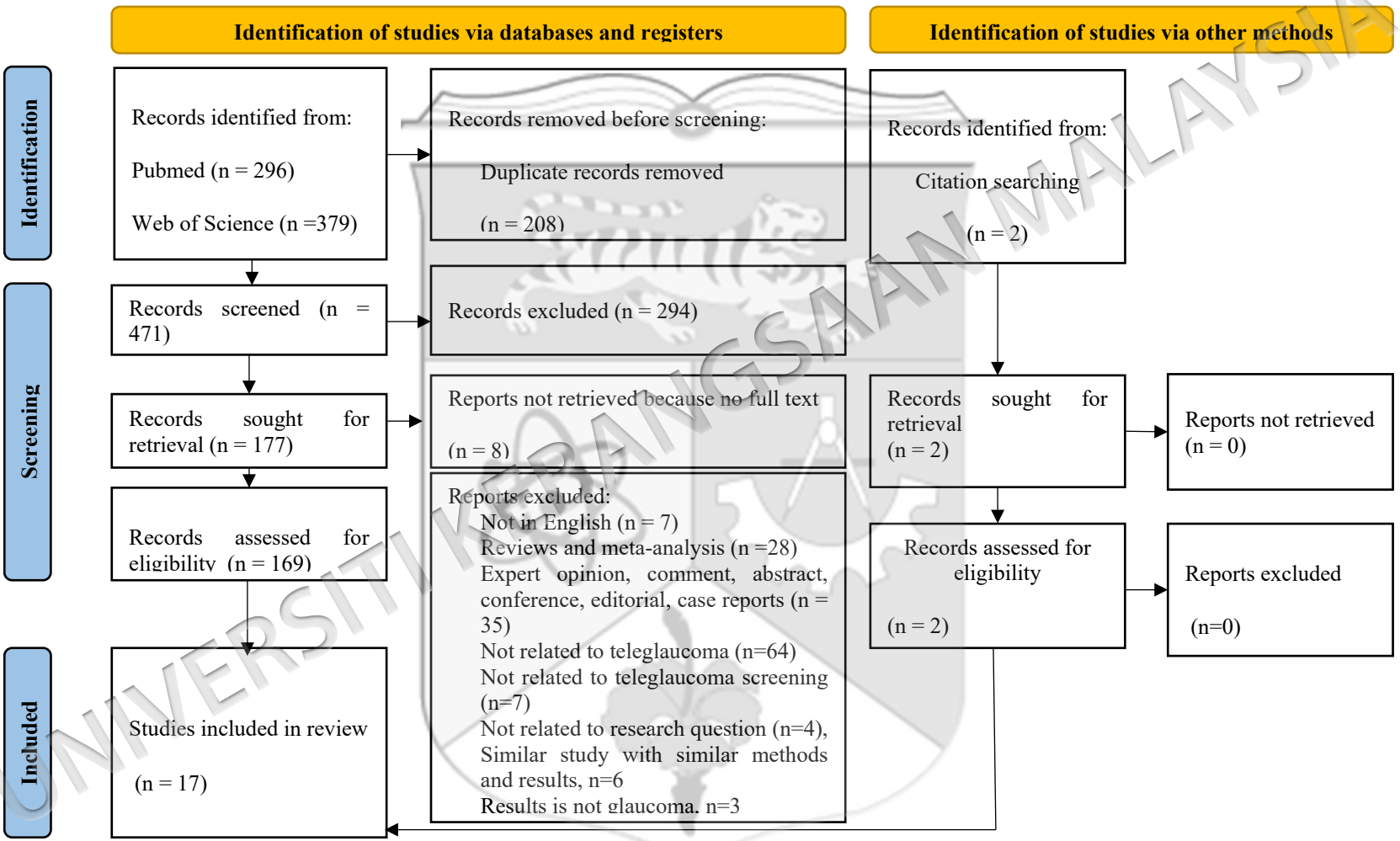

Figure 3.1 Study Flowchart according to PRISMA 2020 guidelines

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Table 3.1 Characteristics of the studies included in the systematic review

Study & country	Modality	Study design	Sample	Location	Examinations	Instruments	Personnel	System	Referral pathway
Staffieri et al. (2011) Tasmania	Store and forward	Quantitative descriptive study	211 first-degree relative of glaucoma patients	Private ophthalmology practice and public outpatient clinics	Visual acuity (VA) test, , refraction, visual field test, tonometry, pachymetry and stereoscopic fundus photography	LogMar Bailey-Lovie vison chart, ARK-30 Type R Nidek autorefractor/ keratometer, Tonopen XL, Humphrey Field Analyser (HFA), Pachmate DGH 55, Nidek 3-Dx Stereodisc fundus camera	Nurse, technician, orthoptists, ophthalmology registrar trainees and a glaucoma specialist	MS Access 2007 (Microsoft Corp., Redmont, WA, USA) for database. The clinical data were sent via a secure server.	Patients diagnosed with glaucoma or as glaucoma suspects were referred to ophthalmologists. Normal patients were discharged and advised for follow up in one, two or five years.
Shahid et al. (2012) United States of America	Synchronous	Quantitative descriptive study	341 underprivileged individuals in New Jersey aged 10 to 82 years old	Urban soup kitchen	History taking, VA test, refraction, fundus photography, tonometry	Vision chart, handheld auto refractor, non-mydriatic fundus camera, non-contact tonometer	Medical and college students, an ophthalmic technician, optometrist, ophthalmologist	Did not specify the teleconferencing system	Patients diagnosed with glaucoma or other eye diseases were referred to an ophthalmologist. Normal patients were discharged.

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Trikha et al. (2012) United Kingdom	Store and forward	Quantitative descriptive study	100 glaucoma suspect patients referred from optometrist	Queen Alexandra Hospital, Portsmouth	Visual field test, tonometry, and fundus photography	GAT, slit lamp, Topcon fundus camera and HFA.	Six specialist optometrists and a glaucoma specialist	The clinical data and images are sent virtually to the ophthalmologist	Patients diagnosed with glaucoma were referred to an ophthalmologist. Normal patients were discharged. Glaucoma suspects and ocular hypertension will underwent follow-up.
Ahmed et al. (2013) United States of America	Store and forward	Quantitative descriptive study	643 diabetic and hypertensive patients	Community health clinic	History taking, fundus photography and tonometry	Topcon TRC-NW6S non-mydriatic fundus camera, Tonopen	A nurse and an ophthalmologist	Did not specify the system used. A storage media was used for an ophthalmologist	Patients diagnosed with glaucoma were referred to an ophthalmologist. Normal patients were discharged or underwent follow-up.
Kiage et al. (2013) Kenya, Africa	Store and forward	Diagnostic accuracy study	309 diabetic patients aged 30 years and above	Diabetic and eye clinic at Muranga District Hospital	History taking, VA test, external eye examination, tonometry, fundus photography and visual field test.	Vision chart, pen torch, Tonopen, Topcon 777 fundus camera, FDT	An ophthalmic technician and a glaucoma specialist	Secure Diagnostic Imaging (SDI) (Secure Diagnostic Imaging Inc,Edmonton, Alberta,Canada) system	No referral as patients were examined by a glaucoma specialist after teleglaucoma

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Arora et al. (2014) Canada	Store and forward	Quantitative non-randomized study	71 glaucoma suspects or open angle glaucoma patients referred from optometrist	Royal Alexandra Hospital eye clinic	History taking, slit lamp examination, visual field test, anterior segment and retinal imaging, and fundus photography	Slit lamp, FDT or HFA, OCT or HRT, Oculus Pentacam topographer and stereo fundus camera	Ophthalmic technicians and a glaucoma specialist	Secure Diagnostic Imaging (SDI) (Secure Diagnostic Imaging Inc,Edmonton, Alberta,Canada) system	Patients who needed further assessment were referred or scheduled for teleglaucoma. Normal patients were discharged.
Verma et al. (2014) Canada	Store and forward	Quantitative descriptive study	247 glaucoma suspects or early open-angle glaucoma patients referred from optometrist	15 sites (13 optometry centre, a community clinic and an eye clinic)	History taking, slit lamp, tonometry, pachymetry, slit lamp, visual field test, and retinal imaging	slit lamp, GAT or tonopen, FDT or HFA, ultrasonic pachymeter, non-mydriatic fundus camera, OCT or HRT	Optometrists, family physician, ophthalmic technicians, ophthalmologist and a glaucoma specialist	Secure Diagnostic Imaging (SDI) (Secure Diagnostic Imaging Inc,Edmonton, Alberta,Canada) system	Patients who needed further assessment were referred or scheduled for teleglaucoma examination. Normal patients were discharged.
Keenan et al. (2015) United Kingdom	Store and forward	Quantitative descriptive study	1733 glaucoma suspect patients	optometry practices	History taking, VA test, slit lamp, pupil reflex, tonometry, gonioscopy, pachymetry, indirect funduscopy, fundus photography, visual field test	Vision chart, pen torch, slit lamp, GAT, gonioscope, ultrasound pachymeter, fundus camera and HFA.	Seven optometrists and a glaucoma specialist	Medisoft EMR (Medisoft Limited, Leeds, UK) and National Health Service email for visual field and fundus images	Patients who were diagnosed with glaucoma or suspected of having glaucoma were referred to ophthalmologists. Normal patients were discharged.

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Kotecha et al. (2017) United Kingdom	Store and forward	Quantitative descriptive study	1380 glaucoma suspect patients	Eye clinic at Moorfields Eye Hospital	History taking, visual acuity, tonometry, visual field test, angle assessment, pachymetry, dilated fundus photography	COMPlog Vision Chart, Reichert Ocular Response Analyzer, HFA, Topcon 3D 2000 OCT, DGH Pachmate, Kowa non-mydriatic WX3D stereo-fundus camera	Three ophthalmic technicians and a glaucoma specialist	OpenEyes electronic patient record (Apperta Foundation CIC, Sunderland, UK)	Patient required further assessment were referred to an ophthalmologist in the eye clinic. Normal patients will be discharged.
Sapru et al. (2017) United States of America	Store and forward	Mixed-method study	651 participants with risk factors of glaucoma	Two Walmart Vision Centers in Alabama	History taking, visual acuity test, refraction, applanation tonometry, pachymetry, slit lamp examination, gonioscopy, stereo fundus photography, optical coherence tomography or visual field test	Vision chart, slit lamp, GAT, gonioscope lens, fundus camera, Cirrus OCT, HFA	optometrists and two ophthalmologists	Electronic medical record (EMR)	Patients who needed further assessment were referred to ophthalmologists. Normal patients were discharged back and follow up with their optometrists.

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Hark et al. (2018) United States of America	Store and forward	Quantitative descriptive study	182 patients with risk factors of glaucoma	Two health centres in Philadelphia	History taking, visual acuity test, anterior and posterior segment photography, and tonometry	Clear Chart 2 digital acuity chart, handheld non-mydriatic fundus camera and TAO1i iCare tonometer	Technicians, a glaucoma specialist, and a retina reader	Wills Eye Telemedicine EMR system	Patients who required further assessment were referred to a glaucoma specialist at the same location within two months to confirm the diagnosis. Patients with severe ocular disease were referred immediately to the ophthalmologists. Normal patients were discharged.
Chandrasekaran et al. (2019) United States of America	Store and forward	Quantitative descriptive study	107 glaucoma or glaucoma suspect patients aged 15 to 85 years old	Glaucoma clinic at University Hospital in New Jersey	History taking, auto-refraction, tonometry, fundus photography, corneal thickness, angle of anterior chamber, and retinal nerve fibre layer assessment	Canon RKF2 autorefractor, Canon TX20 non-contact tonometer, Canon CR2 Plus-AF non-mydriatic fundus camera, Optovue OCT	Glaucoma fellowship-trained ophthalmologists	Optovue, iVue Picture Archiving and Communication System (PACS) was used to store the data and images. Never specify the system used.	No referral as patients were examined by a glaucoma specialist after teleglaucoma

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Giorgis et al. (2019) Ethiopia	Store and forward	Mixed method study	1002 patients aged 35 years or above, with a family history of glaucoma, diabetes and hypertension	Ras Desta Hospital at Addis Ababa, Ethiopia	History taking, visual acuity, autorefraction, slit lamp examination, tonometry, pachymetry, stereoscopic digital fundus photography.	Vision chart, slit lamp, tonopen XL, pachymeter, autorefractor, Topcon non-mydriatic Retinal Camera TRC-NW100.	Nurse, optometrist and three glaucoma specialists	Secure Diagnostic Imaging (SDI) (Secure Diagnostic Imaging Inc,Edmonton, Alberta,Canada) system	Patients who were diagnosed with glaucoma or suspected of having glaucoma were referred to ophthalmologists. Normal patients were discharged.
Grau et al. (2019) Germany	Store and forward	Quantitative descriptive study	931 company employee aged 39 to 65 years	mobile mini clinic at a company	History taking, blood samples, blood pressure, examination of macula and optic nerve head, retinal nerve fibre assessment, and tonometry	Spectralis SD-OCT and non-contact tonometer NT530/510	A technician and an ophthalmologist	MedStage patient record system (Talkingeyes and More GmbH, Erlangen, Germany)	Patients who were diagnosed with glaucoma or other eye diseases were referred to ophthalmologists. Normal patients were discharged.
Hark et al. (2019) United States of America	Store and forward	Quantitative descriptive study	906 patients with risk factors of glaucoma	Seven primary care offices and four Federally Qualified Health Centres	History taking, visual acuity test, tonometry and anterior and posterior segment photography	Clear Chart 2 digital acuity chart, handheld non-mydriatic fundus camera and TAO1i iCare tonometer	Technician, two community health educators, a glaucoma specialist and a retina reader	Wills Eye Telemedicine EMR system	Patients who required further assessment were scheduled for eye examination at the same screening location. Patients with eye disease were referred to ophthalmologists. Normal patients were discharged.

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Kapoor et al. (2020) United States of America	Store and forward	Quantitative descriptive study	326 high-risk participants aged 18 years and above who were willing to join the programme	GlobeChek teleophthalmology kiosk was placed in front of New York Presbyterian Hospital Columbia University Campus	History taking, visual acuity test, tonometry, autorefraction, autokeratometry pachymetry, anterior and posterior segment optical coherence tomography, non-mydriatic fundus photography, and visual field test	Stereo Optical 5000 Visual Acuity chart, Topcon TRK-2P auto keratorefractor/tonometer/pachometer, Topcon 3D OCT-1 Maestro, Reichert 7 auto tonometer, Zeiss Humphrey 710 frequency doubling technology (FDT)	Ophthalmic technicians, medical and college students, an ophthalmologist or optometrist.	Data was transferred to Edward S. Harkness Eye Institute reading centre. Never specify the system used.	Patients who need further assessments were referred to ophthalmologists. Normal patients were discharged.
Maa et al. (2020) United States of America	Store and forward	Diagnostic accuracy study	Patients who have not had an examination for two or more years and have no ocular disease	primary care clinics in Atlanta	History taking, autorefraction, subjective refraction, visual acuity test, pupil test, tonometry, pachymetry, anterior chamber depth, dilated fundus photography	Vision chart, Marco ARK-1S auto-refractor, phoropter, iCare tonometer, Accutome Pachpen, Finhoff transilluminatior, Canon CX-1 fundus camera	An ophthalmic technician and two ophthalmologists	REDCap Database (Vanderbilt University, Nashville, Tennessee, USA)	No referral as patients were examined by a glaucoma specialist after teleglaucoma on the same day

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Table 3.2 Summary of the characteristics of the systematic finding

Characteristic	Frequency (Percentage)	Studies
Setting		
Community	10 (58.8%)	Ahmed et al. (2013); Grau et al. (2019); Hark et al. (2018); Hark et al.(2019); Kapoor et al. (2020); Keenan et al. (2015); Maa et al. (2020); Sapru et al. (2017); Shahid et ,al. (2012); Verma et al. (2014)
Hospital	7 (41.2%)	Arora et al. (2014); Chandrasekaran et al. (2019); Giorgis et al. (2019); Kiage et al. (2013); Kotecha et al. (2017); Staffieri et al. (2011); Trikha et al. (2012)
Target population		
High-risk patients	10 (58.8%)	Ahmed et al. (2013); Giorgis et al. (2019); Grau et al. (2019); Hark et al. (2018); Hark et al. (2019); Kapoor et al. (2020); Kiage et al. (2013); Maa et al. (2020); Sapru et al. (2017); Staffieri et al. (2011)
Glaucoma suspect or glaucoma	6 (35.3%)	Arora et al. (2014); Chandrasekaran et al. (2019); Keenan et al. (2015); Kotecha et al. (2017); Trikha et al. (2012); Verma et al. (2014)
Low socioeconomic status	1 (5.9%)	Shahid et al. (2012)
Examination and Instrument		
Tonometer	16 (94.1%)	Ahmed et al. (2013); Chandrasekaran et al. (2019); Giorgis et al. (2019); Grau et al. (2019); Hark et al. (2018); Hark et al. (2019); Kapoor et al. (2020); Keenan et al. (2015); Kiage et al. (2013); Kotecha et al. (2017); Maa et al. (2020); Sapru et al. (2017); Shahid et al. (2012); Staffieri et al. (2011); Trikha et al. (2012); Verma et al. (2014)
Fundus camera	15 (88.2%)	Ahmed et al. (2013); Arora et al. (2014); Chandrasekaran et al. (2019); Giorgis et al. (2019); Hark et al. (2018); Hark et al. (2019); Keenan et al. (2015); Kiage et al. (2013); Kotecha et al. (2017); Maa et al. (2020); Sapru et al. (2017); Shahid et al. (2012); Staffieri et al. (2011); Trikha et al. (2012); Verma et al. (2014)

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History taking	15 (88.2%)	Ahmed et al. (2013); Arora et al. (2014); Chandrasekaran et al. (2019); Giorgis et al. (2019); Grau et al. (2019); Hark et al. (2018); Hark et al. (2019); Kapoor et al. (2020); Keenan et al. (2015); Kiage et al. (2013); Kotecha et al. (2017); Maa et al. (2020); Sapru et al. (2017); Shahid et al. (2012); Verma et al. (2014)
Visual acuity test	11 (64.7%)	Giorgis et al. (2019); Hark et al. (2018); Hark et al. (2019); Kapoor et al. (2020); Keenan et al. (2015); Kiage et al. (2013); Kotecha et al. (2017); Maa et al. (2020); Sapru et al. (2017); Shahid et al. (2012); Staffieri et al. (2011)
Perimeter	9 (52.9%)	Arora et al. (2014); Kapoor et al. (2020); Keenan et al. (2015); Kiage et al. (2013); Kotecha et al. (2017); Sapru et al. (2017); Staffieri et al. (2011); Trikha et al. (2012);Verma et al. (2014)
Pachymeter	8 (47.1%)	Giorgis et al. (2019); Kapoor et al. (2020); Keenan et al. (2015); Kotecha et al. (2017); Maa et al. (2020); Sapru et al. (2017); Staffieri et al. (2011); Verma et al. (2014)
Ocular coherence imaging (OCT) or Heidelberg retinal tomography (HRT)	7 (41.2%)	Arora et al. (2014); Chandrasekaran et al. (2019); Grau et al. (2019); Kapoor et al. (2020); Kotecha et al. (2017); Sapru et al. (c2017); Verma et al. (2014)
Autorefractor	6 (35.3%)	Chandrasekaran et al. (2019); Giorgis et al. (2019); Kapoor et al. (2020); Maa et al. (2020); Shahid et al. (2012); Staffieri et al. (2011)
Slit lamp	5 (29.4%)	Giorgis et al. (2019); Keenan et al. (2015); Sapru et al. (2017); Trikha et al. (2012); Verma et al. (2014)
Pen torch	3 (17.6%)	Keenan et al. (2015); Kiage et al. (2013); Maa et al. (2020)
Gonioscope	2 (11.8%)	Keenan et al. (2015); Sapru et al. (2017)
Topographer	1 (5.9%)	Arora et al. (2014)
Trans-illuminator	1 (5.9%)	Maa et al. (2020)
Phoropter	1 (5.9%)	Maa et al. (2020)

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Combination of instruments		
6-Instrument Model (fundus camera, tonometer, perimeter, slit lamp, and either two of the instruments (OCT, pachymeter, gonioscope)	3 (17.6%)	Keenan et al. (2015); Sapru et al. (2017); Verma et al. (2014)
5-Instrument Model (Fundus camera, perimeter, OCT, and either two of the instruments (tonometer, slit lamp, topographer, pachymeter)	2 (11.8%)	Arora et al. (2014); Kotecha et al. (2017)
4-Instrument Model (Fundus camera/OCT for fundus imaging, tonometer, and either two of the instruments (slit lamp, perimeter, pachymeter)	4 (23.6%)	Giorgis et al. (2019); Kapoor et al. (2020); Staffieri et al. (2011); Trikha et al. (2012)
3-Instrument Model (Fundus camera, tonometer and either one of the instruments (perimeter, OCT, pachymeter)	3 (17.6%)	Chandrasekaran et al. (2019); Kiage et al. (2013); Maa et al. (2020)
2-Instrument Model (Tonometer and either one of the instruments (fundus camera, OCT)	5 (29.4%)	Ahmed et al. (2013); Hark et al. (2018); Grau et al. (2019); Hark et al. (2019); Shahid et al. (2012)
Personnel		
Ophthalmologist	17 (100%)	Ahmed et al. (2013); Arora et al. (2014); Chandrasekaran et al. (2019); Giorgis et al. (2019); Grau et al. (2019); Hark et al. (2018); Hark et al. (2019); Kapoor et al. (2020); Keenan et al. (2015); Kiage et al. (2013); Kotecha et al. (2017); Maa et al. (2020); Sapru et al. (2017); Shahid et al. (2012); Staffieri et al. (2011); Trikha et al. (2012); Verma et al. (2014)
Ophthalmic technician	11 (64.7%)	Arora et al. (2014); Grau et al. (2019); Hark et al. (2018); Hark et al. (2019); Kapoor et al. (2020); Kiage et al. (2013); Kotecha et al. (2017); Maa et al. (2020); Shahid et al. (2012); Staffieri et al. (2011); Verma et al. (2014)
Optometrist	7 (41.2%)	Giorgis et al. (2019); Kapoor et al. (2020); Keenan et al. (2015); Sapru et al. (2017); Shahid et al. (2012); Trikha et al. (2012); Verma et al. (2014)
Nurses	3 (17.6%)	Ahmed et al. (2013); Giorgis et al. (2019); Staffieri et al. (2011)
Orthoptist	1 (5.9%)	Staffieri et al. (2011)

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Family physician	1 (5.9%)	Verma et al. (2014)
Ophthalmology trainee	1 (5.9%)	Staffieri et al. (2011)
Non-health care personnel (medical students, college students, community health educators)	3 (17.6%)	Hark et al. (2019); Kapoor et al. (2020); Shahid et al. (2012)
Teleglaucoma modality		
Store and forward	16 (94.1%)	Ahmed et al. (2013); Arora et al. (2014); Chandrasekaran et al. (2019); Giorgis et al. (2019); Grau et al. (2019); Hark et al. (2018); Hark et al. (2019); Kapoor et al. (2020); Keenan et al. (2015); Kiage et al. (2013); Kotecha et al. (2017); Maa et al. (2020); Sapru et al. (2017); Staffieri et al. (2011); Trikha et al. (2012); Verma et al. (2014)
Synchronous	1 (5.9%)	Shahid et al. (2012)
Referral pathway		
Traditional pathway (diagnosed patient referred to ophthalmologists)	10 (58.9%)	Giorgis et al. (2019); Grau et al. (2019); Hark et al. (2018); Hark et al. (2019); Kapoor et al. (2020); Keenan et al. (2015); Kotecha et al. (2017); Sapru et al. (2017); Shahid et al. (2012); Staffieri et al. (2011)
Follow up within teleglaucoma programme	3 (17.6%)	Ahmed et al. (2013); Arora et al. (2014); Verma et al. (2014)
No referral pathway (Teleglaucoma patients received the same-day in-person examinations by a glaucoma specialist)	3 (17.6%)	Chandrasekaran et al. (2019); Kiage et al. (2013); Maa et al. (2020)
Follow up by community optometrists	1 (5.9%)	Trikha et al. (2012)

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Table 3.3 showed the referral criteria for the teleglaucoma programmes in the study. Ten studies did not specify referral criteria, as patients were either directly examined by a glaucoma specialist after teleglaucoma programmes, and some studies did not detail the criteria (Ahmed et al. 2013; Arora et al. 2014; Chandrasekaran et al. 2019; Keenan et al. 2015; Kiage et al. 2013; Kotecha et al. 2017; Maa et al. 2020; Sapru et al. 2017; Trikha et al. 2012; Verma et al. 2014).

Elevated IOP was a frequently reported referral criterion. Six studies (Giorgis et al. 2019; Grau et al. 2019; Hark et al. 2018; Hark et al. 2019; Kapoor et al. 2020; Staffieri et al. 2011) specified an IOP greater than 21mmHg as one of the referral criteria.

Another referral criteria were suspicious optic nerve findings, such as abnormalities of optic cup-to-disc ratio (CDR) (e.g., vertical CDR greater than 0.65 or asymmetry greater than 0.2 between both eyes), neuroretina rim thinning, notching, retinal nerve fibre layer (RNFL) defect, disc haemorrhage, and beta zone peripapillary atrophy (Giorgis et al. 2019; Hark et al. 2018; Hark et al. 2019; Kapoor et al. 2020; Staffieri et al. 2011).

Visual field abnormalities were another key criterion for referral. Two studies used visual field defect as one of the referral criteria (Kapoor et al. 2020; Staffieri et al. 2011).

Additional criteria included shallow anterior chamber depth (Kapoor et al. 2020), thin central corneal thickness (Giorgis et al. 2019), family history of glaucoma (Giorgis et al. 2019) and abnormal or unreadable images (Hark et al. 2018; Hark et al. 2019). Two studies specify abnormal OCT scan, such as retinal nerve fibre thinning (Grau et al. 2019), asymmetry between optic discs of both eyes, deterioration of the double-hump pattern on the retinal nerve fibre layer, and superior-inferior asymmetry on the macular ganglion cell analyser as the referral criteria (Kapoor et al. 2020). Shahid et al. (2012) referred to guidelines from the American Optometric and Ophthalmology Associations for the referral criteria.

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Table 3.3 Referral criteria for teleglaucoma programme

Study	Tajuk center
Staffieri et al. (2011)	Large optic cup disc ratio more than 0.7 Rim width at superior or inferior pole < 0.1 cup-disc-ratio Glaucomatous visual field defect IOP more than 21 mmHg
Shahid et al. (2012)	Referral guidelines according to the American Optometric and Ophthalmology Associations (American Optometry Association 2024; Gedde et al. 2021)
Trikha et al. (2012)	Did not specify referral criteria
Ahmed et al. (2013)	Did not specify referral criteria
Kiage et al. (2013)	No referral criteria, as all patients were examined by a glaucoma specialist after teleglaucoma
Arora et al. (2014)	Did not specify referral criteria
Verma et al. (2014)	Did not specify referral criteria
Keenan et al. (2015)	Did not specify referral criteria
Kotecha et al. (2017)	Did not specify referral criteria
Sapru et al. (2017)	Did not specify referral criteria
Hark et al. (2018)	IOP more than 21 mm Hg in at least one eye Vertical cup-disc-ratio (VCDR) more than 0.65 in moderate and large optic discs or more than 0.5 in small discs Asymmetry of VCDR more than 0.2 between eyes Rim width less than 0.2 in any area, notching Optic disc haemorrhage Retinal nerve fibre layer defect Beta zone peripapillary atrophy Abnormal or unreadable images

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Chandrasekaran et al. (2019)	No referral criteria as all patients were examined by a glaucoma specialist after teleglaucoma
Giorgis et al. (2019)	IOP more than 21 mmHg Large vertical cup-disc ratio (VCDR) and asymmetry of VCDR more than 0.2 between eyes Notching or neuroretinal rim thinning Optic disc haemorrhage Retinal nerve fibre thinning Peripapillary atrophy Thin central corneal thickness Family history of glaucoma
Grau et al. (2019)	IOP more than 21 mmHg Retinal nerve fibre thinning
Hark et al. (2019)	IOP more than 21 mm Hg in at least one eye Vertical cup-disc-ratio (VCDR) more than 0.65 in moderate and large optic discs or more than 0.5 in small discs Asymmetry of VCDR more than 0.2 between eyes Rim width less than 0.2 in any area with notching Optic disc haemorrhage Retinal nerve fibre layer defect Beta zone peripapillary atrophy Abnormal or unreadable images
Kapoor et al. (2020)	IOP more than 21 mm Hg VCDR of 0.7 or more Optic disc haemorrhage, notching An abnormal OCT scan, such as asymmetry between the optic discs of both eyes,deterioration of the double-hump pattern on the retinal nerve fibre layer and superior-inferior asymmetry on the macular ganglion cell analyser. Narrow or closed angle at 3 and 9 o'clock Thinning of the nerve fibre layer Abnormal visual field result
Maa et al. (2020)	No referral criteria, as all patients were examined by a glaucoma specialist after teleglaucoma

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Table 3.4 shows the quality assessment results according to MMAT 2018 (Hong et al. 2018). In this review, one study met five criteria reflecting high methodological quality (Hark et al. 2018). Ten studies fulfilled four out of five criteria, suggesting a good quality studies (Ahmed et al. 2013; Arora et al. 2014; Chandrasekaran et al. 2019; Hark et al. 2019; Keenan et al. 2015; Kotecha et al. 2017; Shahid et al. 2012; Staffieri et al. 2011; Trikha et al. 2012; Verma et al. 2014). A total of four studies met three out of five criteria, reflecting moderate methodological quality (Giorgis et al. 2019; Grau et al. 2019; Kapoor et al. 2020; Sapru et al. 2017).

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Table 3.4 Quality assessment of the studies using Mixed Method Appraisal Tool (MMAT) 2018

Studies	Assessment Criteria																						Quality
	Screening Questions		Qualitative					Non-randomized					Quantitative descriptive					Mixed Methods					
	1	2	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	
Staffieri et al. (2011)	Y	Y											Y	Y	Y	N	Y						****
Shahid et al. (2012)	Y	Y											Y	Y	Y	C	Y						****
Trikha et al. (2012)	Y	Y											Y	Y	Y	C	Y						****
Ahmed et al. (2013)	Y	Y											Y	Y	Y	C	Y						****
Arora et al. (2014)	Y	Y						Y	Y	Y	C	Y											****
Verma et al. (2014)	Y	Y											Y	Y	Y	C	Y						****
Keenan et al. (2015)	Y	Y											Y	Y	Y	C	Y						****
Kotecha et al. (2017)	Y	Y											Y	Y	Y	N	Y						****
Sapru et al. (2017)	Y	Y	Y	Y	C	C	Y						Y	Y	Y	C	Y	Y	Y	Y	C	C	***

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Hark et al. (2018)	Y	Y													Y	Y	Y	Y	Y							*****
Chandrasekaran et al. (2019)	Y	Y													Y	C	Y	Y	Y							****
Giorgis et al. (2019)	Y	Y	Y	Y	Y	C	C								Y	Y	Y	C	Y	Y	Y	C	C	Y		***
Grau et al. (2019)	Y	Y													Y	C	Y	C	Y							***
Hark et al. (2019)	Y	Y													Y	Y	Y	C	Y							****
Kapoor et al. (2020)	Y	Y													Y	C	Y	N	Y							***

Note. Y: Yes; N: No; C: Cannot tell

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Table 3.5 shows the quality assessment results according to QUADAS-2 (Whiting et al. 2011). In this review, the risk of bias in flow and timing was high in a study by Kiage et al. (2013). This was due to a high exclusion rate caused by poor image quality, which introduces potential bias. The applicability concerns of the three domains were judged to be low.

Table 3.5 Quality Assessment using QUADAS-2

Study	**Risk of Bias**				**Applicability Concerns**		
	Patient selection	Index Test	Reference standard	Flow and timing	Patient selection	Index Test	Reference standard
Kiage et al. (2013)	L	L	L	H	L	L	L
Maa et al. (2020)	L	L	L	L	L	L	L

L: low; H: high; U: unclear

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3.5.4 Updated Systematic Review Findings

Table 3.6 shows the findings of the systematic review search from 1 January 2021 to 10 May 2025. The data search resulted in eight articles included for qualitative synthesis. Five studies were classified as quantitative descriptive studies (Al-Aswad et al. 2021; Marco et al. 2021; Newman-Casey et al. 2023; Owsley et al. 2024; Polat et al. 2021). Two studies were classified as diagnostic accuracy studies (Anton et al. 2021; Upadhyaya et al. 2025). One study was classified as a randomized clinical trial study (Hark et al. 2024).

Seven studies used store and forward modality (Anton et al. 2021; Hark et al. 2024; Marco et al. 2021; Newman-Casey et al. 2023; Owsley et al. 2024; Polat et al. 2021; Upadhyaya et al. 2025) while one study was a hybrid teleglaucoma programme (Al-Aswad et al. 2021). Six studies focused on the teleglaucoma programme without any comparison to clinical examination (Al-Aswad et al. 2021; Hark et al. 2024; Marco et al. 2021; Newman-Casey et al. 2023; Owsley et al. 2024; Upadhyaya et al. 2025) while a study compared teleglaucoma to in-person clinical examination (Anton et al. 2021). A study compared the diagnosis of teleglaucoma to in-person clinical examination in a pilot study (Polat et al. 2021).

Five studies were conducted in the United States (Al-Aswad et al. 2021; Hark et al. 2024; Newman-Casey et al. 2023; Owsley et al. 2024; Polat et al. 2021). The rest of the studies were conducted in India (n =1, 16.7%) (Upadhyaya et al. 2025), Spain (n =1, 16.7%) (Anton et al. 2021) and Kenya (n =1, 16.7%) (Marco et al. 2021).

Six studies were conducted in community settings such as primary health care clinics, vision centres, community centres and mobile clinics (Al-Aswad et al. 2021; Anton et al. 2021; Hark et al. 2024; Newman-Casey et al. 2023; Owsley et al. 2024; Upadhyaya et al. 2025). Two studies were conducted at a hospital (Marco et al. 2021; Polat et al. 2021).

The included studies primarily targeted high-risk patients, including those of older age (Anton et al. 2021; Hark et al. 2024; Marco et al. 2021; Owsley et al. 2024; Polat et al. 2021), ethnicity (Al-Aswad et al. 2021; Marco et al. 2021; Newman-Casey

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et al. 2023; Owsley et al. 2024), individuals with a family history of glaucoma (Owsley et al. 2024) and diabetes mellitus (Newman-Casey et al. 2023; Owsley et al. 2024). One study recruited the general population undergoing an eye check-up (Upadhyaya et al. 2025).

In all studies, history taking, visual acuity test, tonometry and fundus photography were performed. A study conducted oblique flashlight, extraocular motility and pupil examination (Newman-Casey et al. 2023). Another study also performed pupil examination (Polat et al. 2021).

Types of tonometer used in these studies were the iCare tonometer (3) (Hark et al. 2024; Newman-Casey et al. 2023; Owsley et al. 2024), GAT (2) (Polat et al. 2021; Upadhyaya et al. 2025), non-contact tonometer (2) (Al-Aswad et al. 2021; Anton et al. 2021) and Tonopen (1) (Marco et al. 2021).

The fundus camera was used in six studies (Al-Aswad et al. 2021; Anton et al. 2021; Hark et al. 2024; Marco et al. 2021; Polat et al. 2021; Upadhyaya et al. 2025). Five studies used OCT where two studies used OCT for fundus photography and retinal imaging (Newman-Casey et al. 2023; Owsley et al. 2024) while three studies used OCT for retinal imaging (Al-Aswad et al. 2021; Anton et al. 2021; Polat et al. 2021).

Four studies performed pachymetry (Al-Aswad et al. 2021; Marco et al. 2021; Newman-Casey et al. 2023; Polat et al. 2021). Two studies performed perimetry which HFA and the Melbourne Rapid Test were performed in the study by Owsley et al. (Owsley et al. 2024) while another study used FDT (Al-Aswad et al. 2021). Other instruments used were a pen torch (2) (Newman-Casey et al. 2023; Polat et al. 2021), slit lamp (3) (Marco et al. 2021; Polat et al. 2021; Upadhyaya et al. 2025), autorefractor (3) (Marco et al. 2021; Newman-Casey et al. 2023; Owsley et al. 2024), phoropter (1) (Newman-Casey et al. 2023) and gonioscope (1) (Polat et al. 2021).

Combinations of instruments for glaucoma screening were also observed in the updated systematic review. Three studies employed the most instruments in their studies (Marco et al. 2021; Newman-Casey et al. 2023; Polat et al. 2021). Polat et al. employed

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seven instruments, comprising a vision chart, a pen torch, a tonometer, a slit lamp, a gonioscope, an OCT, and a perimeter (Polat et al. 2021). Two studies used six instruments (Marco et al. 2021; Newman-Casey et al. 2023). Both Marco et al. and Newman-Casey et al. used a vision chart, tonometer, autorefractor, and fundus camera (Marco et al. 2021; Newman-Casey et al. 2023). However, pentorch and OCT were used in Newman-Casey et al. (Newman-Casey et al. 2023), while a slit lamp and pachymeter were used in Marco et al. (Marco et al. 2021). Five instruments, such as vision chart, tonometer, autorefractor, OCT, and perimeter were used in Owsley et al. (Owsley et al. 2024). Two studies utilised four instruments. Both Upadhyaya et al. and Al-Aswad et al. used vision chart, tonometer and fundus camera (Al-Aswad et al. 2021; Upadhyaya et al. 2025). Slit lamp was used in Upadhyaya et al. (Upadhyaya et al. 2025), while Al-Aswad et al. used a perimeter (Al-Aswad et al. 2021). The fewest instruments were used in two studies which consisted of vision chart, tonometer, and fundus camera (Anton et al. 2021; Hark et al. 2024).

In the updated systematic review, ophthalmologists accessed patient data remotely in all the studies. Four studies included optometrists (Al-Aswad et al. 2021; Hark et al. 2024; Marco et al. 2021; Polat et al. 2021), three studies included ophthalmic technicians (Al-Aswad et al. 2021; Newman-Casey et al. 2023; Upadhyaya et al. 2025), one study included nurses (Marco et al. 2021) and two studies included research coordinators (Hark et al. 2024; Owsley et al. 2024) as part of the team. One study included medical students (Al-Aswad et al. 2021) while Hark et al. included community health workers (Hark et al. 2024) as part of the team.

Two studies used web-based systems (Anton et al. 2021; Marco et al. 2021) and another two studies used EMR in their screening programme (Newman-Casey et al. 2023; Polat et al. 2021). Four studies did not specify the system used in their programme (Al-Aswad et al. 2021; Hark et al. 2024; Owsley et al. 2024; Upadhyaya et al. 2025).

Six teleglaucoma programmes discharged patients without glaucoma and referred those with confirmed or suspected glaucoma for in-person examination (Al-Aswad et al. 2021; Marco et al. 2021; Newman-Casey et al. 2023; Owsley et al. 2024; Polat et al. 2021; Upadhyaya et al. 2025). Only one study invited participants for further

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eye examination by a glaucoma specialist (Anton et al. 2021). Another study also scheduled participants who failed glaucoma screening for eye examination by an optometrist at the same location within three weeks (Hark et al. 2024). The optometrist would then refer patients with confirmed or suspected glaucoma to an ophthalmologist (Hark et al. 2024).

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Table 3.6 Characteristics of studies included in the updated systematic reviews

Study & Country	Modality	Study design	Sample	Location	Examinations	Instruments	Personnel	System	Referral
Al-Aswad et al. (2021) United States of America	Hybrid	Quantitative descriptive study	957 high-risk participants aged 18 years and above	Mobile unit at high-risk of glaucoma neighbourhood	History taking, visual acuity (VA) test, tonometry, pachymetry, non-mydriatic fundus photograph, optical coherence tomography (OCT) and perimetry	Snellen chart, Reichert 7CR non-contact tonometer, Topcon 3D OCT-1 Maestro, frequency doubling technology	Technicians, medical college students, an ophthalmologist, and an optometrist	Never specify the system used for asynchronous data transfer. Skype for Business is a video-conferencing system.	Patients who were diagnosed with glaucoma or suspected of having glaucoma were referred to ophthalmologists. Normal patients were discharged
Anton et al. (2021) Spain	Store and forward	Diagnostic accuracy study	4113 participants aged 55–85 years old	Primary care centre	History taking, VA test, tonometry, fundus photography, and OCT	Snellen chart, Topcon CT80 non-contact tonometer, Topcon TRC non-mydriatic fundus camera, and iVue SD-OCT	16 ophthalmologists	Dyseo platform (Technical University of Madrid, Madrid, Spain)	No referral as all teleglaucoma patients were examined by a glaucoma specialist teleglaucoma.

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Marco et al. (2021) Kenya	Store and forward	Quantitative descriptive study	1187 high-risk patients	Nyamira District Hospital Kenya	History taking, visual acuity test, slit lamp examination, tonometry, pachymetry, auto refraction, and stereo fundus photograph	Vision chart, slit lamp, auto refractor, Tonopen Avia, Pachmate 2 pachymeter, stereo Canon fundus camera	Optometrists, ophthalmic nurses, and a glaucoma specialist	Secure Diagnostic Imaging (SDI) (Secure Diagnostic Imaging Inc.Edmonton Alberta, Canada) syste,	Patients who were diagnosed with glaucoma or glaucoma suspect were referred to ophthalmologists. Normal patients were discharged
Polat et al. (2021) United States of America	Store and forward	Quantitative descriptive study	118 veteran patients (secondary study) and 20 veteran patients for the pilot study	The VA Butler Medical Center (secondary study) Pittsburgh VA Medical Center (pilot study and reading centre)	History taking, visual acuity test, pupil reflex, slit lamp examination, fundus photograph, gonioscopy, pachymetry, applanation tonometry, retinal imaging and perimetry	Vision chart, pen torch, slit lamp, Goldmann applanation tonometer, gonioscope lens, fundus camera, Humphrey Field Analyser (HFA), optical coherence tomography (OCT)	Optometrist and a glaucoma specialist	VA Computerized Patient Record System software (Veterans Health Administration, USA) and VistA (Veterans Health Administration, USA) software to store all images	Patients who were diagnosed with glaucoma or suspected of having glaucoma were referred to ophthalmologists. Normal patients were discharged.

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Newman-Casey et al. (2023) United States of America	Store and forward	Quantitative descriptive study	1171 high-risk residents aged 18 years and above	Two primary health clinics	History taking, visual function questionnaire, visual acuity test, refraction, pupil reflex, oblique flashlight test, extraocular motility test, tonometry, pachymetry, mydriatic fundus photograph , and retinal imaging	Snellen chart, near chart, ARK-autorefractor-keratometer, phoropter, pen torch, iCare tonometer, fundus camera, Topcon OCT	Ophthalmic technicians and ophthalmologists	University of Michigan Electronic Health Record (EPIC, Verona, Wisconsin, USA)	Patients who were diagnosed with glaucoma or suspected of having glaucoma were referred to ophthalmologists. Normal patients were discharged.
Hark et al. (2024)	Store and forward	Randomized controlled trial	708 high risk residents aged 40 years and above	Community room or senior centre at New York City Housing Authority	History taking, visual function Questionnaire , visual acuity test, tonometry, fundus photography.	Snellen chart, Ic100 iCare tonometer, hand held non-mydriatic fundus camera.	Community health workers, research staff, optometrist, retinal specialist, glaucoma specialist	Never specify	Participants who failed the screening received a non-dilated exam by an optometrist, while those who were diagnosed with glaucoma or suspected glaucoma were referred to an ophthalmologist

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Owsley et al. (2024) United States of America	Store and forward	Quantitative descriptive study	500 high-risk patients	Three primary health centres	History taking, visual acuity, autorefraction, tonometry, perimetry, fundus photography, and OCT imaging	Snellen chart, iCare tonometer, autorefractor, Topcon Maestro2 OCT, D-Eye, Humphrey Field Analyser, Melbourne Rapid Fields application	Research coordinators and an ophthalmologist	Never specify	Patients who need further assessment were referred to an optometrist who was partnered with the primary health clinic or ophthalmologists. Normal patients were discharged.
Upadhyaya et al. (2025) India	Store and forward	Diagnostic accuracy study	303 participants aged more than 18 years old	Six vision centres	History taking, best corrected visual acuity test, slit lamp examination, Goldmann applanation tonometry, and fundus photography	Snellen chart, FOP NM-10 non-mydriatic fundus camera with Medios Glaucoma AI software, slit lamp, Goldmann applanation tonometer	An ophthalmic assistant, glaucoma specialists	Cloud platform	Patients who were diagnosed with glaucoma or suspected of having glaucoma were referred to ophthalmologists. Normal patients were discharged.

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Table 3.7 shows the referral criteria for the recent teleglaucoma programmes. All studies involved referral criteria based on abnormal optic nerve findings such as excavation of the optic cup, a large CDR of 0.6 or higher, asymmetry greater than 0.2 between both eyes, neuroretina rim thinning, notching, RNFL defect, disc haemorrhage, peripapillary atrophy, and other signs of glaucomatous optic nerve. Six studies included high IOP of more than 21 mmHg (Al-Aswad et al. 2021; Anton et al. 2021; Marco et al. 2021; Newman-Casey et al. 2023; Owsley et al. 2024; Polat et al. 2021). Only one study included a much higher IOP of 30mmHg and higher as one of the referral criteria (Hark et al. 2024).

Abnormalities in the ocular investigations, such as visual field defect (2) (Al-Aswad et al. 2021; Owsley et al. 2024), RNFL thickness defect on OCT (4) (Al-Aswad et al. 2021; Anton et al. 2021; Newman-Casey et al. 2023; Owsley et al. 2024), narrow anterior chamber angle (2) (Al-Aswad et al. 2021; Newman-Casey et al. 2023), thin cornea thickness and family history of glaucoma (1) (Marco et al. 2021) were criteria for referral. Additionally, a study by Newman-Casey et al. (Newman-Casey et al. 2023) included a patient who was previously treated for glaucoma as one of the criteria (Newman-Casey et al. 2023).

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Table 3.7 Referral criteria for studies included in updated systematic research

Study	Referral criteria
Al-Aswad et al. (2021)	Intraocular pressure (IOP) more than 21 mm Hg, with consideration of corneal thickness Glaucomatous appearance of the optic disc Abnormal ocular tomography coherence (OCT) results: Deterioration of double hump appearance, asymmetry between the two eyes in the retinal nerve fibre layer (RNFL), and generalized thinning in the RNFL A narrow angle on anterior segment OCT if they were ≤20 degrees Abnormal Frequency Doubling Technology (FDT) result
Anton et al. (2021)	Large vertical cup-disc-ratio (VCDR) Asymmetry of the cup-disc ratio (CDR) more than 0.3 between the two eyes IOP more than 21 mmHg Neuroretina rim thinning Retinal nerve fibre defect Peripapillary atrophy Optic disc haemorrhage Abnormal OCT result: Presence of one of the following: RNFL defect in thickness map, or global RNFL classification outside 99% normal limits, or at least one 90° RNFL sector outside 99% normal limits, or at least two 90° sectors were outside 95% normal limits
Marco et al. (2021)	Large VCDR Asymmetry of the CDR more than 0.2 between the two eyes Neuroretina rim thinning or notching, Optic disc haemorrhage Retinal nerve fibre defect Peripapillary atrophy IOP more than 21mmHg Thin central corneal thickness Family history of glaucoma
Polat et al. (2021)	Did not specify

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Newman-Casey et al. (2023)	A patient who has undergone glaucoma treatment Narrow angle on pupil reflex exam CDR 0.7 and more Asymmetry of CDR of 0.2 or more between the two eyes, where the larger cup is 0.6 or more Abnormal OCT result (overall RNFL thickness less than 80 microns or thinning at less than 1% certainty in the inferior or superior quadrants) IOP more than 21 mmHg
Hark et al. (2024)	Large CDR Asymmetry of CDR between two eyes Optic disc haemorrhage Peripapillary atrophy Notching Retinal nerve fibre defect IOP 30 mmHg and above
Owsley et al. (2024)	Excavation of the optic cup Asymmetry of CDR more than 0.2 between the two eyes, where the larger cup is ≥0.6 Neuroretina rim thinning or notching RNFL defect Optic disc haemorrhage Abnormal result of Humphrey Field Analyser (HFA): Pattern standard deviation outside the 95% normal limits or a glaucoma hemifield test outside of the 99% normal limits IOP more than 21 mmHg Abnormal OCT result (overall RNFL thickness less than 80 microns or thinning at less than 1% certainty in the inferior or superior quadrants)
Upadhyaya et al. (2025)	VCDR 0.7 or more, asymmetry of VCDR 0.2 and more between the two eyes Vertical elongation (a neuro-retinal rim width reduced to ≤0.1 CDR between 11–10 or 5–7 o'clock) Lamellar dot sign, Peripapillary atrophy, Neuroretina rim thinning, notching Inferior, Superior, Nasal, Temporal (ISNT) rule not obeyed Baring of the circumlinear vessel, optic disc haemorrhage

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Table 3.8 shows the quality assessment results according to MMAT version 2018 (Hong et al. 2018). In this review, three studies fulfilled four out of five criteria, which is a good quality study (Hark et al. 2024; Newman-Casey et al. 2023; Owsley et al. 2024). Another three studies met three out of five criteria, which were considered as a moderate quality (Al-Aswad et al. 2021; Marco et al. 2021; Polat et al. 2021).

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Table 3.8 Quality assessments of the studies included in updated systematic review using MMAT version 2018

Studies	Assessment Criteria													
	Screening Questions		Quantitative Randomized Random trials					Quantitative descriptive					Quality
	1	2	1	2	3	4	5	1	2	3	4	5	
Al-Aswad et al. (2021)	Y	Y						Y	C	Y	C	Y	***
Marco et al. (2021)	Y	Y						Y	C	Y	C	Y	***
Polat et al. (2021)	Y	Y						C	Y	Y	C	Y	***
Newman-Casey et al. (2023)	Y	Y						Y	Y	Y	C	Y	****
Hark et al. (2024)	Y	Y	Y	Y	C	Y	Y						****
Owsley et al. (2024)	Y	Y						Y	Y	Y	C	Y	****

Note. Y: Yes ; N: No; C: Cannot tell

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Table 3.9 shows the results of the quality assessment of the studies included in updated systematic review using QUADAS-2 (Whiting et al. 2011). The risk of bias in flow and timing was high in both studies. This was due to limited information about the time interval, and not all patients received the reference-standard examination. In a study by Anton et al. (2021), the risk of bias for the reference standard (in-person examination) is judged as unclear, as it was not stated whether blinding to the index test (teleglaucoma) was provided to the glaucoma specialist. The applicability concerns of the three domains were judged to be low.

Table 3.9 Quality assessment of the studies included in the updated systematic reviews using QUADAS-2

Study	Risk of Bias				Applicability Concerns		
	Patient selection	Index test	Reference standard	Flow and timing	Patient selection	Index test	Reference standard
Anton et al. (2021)	L	L	U	H	L	L	L
Upadhyaya et al. (2025)	L	L	L	H	L	L	L

L: low; H: high; U: unclear

3.5.5 Discussion

The systematic review findings showed that most studies used store-and-forward for teleglaucoma screening. This finding is aligned with a previous systematic review, which reported that most of the teleophthalmology programmes used store-and-forward (Chong et al. 2021). Store-and-forward modality removes the need for patients, primary eyecare providers, and specialists to be simultaneously available on site, as glaucoma specialists can remotely review the cases at their convenience (Culmer et al. 2023; Sharma et al. 2020). However, the time difference between teleglaucoma examination and remote diagnosis by a glaucoma specialist could delay the diagnosis (Chong et al. 2021). Shahid et al. (2012) used synchronous modality, which allows direct communication with patients and provides real-time diagnosis and management similar to an in-person consultation (Chong et al. 2021; Ertel et al. 2021). However,

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synchronous modality requires both patients and specialists to be available simultaneously. It also requires more proper video conferencing tools and stable internet connections (Chong et al. 2021). Al-Aswad et al. (2021) utilized a hybrid modality, which combined both store-and-forward and synchronous elements (Alenoghena et al. 2023; Ertel et al. 2021). This modality allows patients' data to be reviewed earlier by the specialists at their convenience, and allows patient-doctor consultation during decision making and management for patients (Culmer et al. 2023; Sharma et al. 2020). This direct interaction will reduce the risk of incorrect diagnosis that might arise from a lack of direct interaction in the store-and-forward modality (Alenoghena et al. 2023).

The target population for teleglaucoma in these studies comprised four groups: high-risk glaucoma individuals, glaucoma suspects, glaucoma patients, and the population with low socioeconomic status. Our findings aligned with a previous systematic review, which reported the same findings (Thomas et al. 2014). High-risk glaucoma individuals have a greater chance of developing glaucoma, where Frediani et al. found the rate of glaucoma was higher (13.7%) in individuals aged 32 years and above compared to 3.2% in individuals aged below 32 years (Frediani et al. 2025). Previous studies reported that a community eye screening programme conducted among high-risk glaucoma individuals showed a high percentage of glaucoma or glaucoma suspects ranging from 26% to 27.8% (Grimes et al. 2025; Wang et al. 2025). Screening high-risk populations is more cost-effective than screening the general population (Gedde et al. 2021; Nassiri & Wilson 2025) as screening the entire general population would potentially strain the healthcare systems. Guidelines for screening for glaucoma, such as the Sub-Saharan African Guidelines (Kyari et al. 2021) and the Pan-American Association of Ophthalmology (PAAO) (Román 2019), recommend screening in high-risk groups (Gunzenhauser & Coleman 2024). The United Preventive States Services Task Force (USPSTF), the European Glaucoma Society, and the United Kingdom National Screening Committee advised against population screening due to a lack of scientific evidence to support the benefits of glaucoma screening (Gunzenhauser & Coleman 2024; Mangione et al. 2022; Spaeth 2021; United Kingdom National Screening Committee 2019).

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Glaucoma suspects were also included because of their potential to progress to glaucoma. A study observed that 13.6% of 330 glaucoma suspects with African nationality developed the disease over 6.7 years (Zhao et al. 2025). Glaucoma patients were also recruited in some studies to evaluate the effectiveness of teleglaucoma programmes or to compare the diagnostic accuracy of teleglaucoma programme with in-person examination. A study by Shahid et al. (2012) included homeless participants in their teleglaucoma programme. This is aligned with the World Health Organization policy, which identified underprivileged populations as a high-risk group needing eye examination (Gunzenhauser & Coleman 2024; World Health Organization 2019).

Most studies were conducted in community settings such as primary health care clinics, optometry practices, community centres and mobile clinics. According to Girkin and Owsley (2024), community settings such as retail optometry practices or primary care clinics were suitable for teleglaucoma screening, as high-risk glaucoma individuals are usually seen at these places. The suitability of primary care clinics for teleglaucoma was further supported by a tele retinal programme in Los Angeles that reported 62.9% and 24.5% of 534 diabetic individuals were found to have glaucoma suspects and glaucoma, respectively (Yuen et al. 2023). Similarly, the University of Alabama at Birmingham telemedicine programme, which operated within optometry practices, also reported high positive screening rates for glaucoma, where 19% of 651 participants were identified with glaucoma and 23% as glaucoma suspects (Sapru et al. 2017). However, some studies identified hospitals as the location for the teleglaucoma programme because hospitals are accessible to high-risk individuals such as patients with diabetes mellitus, hypertension, and eye disease. For example, in a hospital-based study, Miraj et al. (2023) observed that 32.25% of 62 diabetic patients from an ophthalmology clinic had glaucoma.

Patient history taking was one of the tests included in most teleglaucoma programmes in the systematic review. It is an important procedure to diagnose and manage patients (Ledford 2024). Patient history, such as family history, age, race, and medical conditions, helps identify high-risk individuals (Saifi et al. 2023). It is shown in previous studies that risk factors of glaucoma, such as diabetes mellitus, family history, and age, increase the incidence of glaucoma among these individuals (Ahmad

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et al. 2020; Ghani & Kumait 2025; Priyadharshini & Bhuvaneswari 2024). Guidelines for teleglaucoma by Gan et al. (2020) also recommended patient history taking as one of the important components in establishing the teleglaucoma programme.

The visual acuity (VA) test was also measured in most studies. It is a simple and accessible tool for screening of ocular diseases (Masthi et al. 2025). Even though primary open-angle glaucoma (POAG) is asymptomatic in early stages, VA testing is still important in glaucoma assessment, as it helps to evaluate the central vision (Fazeenah 2021). A reduced VA in glaucoma patients was associated with impaired blood flow and optic nerve damage, causing glaucoma progression (Kim et al. 2023).

Most studies used a tonometer to measure IOP for the diagnosis of glaucoma. However, a U.S. Preventive Services Task Force Evidence Syntheses group reported that tonometry had a lower sensitivity of 0.48 (95% CI [0.31, 0.66]) and high specificity of 0.94 (95% CI [0.90, 0.96]) compared to OCT which showed sensitivity of 0.79 (95% CI [0.75,0.83]) and specificity of 0.92 (95% CI [0.87, 0.96]) and HFA showed sensitivity of 0.87 (95% CI [0.69, 0.95]) and specificity 0.82 (95% CI [0.66, 0.92]) (Chou et al. 2022). This showed that tonometry is insufficient to detect glaucoma on its own and should be used in conjunction with other diagnostic tests.

Most studies in this systematic review used a non-mydriatic fundus camera for imaging. This finding was similar to a previous systematic review, which reported that the fundus camera was the most frequently used equipment in teleglaucoma programmes (Thomas et al. 2014). Assessment of the optic nerve head is important in diagnosing and monitoring glaucoma (Kaushik et al. 2023). A fundus camera can capture a detailed image of the optic nerve head (Chalam et al. 2022) and allows measurements of the optic cup depth and cup-to-disc ratio (Camara et al. 2022). It is portable, non-invasive (Upadhyaya et al. 2022) and images can be securely transmitted for interpretation by ophthalmologists (Lin et al. 2020). Furthermore, a study has shown that non-mydriatic fundus cameras have a high sensitivity of 96.3% and 94.8% and specificity of 98.5% and 97.8% for two independent graders in detecting glaucoma (Upadhyaya et al. 2022).

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Previous research reported that stereoscopic images offer better accuracy for glaucoma diagnosis compared to two-dimensional images among general ophthalmologists (Yang et al. 2022) and expert readers (Shrestha et al. 2021). However, the accuracy of the interpretation of fundus images was still based on the graders' subjective judgment (Myers et al. 2018). Chan et al. (2014) reported there was no significant difference in the level of agreement among experienced glaucoma specialists when interpreting two-dimensional compared to three-dimensional fundus images in the diagnosis of glaucoma, indicating that grader expertise is crucial (Chan et al. 2014).

Eleven teleglaucoma programmes included a visual field test in their protocols. The visual field test measures visual function in glaucoma (Odden et al. 2020). However, it was not commonly used in many studies because visual field tests require specialised and expensive equipment (Chen et al. 2025; De Francesco et al. 2024; Richardson et al. 2023; Yamada et al. 2020). The equipment is bulky and not portable (Chen et al. 2025; Richardson et al. 2023) as well as requiring a skilled operator (Chen et al. 2025; De Francesco et al. 2024; Yamada et al. 2020), a dark and quiet environment, and patient cooperation to produce accurate results (De Francesco et al. 2024). Recent developments, such as tablet-based (Melbourne Rapid Field (MRF) (Glance Optical Ltd, Melbourne, Australia)) and virtual reality perimetry (RadiusXR VR perimeter (RadiusXR, Pleasanton, CA) and the Olleyes VisALL-K pediatric perimeter (Olleyes, Summit, New Jersey), may allow testing in patients' homes (De Francesco et al. 2024). MRF application demonstrated a shorter test duration and a high diagnostic accuracy (Area Under the Curve (AUC) was 0.92 and 0.93 for Mean Deviation (MD) and Pattern Standard Deviation (PSD), respectively) (Chen et al. 2025), which had been used in Owsley's (Owsley et al. 2024) teleglaucoma programme.

Pachymeter was used in some studies to measure the thickness of the cornea. One recent review emphasizes the use of corneal pachymetry in adults over 50 years to improve glaucoma detection (Agbato et al. 2025). Corneal thickness affects the accuracy of IOP readings (Agbato et al. 2025). A thin cornea can cause a falsely low IOP, while a thick cornea causes a falsely high IOP (Kanski & Bowling 2011). The most used pachymetry instruments were ultrasonic and OCT-based pachymeters.

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However, this measurement in teleglaucoma is not a standard practice because it requires specialized instruments and trained personnel (Rashid et al. 2025).

Slit lamp was used for anterior chamber angle examination, measuring IOP with the Goldmann applanation tonometer, and anterior segment examination. Anterior chamber angle assessment can be conducted using a pen torch (Newman-Casey et al. 2023), gonioscope lens (Keenan et al. 2015; Polat et al. 2021; Sapru et al. 2017), OCT (Al-Aswad et al. 2021; Chandrasekaran et al. 2019; Kotecha et al. 2017), topography (Arora et al. 2014) or Finhoff transilluminator (Maa et al. 2020). This test is important to identify closed-angle glaucoma (Porporato et al. 2020). Pen torch is a simple, accessible screening tool used to assess the pupillary reflex (Majumder 2025; Zeno & Teall 2024) and anterior chamber depth (Raman et al. 2021). However, its diagnostic accuracy of assessment of anterior chamber depth is limited compared to other instruments, as shown in a systematic review, which reported that the oblique flashlight test using a pen torch showed a lower sensitivity of 0.51 (95% CI [0.25, 0.76]) compared to slit lamp using Van Herick technique, which showed a sensitivity of 0.83 (95% CI [0.74, 0.90]) (Jindal et al. 2020).

Usage of the gonioscope in teleglaucoma is limited because it is time-consuming and needs a skilled examiner to capture high-quality images of the anterior chamber angle (Barbour-Hastie et al. 2023). New technology, such as OCT and topography, is more suitable for teleglaucoma as they are fast (Syta et al. 2025; Zeppieri et al. 2023) and non-invasive (Laroche & Nwokeji 2024; Riva et al. 2020).

An autorefractor and a phoropter were used to provide a measurement of the patient's refractive error, which provides risk factors for glaucoma, such as myopia (Syta et al. 2025) and hyperopia (Muthusamy et al. 2023). These instruments can be a complementary tool in a teleglaucoma workflow (Gan et al. 2020). An autorefractor can be used for telemedicine, as technicians can easily perform it (Kumar et al. 2021; Noya-Padin et al. 2025). However, a phoropter requires a skilled eye care practitioner and patient cooperation (Lyakhov 2025).

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Diagnosis of glaucoma requires a combination of tests such as tonometry, visual field test, and optic nerve head assessment (Mangione et al. 2022). This is especially critical in teleglaucoma, where the ophthalmologists cannot physically examine the patient but receive the clinical data virtually. A study reported that combining OCT and fundus photographs achieved a higher glaucoma detection rate (9.2%) (Anton et al. 2021) compared to 3.9% (Ohkubo et al. 2007) and 4.6% (De Mul et al. 2004) glaucoma detection rate in a single device measuring retinal nerve fibre layer thickness, such as Heidelberg retinal tomography (HRT) or GDx scanning laser polarimeter. On further analysis, the combined OCT and fundus photographs showed that 32% of the participants had abnormal findings on OCT, but not in the fundus photographs (Anton et al. 2021). Therefore, a single test can miss a significant number of cases.

Most of the studies used web-based systems incorporated with EMR designed to record, store, organize, and retrieve patients' medical information, such as clinical findings, imaging, diagnosis, and management across multiple healthcare settings (Galgate et al. 2024; Pai et al. 2021). Although EMR is expensive, the expenses incurred with the system decrease over time (Balugaba et al. 2019). EMR has data security features such as encrypted data, passwords, and other tools to protect patient information (Galgate et al. 2024). It also allows tracking patient appointments and follow-ups, which can help re-engage lost-to-follow-up patients up to 40% (Robbins et al. 2021).

Some studies collect clinical data and images manually and transmit them using email, or store the data in a storage medium for assessment at a later time (Ahmed et al. 2013; Keenan et al. 2015). This is useful for situations where internet connectivity is limited, especially in a remote area. Furthermore, using storage media such as CD-ROM or a pen drive allows doctors to review the images offline on their computer (Wright et al. 2014). This is a low-cost alternative for programmes conducted in low-income countries. Data privacy is potentially safer using physical storage media compared to online platforms, which are liable for a malware attack, as demonstrated by a teleglaucoma monitoring programme in Colombia (Lozano et al. 2024).

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In this systematic review, personnel involved in the teleglaucoma screening programme consisted of eye care professionals such as optometrists, nurses, technicians, orthoptists, ophthalmology trainees, and ophthalmologists. Clinical examinations and imaging were performed by primary eye care providers on site and reviewed by ophthalmologists remotely. However, in some programmes, non-healthcare providers performed the clinical examinations and imaging (Al-Aswad et al. 2021; Hark et al. 2024; Hark et al. 2019; Kapoor et al. 2020; Shahid et al. 2012) . The success of the teleglaucoma programme depends on the skill of the personnel (Ertel et al. 2021; Gan et al. 2020). If there is a lack of adequate training in fundus imaging, this will result in poor quality images, which then cause the patients to undergo repeat screenings (Ertel et al. 2021).

The referral pathway in the teleglaucoma programme mostly followed the conventional pathway, as normal patients were discharged, while patients diagnosed as glaucoma or glaucoma suspects were referred to an ophthalmologist for diagnosis and management. Teleglaucoma programme may reduce the number of unnecessary in-person referrals to ophthalmologists (Brandão-De-Resende et al. 2023) as normal patients were discharged which allowed more time for glaucoma specialists to manage severe glaucoma cases (Brandão-De-Resende et al. 2023). Some studies have followed up with accredited community optometrists or the same teleglaucoma programme to monitor high-risk patients. Follow-up appointments for patients can be provided sooner through telemedicine, which helps to address the long waiting lists often found at ophthalmology clinics. The effectiveness of this approach in facilitating follow-up care is supported by a teleglaucoma programme in Colombia, where nearly a third of patients returned for subsequent teleglaucoma visits after their initial visit (Lozano et al. 2024).

Most studies based their referral criteria on the investigations they used. Funduscopy was used in all studies where changes of the optic nerve head could be documented. A large cup-disc-ratio (CDR) (Philippin et al. 2024; Podnar et al. 2023) and an asymmetry of CDR of 0.2 or more between two eyes (European Glaucoma Prevention Study 2007) has a high diagnostic significance for glaucoma in clinical assessments. Moreover, retinal nerve fibre defect (Pazos et al. 2025) and neuroretina rim evaluation, which included thinning and notching (Pazos et al. 2025;

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Podnar et al. 2023) were significant criteria for glaucoma detection as these signs appear in glaucoma. The Inferior Superior Nasal Temporal width pattern (ISNT) rule has been used as a glaucoma referral criterion (Ulain et al. 2025). Maupin et al. (2020) reported that the sensitivity of the ISNT rule in diagnosing glaucoma was high, which was 94.1% (95% CI [90.2, 98.1]), and specificity was 49.2% (95% CI [46.9, 51.6]). Other glaucomatous optic nerve head signs, including laminar dot sign, optic disc haemorrhage, baring of circumlinear vessel and peripapillary atrophy (PPA), were also used as referral criteria. Optic disc haemorrhages (Ariturk et al. 2024), laminar dot sign (Bak et al. 2021) and peripapillary atrophy (PPA) were linked to the risk of glaucoma progression (Ha et al. 2021). Beta zone of PPA was associated with visual field progression (Ha et al. 2021). A study reported that baring of circumlinear vessels, large cup-disc-ratio, notching, and retinal nerve fibre layer defect were the important signs for glaucoma referral in fundus images (Phene et al. 2019).

Patients with a family history of glaucoma were referred to ophthalmologists in some studies because they are at a higher risk of developing glaucoma with an odds ratio of 2.49 (95% CI [1.92, 3.24]) (Shan et al. 2024). A narrow angle is also used as one of the referral criteria, as patients with narrow angles may be at risk of developing angle closure glaucoma, observed in a study which discovered shallow anterior chamber depth and narrow angle were significantly associated with the development of angle closure glaucoma ($p = 0.003$ and $p < 0.001$), respectively (Zhang et al. 2022). The Royal College of Ophthalmologists' UK Clinical Guidelines recommend that patients with narrow angles be referred to ophthalmologists if they have elevated IOP, early signs of glaucoma, or risk factors of glaucoma (The Royal College of Ophthalmologists 2022) Other referral criteria included patients with a history of glaucoma treatment (Newman-Casey et al. 2023) and those with abnormal or unreadable fundus images (Hark et al. 2018; Hark et al. 2019). Patients who have already been diagnosed and treated for glaucoma require much more comprehensive in-person examinations for effective monitoring of disease progression compared to teleglaucoma. This was supported by a systematic review, which reported that in-person examination cannot be replaced by telemonitoring (Jesus et al. 2025). Patients with abnormal or unreadable fundus images should be referred for a comprehensive in-person examination, as they may have an ocular disease. In two teleophthalmology programmes, 37.1% of 35 participants with

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abnormal fundus images were diagnosed with an ocular pathology (Hark et al. 2021), while 65.2% of 906 participants with unreadable fundus images were also found to have at least one ocular disease (Hark et al. 2018).

Many teleglaucoma studies include elevated IOP more than 21mmHg as one of the referral criteria. IOP is a modifiable risk factor for glaucoma development and progression (Dada et al. 2022). Elevated IOP alone may have limited specificity, as many referred individuals do not develop glaucoma or require treatment, as reported by a study that over one-third of patients referred for high IOP alone had no glaucoma (Nilsson & Peters 2021). Therefore, this referral criterion must be combined with other test results.

A visual field defect and abnormal OCT results are good referral criteria for glaucoma. A study comparing telemedicine and in-person glaucoma diagnoses using visual field, OCT, and fundus photography showed moderate agreement between telemedicine and in-person examination (kappa value of 0.49 and 0.44 for the two telemedicine reviewers, respectively) (Balakrishnan et al. 2024). This suggests that telemedicine can provide a reliable diagnosis comparable to an in-person examination using these tests.

Some studies employed referral criteria based on clinical practice guidelines for glaucoma from their countries (American Optometry Association 2024; Gedde et al. 2021). Different countries have established clinical practice guidelines for glaucoma, such as the National Institute for Health and Care Excellence (NICE) guidelines in the United Kingdom, the Scottish Intercollegiate Guidelines Network (SIGN) guidelines in Scotland, and American Academy of Ophthalmology and American Optometric Association (American Optometry Association 2024; Gedde et al. 2021; National Institute for Health and Care Excellence 2017; Scottish Intercollegiate Guidelines Network (Sign) 2015). These guidelines focused on identifying glaucomatous optic neuropathy signs such as large cup-to-disc ratios, visual field defects, elevated IOP, and other risk factors. However, the NICE and SIGN guidelines set higher intraocular pressure (IOP) referral thresholds, which were 24 mmHg and more than 25 mmHg, respectively, than the 21 mmHg criterion employed by most of the teleglaucoma

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programmes (National Institute for Health and Care Excellence 2017; Scottish Intercollegiate Guidelines Network (Sign) 2015). Without standardised referral guidelines, there is a risk of over-referring patients, which wastes valuable specialist resources (Frediani et al. 2025). In Scotland, the implementation of SIGN guidelines led to a decrease in false positive rates from 29.2% to 19.2%, which was statistically significant ($p = 0.004$), with an odds ratio of 0.58 (95% CI [0.40, 0.84]) (Sii et al. 2019).

This systematic review had some limitations, as articles in languages other than English could not be reviewed. Furthermore, some studies do not specify some components such as referral criteria and system used in their programmes.

3.5.6 Conclusion

Based on this systematic review, a successful teleglaucoma programme requires careful consideration of several key components: the location (community or hospital-based), target population (high risk, glaucoma or glaucoma suspect), examinations (history taking, visual acuity, fundus photography, tonometry, with some studies included perimetry, retinal imaging and other tests), technology used for data transmission and storage (web-based system, email, storage media), and skilled personnel who will carry out the screenings and remote reviews. The study also highlighted two referral pathway, conventional and alternative pathways, which incorporate follow-ups with community optometrists or teleglaucoma. These findings provide a crucial framework for developing and implementing effective teleglaucoma screening programmes in Malaysia. Future research should focus on gathering insights from eye care professionals and creating standardized training protocols to ensure the programme success.

3.6 SECTION II: QUALITATIVE SEMI-STRUCTURED INTERVIEW

3.6.1 Introduction

Based on our systematic review, there is a notable gap, which is the absence of standardized teleglaucoma screening protocols because there is no teleglaucoma programme in Malaysia. This lack of standardized protocols suggests that existing

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models may not be easily adopted across different healthcare settings. Malaysia's healthcare system is dual-tiered healthcare system comprising public and private sectors (Adnan et al. 2021; Chow et al. 2021). Public hospitals are heavily subsidized and serve most of the population (Abd Rahim et al. 2020). In contrast, private hospitals provide specific treatment covered by insurance or patients themselves (Abd Rahim et al. 2020). Eye care services were limited in rural areas, especially in East Malaysia (Chew et al. 2018; Ting et al. 2022). Therefore, the direct adoption of current teleglaucoma models may not be suitable due to the characteristics of the Malaysian healthcare setting. This highlights the need for a tailored teleglaucoma programme in Malaysia. Although literature and document reviews identify the components and referral criteria for teleglaucoma, semi-structured interviews were chosen to explore and identify the components of teleglaucoma suitable for Malaysian healthcare.

3.6.2 Objective

This qualitative approach aims to identify components of teleglaucoma screening programme and referral pathway.

3.6.3 Methodology

a. Sampling method

Purposive sampling was used for semi-structured interviews.

b. Study participants

Participants were not required to have prior experience in conducting a teleglaucoma programme, as there is no teleglaucoma programme implemented in the local healthcare setting. Although participants may not have had direct experience with teleglaucoma, their clinical and professional expertise enabled them to provide valuable insights regarding current glaucoma screening and referral pathways. Their perspectives were particularly important for identifying components of the teleglaucoma programme that are feasible, acceptable, and relevant within the local healthcare context. The participants were 1) ophthalmologists who are working in teaching hospitals and Ministry of Health hospitals, 2) optometrists who are working at private optometry

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centres and 3) nurses, ophthalmic technicians, and assistant medical officer who are working at Sentul Health Clinic and Ophthalmology Clinic, Hospital Canselor Tuanku Muhriz (HCTM) Universiti Kebangsaan Malaysia (UKM).

c. Study locations

Semi-structured interviews for ophthalmologists and optometrists were conducted online via Zoom video conferencing (Zoom Video Communications, Inc. San Jose, California, United States) or Skype (Skype Technologies Microsoft, Luxembourg City, Luxembourg). These interviews were conducted online due to the quarantine during the COVID-19 pandemic. However, the semi-structured interviews for nurses, ophthalmic technicians, and assistant medical officer were conducted in a quiet room at their working place as they preferred face-to-face interviews.

d. Sample size calculation

We recruited participants until data saturation was achieved (Hennink et al. 2017). Hennick et al. recommended sixteen to twenty-four participants for data saturation (Hennink et al. 2017).

e. Eligibility criteria

Inclusion criteria were registered healthcare practitioners who could understand Malay or English and understood the purpose of the study. Exclusion criteria included participants who were not motivated to participate in the interviews.

f. Data collection

A list of ophthalmologists and optometrists in Klang Valley was obtained from the National Specialist Register website and the Malaysian Optical Council website respectively. For nurses, ophthalmic technicians, and assistant medical officers, a list was retrieved from the Ophthalmology Clinic HCTM and the Sentul Health Clinic. Participants were approached to participate in this study via email or mobile messaging between December 2020 and February 2021. They were informed of the purpose of the interview. If the participants agreed to participate, the participant information sheet

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(Appendix F) and the informed consent form (Appendix G) were sent to them in either softcopy or hardcopy form. Once the signed informed consent form was received, an interview was arranged.

A topic guide was prepared in English (Appendix H) and Malay language (Appendix I) prior to the interviews to ensure consistency across each interview. The topic guide covered aspects of glaucoma screening, including perspectives on glaucoma screening, the target population, suitable screening locations, appropriate screening instruments, criteria for referring patients, managing inappropriate referrals to the eye clinic and teleglaucoma. A pilot study was conducted prior to the interviews to test the topic guide and refine it as necessary. Two participants were recruited for the pilot study. The participants felt that the questions asked in the interview were clear and appropriate.

Participants were interviewed in either English or Malay language based on their proficiency. Open-ended and probing questions were asked during the interviews. An audio recorder (Huawei P30, Shenzhen, Guangdong, China) was used to record the face-to-face interviews, while online interviews utilised audio-visual recording via the video conferencing platform. Participants were given the option to stop recording if they felt uncomfortable. The interviews lasted 25 to 50 minutes. During the interviews, facial expressions and body language of the participants were observed and recorded by the researcher (WXH). Basic demographic data, including age, race, gender, and occupation, were collected prior to the interviews.

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3.6.4 Data Analysis

The interviewer transcribed the recorded interviews verbatim. Transcripts in Malay were translated into English, followed by a back-translation by a native speaker to confirm accuracy. Transcripts were then imported into NVivo 14 (QSR International, Melbourne, Australia) for inductive thematic analysis. Two researchers (WXH, JCH) independently analysed data using a six-step thematic analysis process: familiarisation, coding, generating, reviewing, defining, naming themes, and report production (Braun

& Clarke 2006). Researchers resolved disagreements through discussion and implemented member check and an audit trail to enhance the study's credibility.

3.6.5 Results

a. Demographic Data

Nineteen eye care professionals from Hospital Canselor Tuanku Mukhriz, Health Clinic Sentul, private optometry centres, teaching hospitals, and Ministry of Health Hospitals in Kuala Lumpur and Petaling Jaya were interviewed. The participants' mean age was 41.47 ± 10.62 years (range: 29-69 years). Of the 19 participants, twelve were women. Sixteen were Malay, and the rest were Chinese (2) and Indian (1). Four participants were ophthalmologists, six optometrists, five nurses, three ophthalmic technicians, and one assistant medical officer. Most participants (16) had five to ten years of working experience, while three had over ten years.

b. Thematic Analysis

Thematic analysis yielded seven themes, which were (1) Type of screening programme (2) Accessible screening locations, (3) Target population, (4) Equipment, (5) Trained personnel, (6) Referral criteria and (7) Telemedicine modality.

Theme I: Type of screening programme

All participants identified two types of glaucoma screening programmes in Malaysia, which were opportunistic case finding and population screening. Eye care professionals usually perform opportunistic case findings in primary care settings, eye clinics, and hospitals. In comparison, population screening was usually conducted by non-profit organizations (NGOs) such as Rotary Club, societies, and organizations in the community setting.

“It is more opportunistic screening in the sense that when patients present to eye clinics, they are routinely screened for the possibility of them having glaucoma when they come for other problems.” (Participant 5, Ophthalmologist)

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"Often a government hospital or a university hospital has glaucoma day. They will do a screening at any public place so people will know what glaucoma is. That's often the case." (Participant 16, Ophthalmic technician)

"Of course, there are also charity organizations as well as associations, they go out to do glaucoma screening. For example, like the Glaucoma Society or AMO, or other societies like NGOs that go out for glaucoma screening." (Participant 8, Optometrist)

"At this time, we are doing outreach, it means that in Selangor, we got retinal disease wellness programme where we go out in the community, do screening for retinal diseases, which include diabetic retinopathy, age-related macular degeneration and glaucoma." (Participant 1, Ophthalmologist)

Some participants perceived that Diabetic Retinopathy Screening Programme conducted by the Ministry of Health at health clinics can also screen patients for glaucoma.

"In Klinik Kesihatan, I would classify it as opportunistic case screening because they run a clinic all the time. And if they have patients coming in for the diabetic retinopathy screening, I think at the same time the screening for glaucoma patients can be done by them." (Participant 4, Ophthalmologist)

Theme II: Accessible screening locations

Primary care facilities, such as optometry practices and health clinics, were suggested by most participants as the screening locations for glaucoma screening. It is because they are easily accessible to the community. Moreover, these facilities are equipped with the necessary instruments and have trained personnel to conduct glaucoma screening.

"Ideally, a location where it's easily accessible to the community. I think it will be good if we can put glaucoma screening in community clinics and also in optometry practices. "(Participant 2, Optometrist)

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"…. definitely the optometry shop. If they have a direct ophthalmoscope, they can look at the optic nerve directly and then if they have the Tono pen, it will be good." (Participant 7, Optometrist)

"Any practice, those who practice optometry and in community health clinics." (Participant 3, Optometrist)

Hospitals are also suggested as one of the screening sites by some participants due to their accessibility to the community. This perspective highlights the potential for hospitals to screen their existing patient population or their relatives for glaucoma.

"…… we have public screening events in the hospital on a day. We get our patients who have relatives to encourage their relatives to come in. It is also open to other people to come for screening." (Participant 4, Ophthalmologist)

Other public locations such as community centres, shopping centres and places of worship were also suggested by some participants. Screening in public places was considered appropriate, offering both easy accessibility and the opportunity to engage a diverse group of people.

"Usually near the place that we feel suitable for people to come, like at a shopping complex, community centres and mosque, church or temple which are convenient for patients to come." (Participant 13, Nurse)

Theme III: Target Population

There were different perceptions regarding who should be screened for glaucoma. The majority of the participants preferred screening individuals with risk factors of glaucoma.

"I always tell my specialist. For every patient who walks into the clinic who is above 40 years old, they need to be screened for glaucoma regardless of whether they have a family history or not. (Participant 1, Ophthalmologist)

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According to the participants, individuals with high risk factors of glaucoma included adults aged 40 years and above, gender, Asian ethnicity, family history of glaucoma, diabetes mellitus, hypertension, have history of ocular surgery, obstructive sleep apnea, high myopia, hyperopia, under steroid medication, high intraocular pressure, large vertical cup disc ratio, thin central cornea thickness and corneal hysteresis.

"There are many things. You look at the risk factors, ocular history, systemic history, or even patients with OSA syndrome, also, you know, tend to be linked to glaucoma. So, even family history also very important. A lot of the time, glaucoma is due to genetic inheritance. So, if your parents had glaucoma, your tendency to have glaucoma is very high. Besides that, I think diabetic mellitus and hypertension. Myopia is considered one of the risk factors of primary open-angle glaucoma. Age, race, high IOP, thin central cornea thickness, corneal hysteresis, and large vertical cup disc ratio are also some of the risk factors. Males gender also tend to have primary open-angle glaucoma, and I don't know why. (Participant 7, Optometrist)

Some participants preferred to screen for all individuals regardless of age. This viewpoint was due to the perception that screening could prevent cases of undiagnosed glaucoma, particularly among high-risk young individuals such as those with a family history of glaucoma, myopia, or under steroid medication.

"…. most people do not know whether they have a history of glaucoma in the family, so I think the best way is to screen for everyone." (Participant 19, Optometrist)

Theme IV: Equipment

Participants suggested a variety of glaucoma screening tests, such as visual acuity test, pupil examination, slit lamp examination, anterior chamber angle assessment, tonometry, funduscopy, visual field test and retinal nerve fibre assessment. The Snellen chart and pen torch were basic screening tools recommended by most participants. Non-mydriatic fundus camera was recommended for fundus examination by all participants, but some participants suggested ophthalmoscopes and Volk lenses. Slit lamp was

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proposed for evaluating the anterior segment, assessing the anterior chamber angle with a gonioscopy lens, measuring the IOP with a tonometer and fundus examination using indirect ophthalmoscopy lens. Humphrey Field Analyser (HFA) (Carl Zeiss Meditec, Dublin, California, USA), frequency doubling technology (FDT) (Carl Zeiss Meditec, Dublin, California, USA), and Melbourne Rapid Field (MRF) (Glance Optical Ltd, Melbourne, Australia) tests were suggested for visual field tests. Several types of tonometers, including contact tonometers (Goldmann applanation tonometer (Haag Streit Diagnostics, USA), iCare (Icare Ltd, Vantaa, Finland), Pascal tonometer (Ziemer Ophthalmic Systems AG, Port, Switzerland), Tonopen (Reichert Technologies, New York, USA) and non-contact tonometer such as air puff tonometer (Reichert Technologies, New York, USA) were recommended for measuring IOP. Optical coherence tomography (OCT) was suggested for assessing the retinal nerve fibre layer and anterior chamber angle. Additionally, some participants suggested using a pachymeter and gonioscope for glaucoma screening.

A significant difference of opinion existed between ophthalmologists and other eye care providers regarding the suitability of specific instruments for glaucoma screening. Instruments such as slit lamp, optical coherence tomography (OCT), HFA, pachymeters, and gonioscopes were suggested by ophthalmologists as being more appropriate for the diagnosis of glaucoma in eye clinics.

“OCT and Humphrey's visual field are not necessary for the screening setting.” (Participant 1, Ophthalmologist)

"So, visual field tests should not be performed during screening. It should be conducted as a further test if you suspect glaucoma.” (Participant 4, Ophthalmologist)

“These instruments would confirm the diagnosis at the secondary level.”(Participant 5, Ophthalmologist)

Furthermore, some eye care professionals suggested that the bulkiness and high cost of these instruments limited their suitability for glaucoma screening.

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“If you have a slit lamp, you can look at the optic nerve and check eye pressure. However, it's a bulky thing and cannot bring anywhere you want. For OCT, it is good to have it. But it is not convenient to carry around.” (Participant 6, Ophthalmologist)

“There is a lot of controversy regarding perimetry because if you get those big instruments, it is very expensive for private practices. That may not be feasible. It is very big, so it needs a big space, again, not very feasible….” (Participant 8, Ophthalmologist)

Some participants believed that portable imaging instruments, such as fundus cameras equipped with artificial intelligence (AI), are ideal for screening glaucoma. AI may improve screening accuracy when the ophthalmologists are not present on site and eye care personnel can refer suspected individuals for diagnosis and management in a secondary or tertiary hospitals.

“I think overseas, they are moving towards AI. AI is big for glaucoma, diabetic retinopathy, and even for ARMD. In fact, what India and a few other countries do nowadays is new equipment that has AI to do the grading. I saw the instrument is portable equipment.”(Participant 8, Optometrist)

Theme V: Trained Personnel

The participants preferred eye care professionals such as ophthalmologists, optometrists, general practitioners, assistant medical officers, nurses, and ophthalmic technicians as the personnel conducting the glaucoma screening.

“ I think everybody in healthcare should be involved. This includes doctors at primary level and secondary level family medicine specialist. This should include optometrists, whether in government or in private.” (Participant 1, Ophthalmologist)

In terms of specific tasks during screening, most participants preferred that trained paramedics, such as ophthalmic technicians, assistant medical officers, and nurses operate the ophthalmic instruments, while the clinical results should be

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interpreted by ophthalmologists and optometrists. They felt that a professionally certified person should review the clinical data after the screening.

"The other measures for glaucoma screening which really is just a measurement of intraocular pressure, can be done by technician, but in terms of assessment of the optic nerve head, it should be done by a trained ophthalmologists or even a senior year trainee. But perhaps some optometrists can be trained to assess the optic nerve head as well to determine whether it's suspicious of glaucoma. But I think in terms of nurses and medical assistant, I think they're more towards, you know, training them to do the instruments rather than the assessment of the optic nerve head" (Participant 4, Ophthalmologist)

"…. technician goes and screen for glaucoma, but you still need an optometrist and ophthalmologist to go through each of the reading." (Participant 8, Optometrist)

However, some participants suggested that paramedics such as nurses and ophthalmic technicians could be trained to diagnose glaucoma as they perceived the roles of assistant medical officers, nurses, and ophthalmic technicians could be expanded to include glaucoma screening, in addition to diabetic retinopathy.

"…paramedics should also be trained in detecting glaucoma, especially if they are doing fundus photography screening for diabetes." (Participant 1, Ophthalmologist)

"…training should have knowledge so that we can diagnose the fundus for glaucoma." (Participant 13, Nurse)

"Like me as a technician, we want to know that this person has glaucoma or suspect. That's all we need to know because technically, we are already good at capturing photos because every day we do it. (Participant 14, Ophthalmic technician)

Most participants disagreed with civilians conducting glaucoma screening as they lack knowledge of glaucoma. They preferred that glaucoma screeners should be well-trained and possess a basic understanding of glaucoma.

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“I don't think it is necessary for them to be involved in the screening. They don't know what they are doing.” (Participant 12, Optometrist)

“ How would a layman know about glaucoma. It is known as a thief of sight which means it's very, very insidious sort of a disease. So, laymen will not be able to be sensitive enough to pick up those changes without the appropriate instrumentation. “(Participant 5, Ophthalmologist)

However, some participants suggested training civilians in specific glaucoma screening tests, such as the visual acuity test, non-contact tonometer, and fundus camera, because technology has made these procedures simple enough for non-specialists to perform.

“…. the second type of category of people that can be involved in glaucoma screening is volunteers, in terms of those that we train to perform, you know, non-contact tonometer, and take vision. These volunteers can consist of, for example, laymen like teachers. (Participant 19, Optometrist)

“They can be involved as in assisting to take a picture and all, but the proper diagnosis or interpretation should come from a properly learned person, such as an optometrist.” (Participant 2, Optometrist)

Theme VI: Referral Criteria

Most participants, especially optometrists, stated that there is no specific referral criteria guideline for glaucoma in Malaysia.

“ ….we're working in private practice doing the glaucoma screening. And what we want is just one single standardized guideline to follow.” (Participant 3, Optometrist)

“We don’t have a specific guideline for glaucoma screening. Some hospitals have implemented some guidelines, but I think not all hospitals in Malaysia.” (Participant 6, Ophthalmologist)

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However, an ophthalmologist suggested that optometrists refer patients suspected of having glaucoma according to the Clinical Practice Guidelines by the Ministry of Health Malaysia.

"I think there is a referral criterion for suspected glaucoma in the latest guidelines for open angle glaucoma. It is available in the Ministry of Health website." (Participant 5, Ophthalmologist)

Theme VII: Telemedicine Modality

Many participants agreed that the store-and-forward method is a suitable modality for telemedicine.

"I think nowadays you know that some of them are using the phone to be a fundus camera. …patient can take their photo and send it to you, the optometrist or ophthalmologist. But of course, they cannot diagnose themself. …the checking and grading are still done by the optometrist and ophthalmologist." (Participant 8, Optometrist)

"Maybe we can give them a link or an email ... So before they refer the patient, they can just contact and clarify with the clinical optometrist or ophthalmologist." (Participant 6, Opthalmologist)

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3.6.6 Discussion

This phase identified key components for a successful glaucoma screening programme, including types of screening programmes, target population, trained personnel, equipment, accessible screening locations, referral criteria and telemedicine modality.

Two types of glaucoma screening programmes were identified by the participants which were the opportunistic case finding and population-based screening. Opportunity case finding was the most common strategy used in glaucoma screening (Thapa et al. 2021). Due to its cost-effectiveness, this strategy is recommended for glaucoma screening in developing countries (Chan & Bourne 2023; Thapa et al. 2021).

However, in China, India, and Spain, community-based screening programmes have shown its cost-effectiveness in glaucoma screening (Anton et al. 2023; John & Parikh 2017; Tang et al. 2019). In the United States, community-based screening programmes identified many positive glaucoma cases within high-risk populations (Gajwani et al. 2020; Hark et al. 2023; Varadaraj et al. 2022). Similarly, a previous study reported that community-based screening detected glaucoma cases earlier compared to opportunistic case finding in South Korea (Song et al. 2019). This finding showed that the type of screening depends on various factors, such as cost-effectiveness and the availability of resources in a Malaysian healthcare setting.

Participants identified primary care settings (specifically community health clinics and optometry practices), hospitals, and public places as potential locations for glaucoma screening. These sites are easily accessible to the public and increase screening uptake in the population. Zhang et al. (2019) conducted a glaucoma screening study at a primary healthcare clinic in China. They found that recruiting high-risk patients was significantly easier within this setting than community-based screening programmes (Zhang et al. 2019). A clinic-based teleglaucoma programme in the USA recruited individuals aged 18 and above at high risk for glaucoma such as diabetes mellitus and African American ethnicity using phone calls from clinics (26.1%), direct communication from a clinic doctor (11.9%), and clinic brochures or flyers (7.9%) (Elam et al. 2023). Both studies suggested that recruitment at the primary care was highly efficient for reaching potential participants for glaucoma screening.

Community-based screening at public places such as places of worship and community centres may benefit the patients who are unlikely to attend eye screening in health clinics (Tan et al. 2020). Grimes et al. (2025) conducted a community glaucoma screening programme at nursing homes, fairs and places of worship which drew 823 participants aged 40 years and above where 199 (27.8%) were diagnosed as glaucoma or glaucoma suspect (Grimes et al. 2025). However, Schettler et al. (2019) reported that 74% (29) of people who underwent screening in a healthcare clinic were more willing to attend additional appointments if given a glaucoma diagnosis than those diagnosed during community-based screening (47.5%,19). This finding showed that glaucoma screening is best conducted in primary healthcare clinics, as it may result in a higher

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subsequent eye check-up appointment rate compared to screening in a community setting.

Some participants in our study suggested that tertiary healthcare facilities, such as hospitals and eye clinics, should be used for glaucoma screening due to their accessibility to the public. A study in Thailand reported a higher rate of hospital-based glaucoma screening participation among patients with a family history of glaucoma (64.5%) compared to community-based screening participation (30.1%) (Nitikarun & Konsap 2024). However, patients' accessibility to tertiary healthcare facilities in Malaysia was limited for the public, as they needed to be referred by primary healthcare clinics (Mutalib et al. 2018). Additionally, eye clinics in Malaysia, particularly government-owned clinics, are in high demand and have experienced a growing number of patients over the years. For instance, the ophthalmology clinic in one of the public hospitals, Hospital Kuala Lumpur, received 49037 patients in 2016, which has increased steadily to 56223 patients per year in 2018 (Suaibun et al. 2022). Although participants identified a range of potential settings for glaucoma screening, primary care settings emerge as the most practical options due to their accessibility, integration with routine care and higher participation in screening and follow-up.

Two perspectives existed regarding the target population for glaucoma screening: targeted screening of high-risk individuals and universal screening. Many participants preferred targeted screening due to its perceived cost-effectiveness compared to universal screening. A pilot study in Malaysia reported that screening high-risk individuals for primary open-angle glaucoma was more cost-effective in detecting early cases of glaucoma (Chelvaraj et al. 2022). The Ministry of Health Malaysia clinical practice guideline on the management of glaucoma also suggested screening high-risk individuals aged above 40 years old instead of population screening (Ministry of Health Malaysia 2017). However, a recent cost-utility analysis study in India, which evaluated screening strategies, found that none of the strategies were cost-effective compared to opportunistic case finding (Purohit et al. 2025). Nevertheless, the researchers recommended that targeted screening for individuals aged 40 years and above, combined with public healthcare financing and availability of medications, could become cost-effective (Purohit et al. 2025). Another perspective recommends universal

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screening to reduce the likelihood of missing glaucoma cases. However, a study by Frediani et al. (2025) found a lower glaucoma cases in individuals aged 18-40 years old. Therefore, universal screening may not be the most efficient approach. Thus, policymakers should consider targeted screening for better resource allocation for screening programmes.

Glaucoma is a complex eye disease often requiring multiple tests and investigations. More tests can increase sensitivity for accurate diagnosis of glaucoma (Mangione et al. 2022; Tan et al. 2020). Many researchers have incorporated a combination of screening tools for glaucoma screening (Terauchi et al. 2020; Watanabe et al. 2022). Similarly in our study, participants suggested various instruments for funduscopy, tonometry, perimetry, anterior chamber angle, corneal thickness measurement and retinal nerve fibre layer assessment for glaucoma screening. Tests for glaucoma usually include the measurement of IOP, evaluation of the optic nerve head, and visual field test (Olawoye et al. 2022). A UK qualitative study on glaucoma screening in healthcare settings reported similar findings, identifying funduscopy or perimetry combined with tonometry as potentially cost-effective tests (The Glaucoma Screening Platform Study 2011). Slit lamp and gonioscopy, as well as optical coherence tomography (OCT) were recommended by some participants in our study for assessing the anterior chamber angle. Gonioscopy is the gold standard for assessing the anterior chamber angle (Esporcatte et al. 2022; Yaisiri et al. 2025). Van Herick technique can be examined through a slit lamp biomicroscope (Sakti 2021). Van Herick technique showed a sensitivity of 0.83 (95% CI [0.74, 0.90]) and specificity 0.88 (95% CI [0.84, 0.92]) in the assessment of the anterior chamber angle for glaucoma screening (Jindal et al. 2020). OCT produces a high-resolution cross-sectional imaging of the anterior chamber angle (Yaisiri et al. 2025). A recent study reported that OCT demonstrated a high sensitivity of 92.16% (95% CI, [87.44, 96.87]) and specificity of 73.91% (95% CI, [66.22, 81.61]) in detecting angle closure (Yaisiri et al. 2025). However, a study concluded that OCT can be considered a clinical diagnostic test for confirming the anterior chamber angle, but not as a screening test (Jaseena & Rekha 2022). OCT was also recommended for assessing the retinal nerve fibre layer due to its ability to provide detailed retinal imaging which facilitates more accurate and early glaucoma detection (Akar et al. 2022; Cirafici et al. 2021; Yamada et al. 2020). Pachymeter was also

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recommended by some participants in our study to measure corneal thickness. Corneal thickness affects the IOP measurement (Agbato et al. 2025). Thin corneas can cause an underestimation of IOP, and vice versa (Kanski & Bowling 2011). Therefore, this instrument helps to enhance the accuracy of IOP readings.

Most ophthalmologists perceived OCT, automated perimetry, pachymeter, and gonioscopes as unsuitable for screening, as these instruments were more appropriate for confirming a glaucoma diagnosis rather than screening. High cost and the requirement for trained operators for these instruments may render them impractical for screening programmes (Lanzetta et al. 2020; Song et al. 2021; Yamada et al. 2020). This finding aligns with the World Health Organization (2020) guidelines, which emphasized that screening tests should be simple, safe, and affordable (World Health Organization 2020). Furthermore, the International Agency for the Prevention of Blindness (2017) recommended simple tools such as a visual acuity chart, a pen torch, ophthalmoscopes, and a tonometer for glaucoma screening in primary care settings (International Agency for the Prevention of Blindness 2017).

All participants suggested the use of a non-mydriatic fundus camera for screening. Non-mydriatic fundus camera showed a high sensitivity of 96.3% and specificity of 94.8% in detecting glaucoma compared to a dilated fundus examination (Upadhyaya et al. 2022). This suggests that non-mydriatic fundus photography reliably detects glaucoma without pupil dilation and can be used in community screening where dilation is impractical. However, a study reported that the reliability of non-mydriatic fundus camera images was low (11.9%) among 8616 participants (17232 images) aged 50 and above who underwent glaucoma screening due to lens opacity, small pupil, ptosis, error in focus and exposure (Chen et al. 2023). Nevertheless, non-mydriatic fundus cameras are widely available in primary health clinics in Malaysia for diabetic retinopathy screening (Chelvaraj et al. 2022) which can be used for glaucoma screening.

Some participants in our study preferred portable instruments for glaucoma screening. These instruments were easier to transport, especially for community screening (Garba et al. 2024). In addition, portable instruments such as a fundus camera are ideal for telemedicine due to their wireless connectivity which allows them to

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transmit results to a telemedicine centre (Lin et al. 2020). Artificial intelligence (AI) built in portable instruments can be beneficial in glaucoma screening. Many studies have reported the detection of probable glaucoma using AI in fundus images (Fan et al. 2022; Nakahara et al. 2022; Sharma et al. 2025). This suggests that AI can potentially detect glaucoma in screening programmes.

Participants in our study preferred trained eye care providers to perform glaucoma screening as they felt that non-eye care personnel have a low level of knowledge about glaucoma, which may lead to an inability to perform glaucoma screening. Clinical Practice Guideline Management of Glaucoma Ministry of Health Malaysia also recommended that trained eye care providers perform glaucoma screening (Ministry of Health Malaysia 2017). Eye care providers, especially optometrists, physicians, and ophthalmologists, are equipped with the knowledge and skills for glaucoma screening. However, Kyari and Khanna (2022) suggested primary health care providers could be trained to identify high-risk patients especially in low-income countries (Kyari & Khanna 2022).

Some participants in our study suggested that non-eye care personnel could be trained to operate the instruments such as the non-contact tonometer and fundus camera. In a Thai study, research assistants without an ophthalmic background performed eye tests such as visual acuity, IOP measurement using an iCare tonometer, and non-mydriatic fundus photography on 889 patients. The study reported good agreement in cup-to-disc ratio (CDR) measurements between the research assistants and the ophthalmologist using a non-mydriatic fundus camera, with an intraclass correlation coefficient (ICC) of 0.65 (Ausayakhun et al. 2021).

Most ophthalmologists and optometrists preferred clinical interpretations to be performed by optometrists or ophthalmologists. However, the heavy workload of ophthalmologists in clinics and their shortage, particularly in developing countries, renders community-based screening by them impractical. A study in Australia suggested that optometrists can effectively interpret clinical results, where they demonstrated moderate inter-observer agreement (kappa coefficient, k= 0.53, 95% CI [0.50,0.54]) in glaucoma detection from fundus photographs between optometrists and

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ophthalmologists (Jan et al. 2025). In Malaysia, a study reported a high degree of diagnostic concordance (87%) between optometrists and ophthalmologists in the identification of ocular disease (Hussin et al. 2019).

Some participants suggested that other healthcare providers, such as ophthalmic technicians and nurses, could be trained to detect glaucoma. A study in India demonstrated that there was a high agreement in cup-to-disc ratio (CDR) between trained ophthalmic technicians and the ophthalmologist, with an intraclass correlation coefficient (ICC) of 0.90 (Rengappa et al. 2021). Another study also found that a trained ophthalmic nurse showed a high agreement in diagnosis compared with an ophthalmologist (kappa coefficient, k=0.874, (95% CI [0.818,0.914]) (Bubb et al. 2021). The evidence from these findings demonstrates the potential of primary eye care providers to accurately detect glaucoma with adequate training.

Most optometrists stated that there were no clear referral criteria for glaucoma screening in Malaysia. Clear referral criteria are crucial, as population screening would cause an increase in false positive referrals compared to opportunistic case finding due to the low prevalence of glaucoma (Hamid et al. 2022). This situation will place a significant burden on tertiary glaucoma care, causing delayed care for high-risk patients (Hamid et al. 2022). Therefore, referral guidelines may reduce the number of false positive referrals to the hospital (Frederiksen et al. 2025). Guidelines for glaucoma referrals are available worldwide such as the American Academy of Ophthalmology, American Optometric Association, Scottish Intercollegiate Guidelines Network (SIGN), National Institute for Health and Care Excellence (NICE) in the United States, Scotland, and United Kingdom (American Optometry Association 2024; Gedde et al. 2021; National Institute for Health and Care Excellence 2017; Scottish Intercollegiate Guidelines Network (Sign) 2015). Sii et al. (2019) reported a decrease in false positive referrals after implementing the SIGN guideline, indicating that well-defined referral guidelines can reduce unnecessary hospital referrals (Sii et al. 2019). In Malaysia, the Ministry of Health Malaysia established a guideline known as the Clinical Practice Guideline Management of Glaucoma Second Edition (Ministry of Health Malaysia 2017). Some ophthalmologists in our study recommended this guideline for referring patients with glaucoma or suspected glaucoma. However, this guideline is not widely

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known by most optometrists. Therefore, it is recommended that a workshop be conducted to introduce this guideline to eye healthcare practitioners, as clear guidelines will enhance the accuracy of referrals and reduce false-positive referrals.

Store-and-forward teleglaucoma was the modality identified among most participants. Two systematic reviews have reported that most teleophthalmology studies used the store-and-forward modality (Chong et al. 2021; Pengput & Schwartz 2022). This modality does not require providers and patients to be available simultaneously as it does not require real-time interaction (Culmer et al. 2023; Sharma et al. 2020). It also reduces reliance on high-speed internet connectivity compared to the synchronous modality, which requires a much higher speed internet connection (Alenoghena et al. 2023). This advantage is highly relevant in the Malaysian setting especially in rural areas with limited internet connectivity, which will limit the feasibility of real-time teleconsultations. Furthermore, store-and-forward modality can effectively detect ocular disease, as demonstrated by Pinhas et al. (2025) who showed 87.5% (28) of patients referred to the ophthalmology clinic had a diagnosis consistent with the screening results (Pinhas et al. 2025).

There were some limitations in this phase. Firstly, some participants involved in online interviews experienced slow internet connections, causing interruptions to their interviews, which led to disturbing their thought process and prevented them from conveying their perspectives smoothly. Secondly, the interviews did not include glaucoma patients, who would provide a different perspective from that of the eye care professionals. Lastly, this study was conducted in the Klang Valley. Therefore, the findings might not represent all eye care professionals in Malaysia.

3.6.7 Conclusion

This phase outlines the essential components of glaucoma screening from the perspective of eye care professionals in Malaysia. Screening of high-risk individuals conducted by trained eye care providers at accessible screening locations was recommended. A combination of ophthalmic instruments was suggested to enhance the sensitivity of glaucoma detection, with a non-mydriatic fundus camera being a

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frequently chosen option. The use of tele-glaucoma in glaucoma screening was recommended by most participants, particularly the store-and-forward modality. This phase also emphasizes the importance of clear referral criteria when screening for glaucoma.

3.6.8 Integration of Mixed Method Study

The systematic review identified primary care and community-based settings as the most commonly reported screening locations for the teleglaucoma programme due to their accessibility to high-risk populations. This aligns with the qualitative findings, in which interviewees stressed that accessible locations are crucial for minimizing barriers for the target participants. These findings highlighted the importance of primary care and community-based settings as strategic locations for implementing teleglaucoma.

Furthermore, the mixed-method study identified high-risk individuals due to their increased likelihood of developing glaucoma. These findings emphasized the value of a targeted screening approach, which may improve screening efficiency.

The systematic review demonstrated that history taking, fundus photography, tonometry, visual field testing, and visual acuity assessment were among the most frequently utilized screening tests in teleglaucoma programmes. Fundus photography was particularly prominent across studies and was often combined with other examinations to improve diagnostic accuracy. Interview participants likewise emphasized the importance of having appropriate equipment to facilitate remote glaucoma assessment and support referral decisions. The qualitative findings provided additional insights into practical considerations such as portability. Together, these findings indicate that appropriate screening equipment forms an essential component of an effective teleglaucoma programme.

Human resources was one of the components of the teleglaucoma programme. The systematic review found that trained personnel play a critical role in teleglaucoma screening, with many studies using trained healthcare workers to perform examinations, collect patient data, diagnose, and manage patients. Some studies have also demonstrated that non-eye-care personnel can be successfully trained to operate

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screening equipment. Interview participants similarly emphasized the importance of eye healthcare professionals to ensure efficient service delivery. However, participants also highlighted the need for clearly defined roles and responsibilities. The integration of findings indicates that trained eye care personnel are essential to the successful implementation of the teleglaucoma programme.

Referral criteria were also among the essential components of teleglaucoma. The systematic review highlighted that existing programme rely on equipment-specific referral criteria to manage suspected or confirmed glaucoma cases. Interview participants also stressed the importance of standardized referral criteria to guide clinical decision-making and ensure appropriate patient management. These findings demonstrate that clearly defined referral criteria are essential for maintaining the effectiveness of teleglaucoma screening programmes.

The systematic review and qualitative interviews identified store-and-forward telemedicine as the most commonly used and feasible modality in teleglaucoma programmes. This approach allows clinical information and images to be captured, stored, and reviewed asynchronously by specialists, thereby improving flexibility and reducing the need for simultaneous patient-provider interactions.

3.6.9 Overall Conclusion

The integration of findings from the systematic review and qualitative interviews identified seven essential components of a teleglaucoma screening programme: (1) accessible screening locations, (2) high risk screening participants, (4) examinations such as history taking, visual acuity assessment, tonometry, fundus photography, and visual field testing (5) trained personnel, (6) referral criteria, and (7) telemedicine store and forward modality. One of the key components of a teleglaucoma screening programme is the training of the eye care providers. As the education levels of eye care providers varied, a standardized training module may help ensure their competency in glaucoma screening. The content for the training module must be developed through a needs assessment and by identifying the skills required for a glaucoma screener. These

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components of a training programme for glaucoma screeners will be identified in Chapter IV.

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CHAPTER IV

PHASE II: IDENTIFY COMPONENTS OF TRAINING PROGRAMME FOR GLAUCOMA SCREENERS

4.1 INTRODUCTION

Effective teleglaucoma programme depends on skilled personnel. Specialised training is required to ensure proper patient communication, accurate image acquisition, identification of high-risk individuals and referral by eye care providers. A standardised training programme is essential for ensuring quality and efficiency in teleglaucoma programme. Identification of components of a training programme is a prerequisite for developing an effective training programme for glaucoma screeners prior to implementation of teleglaucoma programme. In this phase, a systematic review was conducted to identify the components required to develop a training programme for glaucoma screeners from previous studies across the world while semi-structured interviews were performed to explore components of training programme from a local perspective that may not be fully addressed in the systematic review.

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4.2 OBJECTIVE

The objective for this phase is to identify and determine the appropriate components for training programme for glaucoma screeners.

4.3 STUDY DESIGN

The study design was a mixed-method study, which included a systematic review (Section I) to identify the components of a training programme for glaucoma screeners from previous studies worldwide, while semi-structured interviews (Section II)

explored themes from a local perspective that may not be fully addressed in the literature.

4.4 SECTION I: SYSTEMATIC REVIEW

4.4.1 Methodology

The systematic review was performed from 1 January 2010 to 31 December 2020 in the following database: PubMed, Scopus and Web of Science. We selected this timeframe to identify relevant literature on training for glaucoma screeners. Language restrictions were not applied during the database searches. The systematic review search strategy was shown in Appendix J.

Full-text articles were included if they consisted of any part of a training programme for glaucoma screening, English language, and human subjects. Articles identified during the search of the reference lists of the included studies were also included. Exclusion criteria include articles published before 2010, reviews, case reports, duplicate studies, commentaries, letters, books, and abstracts. The search results were imported into EndNote 20, where the duplicates were removed.

Two reviewers (WXH and JCH) independently screened titles and abstracts according to eligibility criteria, followed by a full-text review to assess article eligibility. Disagreements were resolved through discussion and consensus. The study selection process was illustrated in the PRISMA flowchart (Figure 4.1). The quality of the studies was assessed using Mixed Methods Appraisal Tool (MMAT) version 2018 by the two investigators independently (WXH and JCH).

MMAT tool was used in our research because it can appraise the quality of different types of studies such as quantitative, qualitative and mixed methods studies (Hong et al. 2018). The MMAT tool consists of two screening questions and five questions for each category of the type of studies to be scored (Appendix D). If there were any disagreements, they were resolved through discussion and mutual agreement. MMAT does not recommend presenting an overall score as it may not provide information on the problematic aspects of the studies (Hong et al. 2018). They suggested

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reporting MMAT score as stars (*) or percentage (%), which were 1* or 20% quality criteria met, 2** or 40% quality criteria met, 3*** or 60% quality criteria met, 4**** or 80% quality criteria met and 5***** or 100% quality criteria met (Hong et al. 2018).

QUADAS-2 was used because MMAT is unsuitable for diagnostic accuracy studies (Hong et al. 2018). It has four domains: patient selection, the index test, the reference standard test, the flow of patients and timing of tests (Appendix E). Quality assessment was based on the risk of bias and applicability concerns (Whiting et al. 2011). However, applicability concerns were assessed only in three domains: patient selection, the index test and the reference standard test. The risk of bias consists of signalling questions which identify aspects of study designs that are exposed to risk of bias. The risk of bias was classified as low, high, or unclear (Whiting et al. 2011). If the answers to signalling questions for a domain were "yes," then the risk of bias was rated as "low" (Whiting et al. 2011). If the answers to signalling question was "no" or "unclear", it was rated as "high" or "unclear" (Whiting et al. 2011). Applicability concerns were also rated as low, high or unclear (Whiting et al. 2011).

4.4.2 Data Synthesis

Microsoft Excel 2020 (Microsoft Corp., Redmond, Washington, USA) was used for data extraction and analysis. The quantitative analysis was not performed due to heterogeneity across the articles, resulting from different types of training for glaucoma screening. Thus, only qualitative synthesis was performed. Data were extracted from the full-text articles and transferred into an Excel sheet. The extracted data included the author's name, publication year, study participants, the content of the training programme, the training method, the trainers, and the training hours.

4.4.3 Results

Figure 4.1 shows the results of the study selection procedure according to PRISMA 2020 flowchart. Eleven studies were included in this study. Table 4.1 shows the summary of findings table from the systematic review.

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The studies included three quantitative descriptive studies (Bourne et al. 2010; Devarajan et al. 2011; Syam et al. 2010), three quantitative non-randomized studies (Mihailovic et al. 2020; Myint et al. 2014; Yoshioka et al. 2015), two mixed-method studies (Black et al. 2017; Dean et al. 2012), two diagnostic studies (Johnson et al. 2018; Sinha & Astbury 2011) and a quantitative randomized controlled trial (Scheetz et al. 2019).

Most studies were conducted in the United Kingdom (n=5) (Black et al. 2017; Bourne et al. 2010; Devarajan et al. 2011; Myint et al. 2014; Syam et al. 2010) while the remaining studies were conducted in the United States (n=2) (Johnson et al. 2018; Mihailovic et al. 2020), Australia (n=2) (Scheetz et al. 2019; Yoshioka et al. 2015), India (n=1) (Sinha & Astbury 2011) and Africa (n=1) (Dean et al. 2012).

The training participants in this systematic review were eye care providers, including optometrists (n=6) (Black et al. 2017; Bourne et al. 2010; Devarajan et al. 2011; Myint et al. 2014; Syam et al. 2010; Yoshioka et al. 2015), ophthalmic technicians (n=3) (Johnson et al. 2018; Mihailovic et al. 2020; Sinha & Astbury 2011), nurses and ophthalmic technicians (n=1) (Dean et al. 2012).

Training content typically includes either theoretical or practical components of: 1) ocular examinations such as the visual acuity test (Dean et al. 2012; Sinha & Astbury 2011), pupil examination (Dean et al. 2012), Van Herick technique (Black et al. 2017; Johnson et al. 2018; Syam et al. 2010), intraocular pressure (IOP) measurement (Black et al. 2017; Devarajan et al. 2011; Mihailovic et al. 2020; Sinha & Astbury 2011; Syam et al. 2010), funduscopy (Black et al. 2017; Dean et al. 2012; Devarajan et al. 2011; Sinha & Astbury 2011; Syam et al. 2010; Yoshioka et al. 2015) and optic disc assessment (Black et al. 2017; Bourne et al. 2010; Dean et al. 2012; Devarajan et al. 2011; Myint et al. 2014; Scheetz et al. 2019; Sinha & Astbury 2011; Syam et al. 2010), 2) ocular investigations such as a visual field test (Devarajan et al. 2011; Sinha & Astbury 2011; Syam et al. 2010; Yoshioka et al. 2015), and a combination of gonioscopy, optical coherence tomography (OCT) and Heidelberg retinal tomography (HRT) (Yoshioka et al. 2015), A-Scan (Sinha & Astbury 2011), 3) glaucoma diagnosis

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and management (Myint et al. 2014; Sinha & Astbury 2011; Syam et al. 2010) and 4) patient referral and follow-up (Dean et al. 2012).

Lectures were the most common training method (n=5) (Black et al. 2017; Dean et al. 2012; Johnson et al. 2018; Scheetz et al. 2019; Yoshioka et al. 2015), followed by a combination of lectures with practical sessions (n=4) (Bourne et al. 2010; Devarajan et al. 2011; Myint et al. 2014; Syam et al. 2010) and only practical sessions (n=1) (Mihailovic et al. 2020). One study did not specify the method of training given to the participants (Sinha & Astbury 2011).

The evaluation of training was assessed through various methods, such as direct observation of procedural skills (n=3) (Mihailovic et al. 2020; Sinha & Astbury 2011; Syam et al. 2010), online quiz (n=2) (Myint et al. 2014; Scheetz et al. 2019), case-based test (n=2) (Myint et al. 2014; Yoshioka et al. 2015), multiple choice questions (n=1) (Johnson et al. 2018) and short answer free-ended questions (n=1) (Myint et al. 2014). The other four studies did not provide an evaluation method for participants' performance (Black et al. 2017; Bourne et al. 2010; Dean et al. 2012; Devarajan et al. 2011).

The trainers were most often glaucoma specialists or ophthalmologists (n=5) (Bourne et al. 2010; Dean et al. 2012; Devarajan et al. 2011; Mihailovic et al. 2020; Scheetz et al. 2019), followed by ophthalmic technicians (n=1) (Dean et al. 2012). The remaining five studies did not specify the qualifications of their trainers (Black et al. 2017; Johnson et al. 2018; Myint et al. 2014; Sinha & Astbury 2011; Syam et al. 2010; Yoshioka et al. 2015).

Training durations ranged widely from four hours (Yoshioka et al. 2015) to four weeks of online modules (Scheetz et al. 2019). Other studies offered 18 hours of training (Syam et al. 2010), four half day training (Bourne et al. 2010), one-day workshop (Dean et al. 2012) or three-day courses (Myint et al. 2014; Sinha & Astbury 2011). Four studies never specified the total hours of training (Black et al. 2017; Devarajan et al. 2011; Johnson et al. 2018; Mihailovic et al. 2020).

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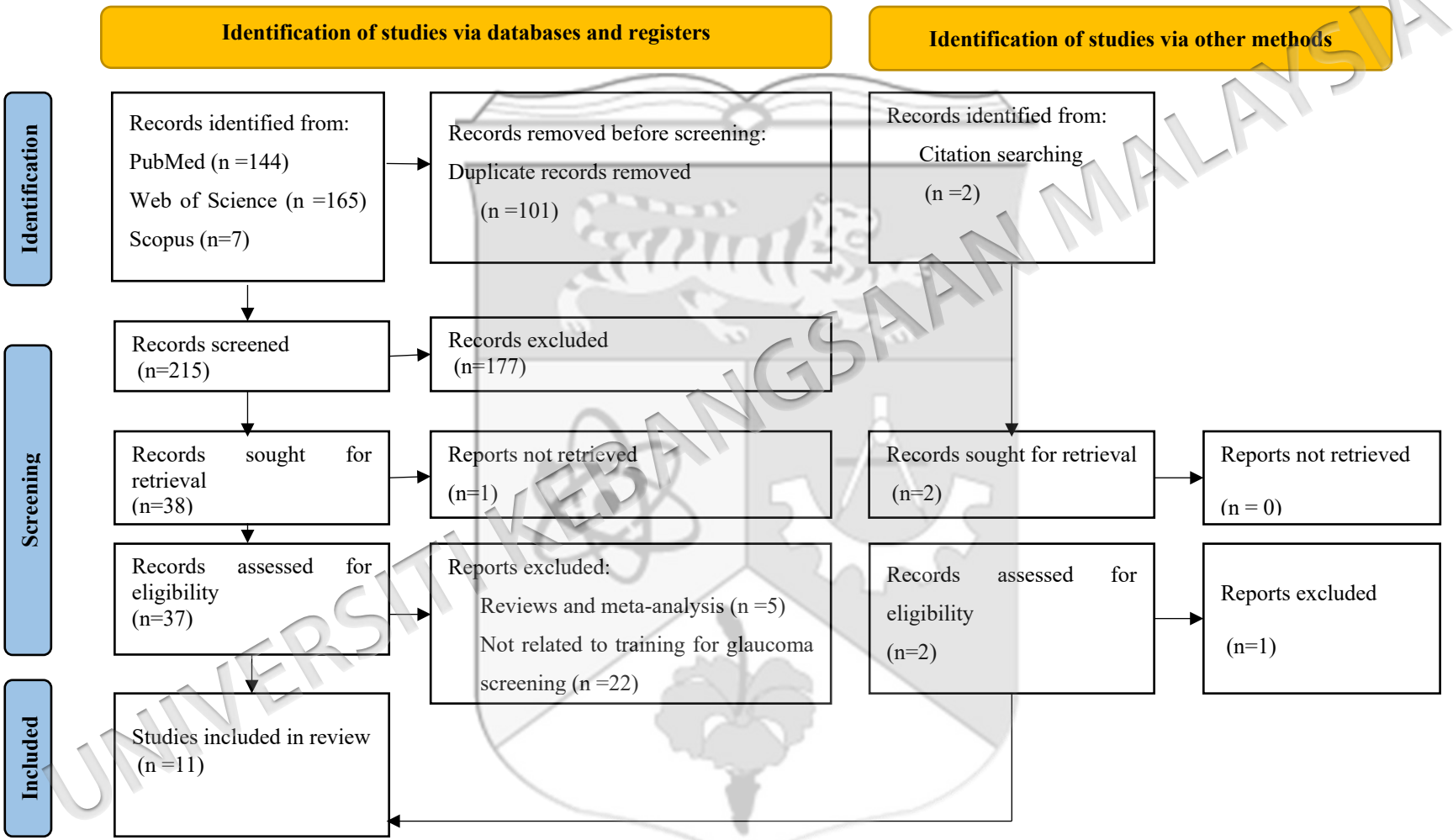

Figure 4.1 Study flowchart according to PRISMA 2020 guidelines

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Table 4.1 Results from the Systematic Review

Study	Country	Study design	Participants	Content of the Training	Training Method	Training Evaluation	Trainers	Training hours
Bourne et al. (2010)	United Kingdom	Quantitative descriptive study	Eight optometrists with recognized postgraduate certificate in glaucoma shared care	Theory and practical examination of the optic disc	Lectures, practical examination and clinical placements at the hospital glaucoma clinic	Did not specify	Glaucoma specialists	Four half-day sessions
Syam et al. (2010)	United Kingdom	Quantitative descriptive study	Ten optometrists	Theory sessions: basic aspects of glaucoma, including diagnosis and management of different types of glaucoma. Practical sessions: intraocular pressure measurement using Goldmann applanation tonometry, Van Herick's technique, indirect ophthalmoscopy, interpretation of the result of Humphrey visual field test, identification of other eye diseases and recognising the signs of glaucoma.	Theory and three practical sessions	Direct observation of procedural skills	Did not specify	18 hours

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Devarajan et al. (2011)	United Kingdom	Quantitative descriptive study	19 accredited optometrists	Tonometry with Perkins or Goldman tonometer, indirect ophthalmoscopy, visual field test with either of the instruments: Humphrey Visual Field Analyzer, Dicon 400 or Henson Bowl Perimeter and assessment of optic disc.	Lecture, patient examination, and feedback on optic disc assessment.	Did not specify	Senior eye specialists.	Did not specify
Sinha and Astbury (2011)	India	Diagnostic accuracy	Four ophthalmic technicians	Visual acuity test, examination of anterior segment with pentorch, tonometry with a Tonopen, visual field test using frequency doubling technology (FDT) perimetry, A-scan to measure central anterior chamber depth (ACD), dilated fundus examination with ophthalmoscopy and diagnosis of glaucoma or glaucoma suspect.	Structured training with weekly feedback sessions	Direct observation of procedural skills	Did not specify	Three days of training with an hour of feedback session each week
Dean et al. (2012)	Africa	Mixed method study	87 clinic nurses and two ophthalmic technicians	Nurse: The importance of glaucoma as a cause of blindness, the procedure of pinhole visual acuity, and the referral of glaucoma suspect patients Ophthalmic technicians: Pupil examination which included identification of afferent pupil defect, direct ophthalmoscopy, assessment of optic disc and referral or follow-up protocols	Lectures	Did not specify	ophthalmic technicians to train nurses and an ophthalmologist to train ophthalmic technicians	One day

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Myint et al. (2014)	United Kingdom	Quantitative non-randomized study	53 community optometrists	Diagnosis and management of glaucoma	Lectures and practical sessions with assessment at the end of the course.	short answer questions, online quiz and case-based test.	Did not specify	Three days
Yoshioka et al. (2015)	Australia	Quantitative non-randomized study	54 community optometrists	Theory about risk factors of glaucoma, optic nerve head assessment, visual field, gonioscopy, funduscopy, OCT, HRT and interpretation of visual field	Three lectures	Case-based test	Did not specify	Four hours
Black et al. (2017)	United Kingdom	Mixed method study	Twelve optometrists	Applanation tonometry, indirect ophthalmoscopy, assessment of optic disc and Van Herick technique	Video lectures	Did not specify	Did not specify	Did not specify
Johnson et al. (2018)	USA	Cross-sectional diagnostic accuracy study	Eleven ophthalmic technicians	Van Herick technique	Video about Van Herick technique	Three multiple-choice questions and grading of five anterior chamber angle images as open or narrow angle.	Did not specify	Did not specify

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Scheetz et al. (2019)	Australia	Quantitative randomized controlled trial	46 orthoptists	Optic disc assessment	Online learning modules with videos, PowerPoint lectures, slides on optic disc assessment, and quizzes.	Online quiz about optic disc assessment with the GONE system	Two glaucoma specialists	Four weeks
Mihailovic et al. (2020)	USA	Quantitative non-randomized study	Six ophthalmic technicians	Goldmann applanation tonometry	Three practical sessions for each participant	Direct observation of procedural skills	Glaucoma specialists	Did not specify

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Table 4.2 shows the results of quality assessment based on the Mixed Method Appraisal Tool (MMAT) 2018 (Hong et al. 2018). Seven studies fulfilled four out of five criteria, suggesting a good quality study (Black et al. 2017; Devarajan et al. 2011; Mihailovic et al. 2020; Myint et al. 2014; Scheetz et al. 2019; Syam et al. 2010; Yoshioka et al. 2015). One study met three out of five criteria, reflecting moderate methodological quality (Bourne et al. 2010) and one study met two out of five criteria, which reflects low methodological quality (Dean et al. 2012).

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Table 4.2 Quality assessment using Mixed Method Appraisal Tool (MMAT) 2018

Studies	Assessment Criteria																											Quality
	Screening Questions		Qualitative					Quantitative randomized random trials					Non-randomized					Quantitative descriptive					Mixed Methods					
	1	2	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	
Bourne et al. (2010)	Y	Y																Y	C	Y	C	Y						***
Syam et al. (2010)	Y	Y																Y	Y	Y	C	Y						****
Devarajan et al. (2011)	Y	Y																Y	Y	Y	C	Y						****
Dean et al. (2012)	Y	Y	Y	Y	C	C	Y											Y	C	Y	C	Y	Y	C	C	C	Y	**
Myint et al. (2014)	Y	Y											Y	Y	Y	C	Y											****
Yoshioka et al. (2015)	Y	Y											Y	Y	Y	C	Y											****
Black et al. (2017)	Y	Y	Y	Y	Y	Y	Y											Y	Y	Y	N	Y	Y	Y	Y	Y	Y	****
Scheetz et al. (2019)	Y	Y						Y	Y	Y	C	Y																****
Mihailovic et al. (2020)	Y	Y											Y	Y	Y	C	Y											****

Note. Y: Yes; N: No; C: Cannot tell

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Table 4.3 shows the results of the quality assessment of two studies using QUADAS 2 (Whiting et al. 2011) as these studies were diagnostic accuracy studies. The risk of bias for all four domains was low in both studies. The applicability concerns of the three domains were also judged to be of low concern in both studies.

Table 4.3 Quality assessment result using QUADAS 2

Study	Risk of Bias				Applicability Concerns		
	Patient selection	Index test	Reference standard	Flow and timing	Patient selection	Index test	Reference standard
Sinha and Astbury (2011)	L	L	L	L	L	L	L
Johnson et al. (2018)	L	L	L	L	L	L	L

L: low; H: high; U: unclear

4.4.4 Updated Systematic Review Findings

Table 4.4 shows the findings of a systematic review search from 1 January 2021 to 10 May 2025. The data search resulted in five articles included for qualitative synthesis. Of the five studies, three studies (60%) were classified as quantitative descriptive studies (Bubb et al. 2021; De Araujo et al. 2021; Jindal et al. 2025), one study was a quantitative non-randomised study (Olawoye et al. 2023), and one study was mixed method study (20%) (Young et al. 2023).

Two studies were conducted in the United Kingdom (40%). The rest of the studies were conducted in Brazil (n = 1, 20%), Australia (n = 1, 20%), and Vietnam (n= 1, 20%).

Most of the training participants were nurses (Bubb et al. 2021; De Araujo et al. 2021; Young et al. 2023). One study included healthcare professionals such as nurses, ophthalmic technicians and physicians as their participants (Olawoye et al. 2023) while another study recruited optometrists (Jindal et al. 2025).

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Training content typically included topics such as anterior segment examination (Bubb et al. 2021), Van Herick technique (Jindal et al. 2025), gonioscopy (Bubb et al. 2021), fundus and slit lamp photography (De Araujo et al. 2021), optic disc evaluation (Bubb et al. 2021; Olawoye et al. 2023; Young et al. 2023), visual field test (Bubb et al. 2021; Young et al. 2023), ocular tomography coherence (Bubb et al. 2021; Young et al. 2023). Some studies focused on the knowledge of primary angle closure glaucoma (Jindal et al. 2025), anti-glaucoma drugs including their classes and mechanisms of action and glaucoma management strategies with follow-up schedule (Young et al. 2023).

Four studies combined theoretical lectures with practical skills as training method (Bubb et al. 2021; De Araujo et al. 2021; Olawoye et al. 2023; Young et al. 2023) while one study consisted of only online recorded lectures (Jindal et al. 2025).

There were several methods used to evaluate the training participants such as Objective Structured Clinical Examination (OSCE) (Bubb et al. 2021) and online quiz (Jindal et al. 2015; Olawoye et al. 2023). Two studies did not provide an evaluation method (De Araujo et al. 2021; Young et al. 2023).

Two studies employed glaucoma specialists or ophthalmologists as trainers (Bubb et al. 2021; Olawoye et al. 2023). One study utilised ophthalmologists with a senior nurse and an ophthalmic photographer to train in slit lamp and fundus photography (De Araujo et al. 2021). Another study utilised an ophthalmologist, medical photographers, and an orthoptist to train the participants (Young et al. 2023). One study did not specify trainers in their methodology (Jindal et al. 2025).

Training durations ranged widely from 1.5 hours (Jindal et al. 2025) to one week of training (De Araujo et al. 2021). One study offered five hours of lectures with an additional one-to-one training of 20 to 30 minutes (Olawoye et al. 2023). Another study has 100 hours of training (Young et al. 2023). One study did not specify the total hours of training (Bubb et al. 2021).

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Table 4.4 Updated Systematic Review Results

Study	Country	Study design	Participants	Content of the Training	Training Method	Training Evaluation	Trainers	Training hours
Bubb et al. (2021)	United Kingdom	Quantitative descriptive study	A nurse with experience working with a glaucoma specialist	Assessment of the anterior segment, optic disc assessment, gonioscopy, and the interpretation of the results of visual field test and optical coherence tomography (OCT)	Lectures and practical skills training	Objective Structured Clinical Examination (OSCE)	Glaucoma specialists	Did not specify
De Araujo et al. (2021	Brazil	Quantitative descriptive study	A nurse and five nurse technicians	Fundus and slit-lamp photography	Theory and practical sessions followed by supervised working under the head nurse.	Did not specify	Ophthalmologists, a head nurse and an ophthalmic photographer	One week of training with unspecified hours of supervised work
Olawoye et al. (2023)	Vietnam	Quantitative non-randomised study	43 non-ophthalmic diabetic retinopathy graders (nurses, technicians and physicians)	Module on optic disc grading for glaucomatous optic nerve. Three modules were in the module, which were Module 1: introduction to glaucoma, Module 2: characteristics of a standard optic disc and images of glaucomatous optic nerve, and Module 3: "5 Cs" method for assessment of optic disc photographs for glaucomatous optic nerve	Online lectures and an additional one-to-one training with a glaucoma specialist	Online quiz on grading optic nerve images	A glaucoma specialist	Five hours of online training with 20 to 30 minutes of additional training

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Young et al. (2023)	Australia	Mixed method	Nurses	Knowledge of glaucomatous changes to the optic disc and retinal nerve fibre layer, glaucoma drugs, their classes and mechanisms of action, medical and surgical management strategies, performing skills of glaucoma assessment such as history taking, using Humphrey Field Analyser, iCare tonometer and OCT, interpretation of the results of the assessments, and follow up.	Practical and theory (self-directed study using key reading texts, online glaucoma classes, online optic disc evaluations exercise using glaucomatous optic neuropathy evaluation (GONE) training programme	Did not specify	Medical photographers, an orthoptist and ophthalmologist	100 hours (84 hours practical and 16 hours of theory)
Jindal et al. (2025)	United Kingdom	Quantitative non-randomised study	52 optometrists	Lectures on primary angle closure glaucoma. The lecture on primary angle closure glaucoma included interpretation and application of Van Herick, classification of glaucoma, mechanisms, risk factors, assessments, diagnosis, management and referral guidelines of primary angle closure glaucoma.	Recorded lecture with multiple-choice questions and links to articles.	Online quiz of grading 84 images for Van Herick technique.	Did not specify	1.5 hours

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Table 4.5 shows the quality assessment results according to MMAT version 2018 (Hong et al. 2018). All studies met four out of five criteria, which is a good quality study (Bubb et al. 2021; De Araujo et al. 2021; Jindal et al. 2025; Olawoye et al. 2023; Young et al. 2023).

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Table 4.5 Quality assessment using MMAT 2018

Studies	Assessment Criteria																							
	Screening Questions		Qualitative					Non-randomized					Quantitative descriptive					Mixed Methods					Quality
	1	2	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	
Bubb et al. (2021)	Y	Y											Y	Y	Y	C	Y						****
De Araujo et al. (2021)	Y	Y											Y	C	Y	Y	Y						****
Olawoye et al. (2023)	Y	Y						Y	Y	Y	C	Y											****
Young et al. (2023)	Y	Y	Y	Y	Y	Y	Y						Y	Y	Y	C	Y	Y	Y	Y	C	Y	****
Jindal et al. (2025)	Y	Y						Y	Y	Y	C	Y											****

Note. Y: Yes; C: Cannot tell

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4.4.5 Discussion

The training programmes in the systematic review were designed for primary eye care providers, including optometrists, ophthalmic technicians, nurses, and orthoptists. The type of skills and content taught is often tailored to the role of the participants, their levels of knowledge, and the resources available in their practice. This was proven by a survey, which found that 59% of ophthalmic specialist nurses in the UK were involved in nurse-led ophthalmology clinics (Rattanasirivilai & Shirodkar 2021). Thus, their role in ophthalmology clinics requires more comprehensive training that covers a wider range of skills, from tonometry and visual field testing to the diagnosis and management of glaucoma. Training of optometrists is also mostly more comprehensive, especially in some studies conducted in the UK. This is because the optometrists in these studies are trained for the glaucoma referral refinement scheme, as participation in this scheme requires training in clinical skills such as Goldmann tonometry, funduscopy, and visual field test (Ratnarajan et al. 2013). Therefore, their training content is more comprehensive, ensuring higher competency than standard optometry training. However, training for nurses and ophthalmic technicians usually focuses on clinical skills. This approach is important for ensuring accurate data collection, which will facilitate efficient referral to an ophthalmologist. This was demonstrated in a recent training programme, which taught primary healthcare workers the visual acuity test (Sodani et al. 2025). However, some studies equipped ophthalmic technicians or orthoptists with diagnostic skills, such as optic nerve head assessment which expands their roles to help identify glaucoma cases. Training these personnel in optic nerve head evaluation could enhance the efficiency of glaucoma screening programmes by allowing them to identify glaucoma cases, particularly in settings with limited access to ophthalmologists. Studies have shown that non-ophthalmic personnel can achieve detection accuracy of glaucomatous optic nerve head comparable to that of ophthalmologists ($p=0.384$) after training (Olawoye et al. 2023) and high agreement in measuring the cup-to-disc ratio (CDR) (intraclass correlation coefficient 0.90) (Rengappa et al. 2021).

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The content of the training programmes focused on the theory of glaucoma and its management, as well as practical procedures such as visual acuity testing, pupil examination, anterior segment examination, anterior chamber angle assessment, tonometry, automated visual field testing, optic disc assessment, and retinal nerve fibre layer assessment. The theory of glaucoma and its management was included as part of the components in some training programmes to enable participants to understand glaucoma, identify risk factors, and refer patients effectively. A previous study found that 65.8% of 123 physicians had poor knowledge of glaucoma, which caused 33.1% to have poor referral practice (Alwazae et al. 2020). Therefore, the authors suggested that there was a need to increase education on glaucoma risk factors and management, and to provide training on glaucoma screening among physicians to improve their referral practice (Alwazae et al. 2020). However, some training programmes did not include the theory of glaucoma and its management as they were focused on practical ophthalmic procedures. A variety of practical ophthalmic procedures need to be taught, as multiple tests can enhance sensitivity in detecting glaucoma (Mangione et al. 2022; Tan et al. 2020).

The methodologies employed for training programmes differ significantly, such as didactic lectures, practical sessions, supervised clinical examinations with real patients and feedback sessions. Lectures and practical sessions were mostly employed, similar to the delivery method used in postgraduate glaucoma courses offered by universities in the UK (Myint et al. 2014). This method was also used in a training programme in Brazil, which trained their nursing technicians using lectures and practical training with the equipment used in their teleophthalmology screening programme (Garcia Moraes Pagano et al. 2021). However, some studies only used either lectures or practical sessions to teach the participants the clinical skills of glaucoma screening. Practical procedures in glaucoma screening require hands-on training sessions to develop the proficiency needed for operating equipment. A previous study also used a workshop to teach undergraduate healthcare students clinical eye examination skills such as visual acuity, anterior segment examination, funduscopy, and identifying eye diseases (O' Carroll et al. 2023). They found that the workshop significantly improved the clinical identification skills of the participants from 60.6% to 84.6% ($p < 0.001$) (O' Carroll et al. 2023). Therefore, this finding showed that

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practical sessions can enhance students' clinical skills. Three training programmes utilized online learning such as online modules and instructional videos (Black et al. 2017; Johnson et al. 2018; Scheetz et al. 2019). This technology approach enhanced accessibility for participants living in rural areas (Al-Khaled et al. 2022) and also enabled flexible, self-paced learning for working participants (Yan et al. 2021). The effectiveness of online education was demonstrated in a study that found that Year 2 optometry students who spent most of their training online due to the COVID-19 pandemic were able to measure vertical cup-to-disc ratios based on fundus images, similar to their seniors (Hairol & Lee 2022).

Training hours in the studies ranged from 1.5 hours to a month. This finding highlights a significant lack of consensus regarding the optimal duration of training required for an effective training programme. Some studies have shown minimal or no improvement in screener competency after a short training period ranged from four hours to three days (Myint et al. 2014; Yoshioka et al. 2015). However, this finding contrasts with other studies, which reported positive outcomes of skill improvement after a brief training period ranged from 1.5 hours to three days (Bourne et al. 2010; Jindal et al. 2025; Olawoye et al. 2023; Sinha & Astbury 2011; Syam et al. 2010). A recent two-month training programme demonstrated that a training module that focused on seven key glaucomatous optic disc characteristics was found to improve the interpretation skills of ophthalmology residents (Tanjirawatana et al. 2025). Therefore, this finding suggests that a longer training duration may be necessary to enhance skills for evaluating the optic disc in glaucoma.

The evaluation methods to evaluate participants' competency also varied across the studies. The assessments were usually administered at the end of the training programme. It involved evaluations of theoretical knowledge via multiple-choice questions (MCQs), optic disc grading, and skills assessments. MCQs were the most common assessment used in education as they have high validity and reliability in assessing knowledge (Parekh & Bahadoor 2024). Practical assessments evaluate higher levels of Miller's pyramid, including clinical skills and real-life performance, which MCQs cannot assess (Parekh & Bahadoor 2024). Thus, standardizing these assessment

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methods is crucial in ensuring that the assessment of the participants' competency in different groups and locality is consistent and reliable.

Ophthalmologists served as trainers in most training programmes because they provided medical expertise in glaucoma screening such as theoretical knowledge about glaucoma and clinical skills. This was shown in two previous studies where their screeners were trained by ophthalmologists on the screening protocols for their respective screening programmes (Buttan et al. 2022; Garcia Moraes Pagano et al. 2021). In some studies, nurses and ophthalmic technicians were included as trainers to teach the clinical skills for glaucoma screening, as demonstrated in a study that employed a skilled technician to train other technicians in fundus photography (Xiao et al. 2020).

This systematic review has several limitations. Firstly, the heterogeneity of training programmes components caused direct comparisons to be difficult. Secondly, few studies have evaluated the long-term retention of skills among glaucoma screeners. Finally, most studies were conducted in high-income countries. Therefore, applying these findings in low- and middle-income countries is challenging, as trained eye care providers are required for glaucoma screening.

4.4.6 Conclusion

The systematic review showed that training programmes for primary eye care providers varied in the training content, delivery methods, duration, trainers and evaluation. These results suggested that training programmes were tailored to participants, the learning outcomes, and the training environment, especially in low-resource settings. However, the heterogeneity of programme content across studies highlights the need for standardized training for primary eye care providers in glaucoma screening. Thus, future research should focus on developing standardized and effective training programmes for glaucoma screeners, especially in low and middle-income countries.

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4.5 SECTION II: QUALITATIVE SEMI-STRUCTURED INTERVIEWS

4.5.1 Introduction

The systematic review successfully described the variations of the training programmes. However, its descriptive nature was unable to capture the content specific to the Malaysian environment. Therefore, we selected semi-structured interviews to elicit the data necessary to address this critical gap and explore the perspectives of eye health care professionals on the content of training programs in Malaysia. Semi-structured interviews are the most appropriate method as they allow for the exploration of the individual's experiences and opinions that might arise during the interview (Magaldi & Berler 2020).

4.5.2 Methodology

a. Sampling method

Purposive sampling was used in this phase.

b. Study participants

The study participants were 1) ophthalmologists who are working in teaching hospitals and Ministry of Health hospitals, 2) optometrists who are working at private optometry centres and 3) nurses, ophthalmic technicians, and assistant medical officers who are working at Sentul Health Clinic and Ophthalmology Clinic, Hospital Canselor Tuanku Muhriz (HCTM) Universiti Kebangsaan Malaysia (UKM).

c. Study locations

Face-to-face interviews were conducted with ophthalmic technicians, nurses, and assistant medical officers in a meeting room at the Health Clinic Sentul and Ophthalmology Department, Hospital Canselor Tuanku Muhriz (HCTM). While, video conferencing platforms like Zoom (Zoom Video Communications, Inc. San Jose, California, United States) or Skype (Skype Technologies Microsoft, Luxembourg City, Luxembourg) were used to interview ophthalmologists and optometrists.

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d. Sample Size Calculation

Participants were recruited until data saturation was achieved (Hennink et al. 2017). According to Hennink et al. (2017), data saturation can be achieved with sixteen to twenty-four participants.

e. Eligibility Criteria

Inclusion criteria were healthcare practitioners, able to understand Malay or English, and able to understand the purpose of the study. While exclusion criteria included participants who were not motivated to participate in the interviews.

f. Data Collection

A list of ophthalmologists and optometrists in Klang Valley was obtained from the National Specialist Register website and the Malaysian Optical Council website, respectively. For nurses, ophthalmic technicians, and assistant medical officers, a list was retrieved from the Ophthalmology Clinic HCTM and the Sentul Health Clinic. Participants were approached to participate in this study via email or mobile messaging between December 2020 and February 2021. They were informed of the study's purpose and provided with the study information sheet (Appendix K). Those who agreed to participate in the study signed the consent form (Appendix G) either digitally or in physical form. Interviews were arranged after receiving signed consent forms.

A topic guide in both English (Appendix L) or Malay language (Appendix M) was prepared before the interviews to ensure consistency. The topic guide covered the training module content, target personnel, training methods, and duration. The topic guide was tested and refined through a pilot study which involved two participants. The pilot study found that participants felt that the interview questions were sufficient. Thus, their data were included in the analysis.

Participants were interviewed in a quiet room. Basic demographic data (age, race, gender, occupation) was collected before the interviews started. Participants were interviewed in either English or Malay language based on their language proficiency. Open-ended and probing questions were asked during the interviews. An audio recorder

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(Huawei P30, Shenzhen, Guangdong, China) was used to record the face-to-face interviews, while online interviews used the audio-visual recording via the video conferencing platform. Participants were given the option to stop recording if they felt uncomfortable. The interviews lasted for 25 to 50 minutes.

g. Data Analysis

The interviewer transcribed the recorded interviews verbatim. Transcripts in Malay were translated into English, followed by a back-translation to confirm accuracy. Transcripts were then imported into NVivo 14 (QSR International, Melbourne, Australia) for thematic analysis, which was selected for its flexibility (Braun & Clarke 2006). Two researchers (WXH, JCH) independently analysed data using six-step thematic analysis process: familiarisation, coding, generating, reviewing, defining, naming themes, and report production (Braun & Clarke 2006). Researchers resolved disagreements through discussion and implemented member check and an audit trail to enhance the credibility of the study.

4.5.3 Results from Semi-Structured Interviews

a. Demographic Data

Nineteen eye care professionals from HCTM, Sentul Health Clinic, private optometry practices, and public hospitals in Kuala Lumpur and Petaling Jaya were interviewed. The participants' mean age was 41.47 ± 10.62 years (range: 29-69 years). Of the 19 participants, twelve were women. Sixteen were of Malay ethnicity, and the rest were Chinese (2) and Indian (1) ethnicity. The participants included four ophthalmologists, six optometrists, five nurses, three ophthalmic technicians, and an assistant medical officer. Most participants (16) had five to ten years of working experience, while three had over ten years.

i. Thematic Analysis

There were five major themes, which were (1) content of training module, (2) target training personnel, (3) training method, (4) training hours and (5) assessment method.

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Theme 1: Content of training module

Most participants suggested that the training module cover the introduction and epidemiology of glaucoma, signs and symptoms, risk factors, causes, diagnosis and management of glaucoma. They also suggested incorporating related anatomy and physiology of the eye to glaucoma in the module. Another suggestion was instructions on using and operating ophthalmic instruments such as fundus cameras and tonometers, as well as clinical skills in visual acuity test and history taking.

"The content should include the history taking, fundus photo taking, pressure taking, and then simple evaluation on the visual field changes, detection on the risk factor and examination of the patient in the whole. Anatomical and physiology of the eye is the first thing that they need to be introduced to if you don't have exposure at all to eye right. That's the first thing they need to know." (Participant 6, ophthalmologist)

"You cannot use the same platform to teach in different audience. I mean, you're not going to teach management and anti-glaucoma, or the glaucoma surgery for paramedic. Just got teach them anatomy, physiology and maybe how abnormal optic disc looks like." (Participant 2, ophthalmologist)

"That means optometrist should be taught on how to diagnose better, especially in terms of history taking and you know managing the patient, how quick they need to refer the patients. All must be included in the module. You can have anatomy and physiology but it's more of you know a summary because they have studied before. It's just a refresher course. The etiology, the causes and everything." (Participant 2, optometrist)

Theme 2: Target training participants

Most participants agreed that healthcare professionals such as general practitioners, optometrists, ophthalmic technicians, assistant medical officers, and nurses who were involved in glaucoma screening should be trained for glaucoma screening.

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"Doctors, nurses, optometrists, health assistants can be trained. Medical assistant and ophthalmic technicians that handles the machine can be trained too. "(Participant 18, nurse)

"…. we must train the staff, the medical personnel but they need a training to detect glaucoma, and those who are high risk to have glaucoma. Optometrists are the best next personnel other than paramedics. They can be trained as they have the basic knowledge. I think the GP either in private or government sector can be trained too." (Participant 6, ophthalmologist)

"Yes. I think optometrists, assistant medical officers, ophthalmic technicians, and nurses should be trained as well. (Participant 4, optometrist)

"… the fact that the primary care providers especially the doctors in the primary care system, in general they are not skilled or train or they may not have enough knowledge to pick up the disease because their exposure generally in training is very minimal. So, they should be trained" (Participant 5, ophthalmologist)

Theme 3: Training method

Most participants expressed that the delivery method of the training programme should consist of both theory and practical.

"Yes, there must be theory and practice." (Participant 13, nurse, Participant 17, assistant medical officer)

"Practical and hands on" (Participant 12, optometrist)

"Yeah, combination. I think more on theory. Because on examination, there's not much. They need the fundus training and eye pressure training." (Participant 6, ophthalmologist)

While, some participants recommended attachment to a glaucoma specialist for the training programme.

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"I think the paramedics must train with the glaucoma specialists. (Participant 6, ophthalmologist)

"The training should be introduced with the glaucoma clinic itself. (Participant 12, optometrist)

Theme 4: Training hours

Participant opinions on training duration varied, ranging from a day to three months.

"Full day workshop or two days." (Participant 7, ophthalmologist)

" Two to three days. Can not be too compact." (Participant 17, medical assistant)

"Just for training course? Maybe two weeks." (Participant 16, ophthalmic technician)

"If you want to do an intensive course, it should be a full three months but if have no budget or time constraints, once a day, once a week or two times a week." (Participant 13, nurse)

"Follow the training hours for the training module for diabetic retinopathy screening." (Participant 4, ophthalmologist)

Theme 5: Training evaluation

Most participants preferred theory and practical exams to evaluate the skills of the eye care providers after the training programme. However, some participants preferred only a theory exam to determine the competency of the screeners.

"To assess the competency, I think you must have a competency examination. So, it can involve both theory and practical sessions." (Participant 2, optometrist)

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“I will suggest theory only. I think in the form of pre- and post-test questions, but that again, once they go back to wherever they come from, the HOD needs to make sure they are competent.” (Participant 1, ophthalmologist)

“For the optometrists, they need to be tested by giving case studies and answer the case orally.” (Participant 11, optometrist)

“Maybe they can check the glaucoma patient from beginning to end and give the result and diagnosis.” (Participant 16, ophthalmic technician)

Most participants preferred that the screeners be credentialed to ensure they are competent in glaucoma screening.

“ They need to be trained and then need to be tested and need to be certified that they are competent then only they are sort of certified to co-manage with the ophthalmologist.” (Participant 7, optometrist)

“I think if we want to set up a proper way to screen glaucoma patients, those who we sent outside to do the screening must undergo a certain period of training and certified by us. Only then can they go out there and do a screening.” (Participant 6, ophthalmologist)

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4.5.4 Discussion

The results showed that most participants recommended the training content of the glaucoma screening module to include basic knowledge of anatomy and physiology of the eye, epidemiology of glaucoma, signs, and symptoms, risk factors, causes, and diagnosis and management of glaucoma, followed by skills in optic disc evaluation and clinical procedures. The clinical procedures included history taking, visual acuity test, tonometry, visual field test, anterior chamber angle grading, and funduscopy. This result was similar to an online training programme for diabetic retinopathy graders in Vietnam where the content of the programme included an introduction to glaucoma, characteristics of a normal optic disc, and the "5 Cs" method for evaluating optic disc photographs for glaucomatous changes (Olawoye et al. 2023). In contrast, Jindal et al.

(2025) conducted a training on the Van Herick technique for community optometrists in the United Kingdom focused on primary angle closure glaucoma through video lectures covering classification of glaucoma, mechanisms, risk factors, examination including Van Herick technique and interpretation, diagnosis, management, and referral (Jindal et al. 2025). Both studies showed that the training content was tailored to the specific learning objectives and target participants.

The target training participants recommended by most participants were primary eye care providers, including optometrists, general practitioners, assistant medical officers, ophthalmic technicians, and nurses. Optometrists were an ideal candidate for training, as they had good knowledge about glaucoma screening (Saravanan et al. 2022) and learn to perform eye examinations in their four-year undergraduate studies (Chen & Ahmad Nazri 2021). Implementing these trainings for primary eye care providers will expand their scope of practice and improve diagnostic accuracy, particularly in rural areas with limited access to eye care services. This was demonstrated by successful referral schemes in the UK and Australia, involving accredited optometrists, which have reduced both false positive and false negative rates in glaucoma referrals (Gunn et al. 2019; Huang et al. 2020). Rengappa et al. (2021) also found a strong agreement between trained ophthalmic technicians and glaucoma specialists in identifying glaucoma suspects.

Most ophthalmologists in the study suggested that general practitioners can be trained in glaucoma screening. In Japan, general practitioners often interpret optic nerve head images from fundus photographs during health examinations (Wada-Koike et al. 2024). However, this study demonstrated that general practitioners exhibited lower sensitivity than ophthalmologists in detecting glaucomatous changes in fundus photography (Wada-Koike et al. 2024). Therefore, general practitioners require specialized training to detect glaucoma accurately (Wada-Koike et al. 2024).

Most participants in this study preferred a combination of lecture and practical sessions. These results aligned with findings from Yoshioka et al. (2015), who suggested that didactic teaching combined with practical sessions improves the detection of glaucoma. However, in India, Saravanan et al. (2022) found that screeners

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with ophthalmic knowledge such as optometrists and optometry students preferred practical sessions as it is more beneficial for glaucoma screening (Saravanan et al. 2022). Some participants in this study advocated for clinical attachments within glaucoma clinics to improve the diagnostic accuracy of glaucoma by allowing screeners to apply theoretical knowledge in real patient settings through exposure to glaucoma cases. This was shown in the UK, where optometrists undergo a two-week clinical attachment in a hospital eye clinic to increase their exposure to ocular diseases before becoming registered optometrists (Rehan & Mcpherson 2024). A study found that placing final-year optometry students for six weeks in an optometry referral centre in Australia was effective in teaching the students about advanced ocular imaging and diagnosis (Chiang et al. 2018). According to their supervisors, the students' clinical skills improved (Chiang et al. 2018) suggesting that practical exposure during clinical placement is important in enhancing clinical skills.

There is no standard duration for training hours. The duration suggested by the participants in this study ranged from one day to three months. A diabetic retinopathy screening programme conducted by the Malaysian Ministry of Health consisted of a two-day duration training programme for assistant medical officers, followed by credentialing and privileging (Ministry of Health Malaysia 2017). While, in Vietnam, a five-hour online course to detect glaucomatous optic disc was shown to improve the ability of 43 non-ophthalmic graders (mean score improved from 33.3±14.3% to 55.8±12.6% after training, $p<0.001$) (Olawoye et al. 2023). Training hours should be tailored to the programme's content to ensure effective implementation of training.

Participants in this study preferred theory-based and practical examinations to evaluate the skills of screeners at the end of the training programme. Pre and post-tests have been used to assess the effectiveness of participants' knowledge before and after training (Olawoye et al. 2023; Tanjirawatana et al. 2025). Practical examinations such as objective structured clinical examinations (OSCE) and direct observation of procedural skills (DOPS) were typically used to assess participants' competency in performing clinical skills (Atinga et al. 2025; Badyal & Sharma 2020; Dejene et al. 2024). This has been demonstrated in Bubb et al. (2021) who used OSCE while Mihailovic et al. (2020) used DOPS.

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Some participants in this study suggested that screeners should be credentialed to ensure that they are competent to perform glaucoma screening. According to Golnick and Anderson (2014), a certification is necessary to ensure the competence of primary eyecare providers via a standardised competence test. This was demonstrated in a recent study, which found that medical officers with credentialing and privileging for diabetic retinopathy screening training programme showed a higher accuracy in fundus interpretation (adjusted OR 2.32, 95% CI: 1.32–2.88) compared to those without credentialing & privileging (Kuthoose et al. 2025). Apart from clinical interpretation skills, credentialing and privileging can be done for handling ophthalmic instruments such as a non-mydriatic fundus camera (Kuthoose et al. 2025).

This study had several limitations that need to be addressed. Firstly, the data collection was conducted in the Klang Valley. Therefore, the perspectives of eye healthcare professionals in other parts of Malaysia may differ, which may limit the generalizability of the results. Lastly, some participants were interviewed face-to-face, while others participated through online interviews. These different data interview methods may have influenced the depth, quality, and consistency of responses, as they can affect participants' engagement, comfort level, and interpretation of questions.

4.5.5 Conclusion

In conclusion, primary eye care providers were recommended to screen for glaucoma. The training programme should encompass theoretical knowledge, clinical procedures, glaucoma diagnosis, and the referral pathway pertaining to glaucoma, which can be delivered through a combination of theoretical and clinical skills sessions. Training hours should be aligned with the training content to ensure effective training. Competency post-training should be assessed through both theory and practical examinations. Credentialing and privileging may ensure the proficiency of glaucoma screeners over time. These findings provide insight into developing and implementing an effective glaucoma screener training programme in Malaysia.

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4.5.6 Integration of Mixed Method Study

This study identified that training should target a multidisciplinary range of primary eye care providers, including optometrists, nurses, ophthalmic technicians, and medical officers. Moreover, training content must consist of both theory and practical application. A blended learning approach was identified as the most effective delivery strategy. Theoretical components are best delivered through didactic lectures or asynchronous online modules, whereas practical sessions are essential for building skills.

Ophthalmologists and glaucoma specialists are identified as the trainers, as they provide the advanced clinical expertise and theoretical knowledge required to teach glaucoma screeners. However, a multidisciplinary team can also be deployed to train glaucoma screeners.

Assessments of glaucoma screeners' competency must evaluate both knowledge and practical skills. Knowledge-based assessment should be delivered via multiple-choice questions (MCQs) or online quizzes. Practical assessments, such as Objective Structured Clinical Examinations (OSCEs) or Direct Observation of Procedural Skills (DOPS), can be conducted to evaluate practical skills.

Finally, establishing an ideal training duration for these programs remains challenging due to extreme heterogeneity in the systematic review. Similarly, qualitative interviews recommended a flexible duration ranging from a single day to three months, ultimately concluding that the training duration must be tailored to the content of the training programme.

4.5.7 Overall Conclusion

The mixed method study identified six essential components of a training programme for glaucoma screeners: (1) primary eye care providers as target participants, (2) theory and practical curriculum, (3) blended delivery methods, (4) ophthalmologists as primary trainers, (5) theory and practical assessments, and (6) a flexible training duration. These

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components identified in this chapter will be used to develop and evaluate the training programme in Chapter V.

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CHAPTER V

PHASE III: DEVELOPMENT AND EVALUATION OF A TRAINING PROGRAMME FOR GLAUCOMA SCREENERS

5.1 INTRODUCTION

The effectiveness of the teleglaucoma programme depends on the competency of glaucoma screeners. Therefore, glaucoma screeners must be trained to ensure that teleglaucoma screening can be implemented successfully. In Malaysia, there is no known training module for training glaucoma screeners. This chapter presents the development and evaluation of a training programme designed to equip glaucoma screeners with the necessary knowledge and skills to conduct efficient screening. There were three sections in this phase: (i) development of the training module and programme, (ii) validation of the training module, and (iii) effectiveness of the training module and programme.

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5.2 OBJECTIVES

The following were the specific objectives as follows:

i) To develop a training module for glaucoma screeners in the teleglaucoma screening programme.

ii) To determine the validity of the training module to be used in the teleglaucoma screening programme.

iii) To determine the effectiveness of the training module for glaucoma screeners in the teleglaucoma screening programme.

5.3 SECTION 1: DEVELOPMENT OF TRAINING MODULE AND PROGRAMME

5.3.1 Methodology

The study design was a design and development research. The research team, which consisted of two ophthalmologists (JCH, RN), three optometry lecturers (MIH, SK, MHR), a public health lecturer (ZMI), and a PhD student (WXH), reviewed and synthesized the systematic review and semi-structured interview findings from Phase I and II. This information was used to design the training programme such as learning objectives, teaching methods, teaching materials such as training module and assessment for screeners.

From findings from a mixed-methods study in previous chapter, six essential components of a training programme were identified: (1) primary eye care providers as the target participants, (2) theoretical and practical curriculum, (3) blended delivery method, (4) ophthalmologists as primary trainers, (5) theory and practical assessments, and (6) flexible training duration. The integration of findings from the systematic review and qualitative interviews identified seven essential components of a teleglaucoma screening programme: (1) accessible screening locations, (2) high risk screening participants, (4) examinations such as history taking, visual acuity assessment, tonometry, fundus photography, and visual field testing (5) trained personnel, (6) referral criteria, and (7) telemedicine store and forward modality. The research team developed the training module based on the synthesis of findings from Phases I and II.

The researchers (JCH, RN, MIH, SK, MHR) developed the training module content, including eye anatomy, glaucoma diagnosis and management, and clinical examinations while an ophthalmic technician provided guidance on operating the fundus camera. The training modules were developed in both English and Malay. The English version of the module was developed initially and reviewed by an ophthalmologist. The module was then revised based on the ophthalmologist's feedback. Following the final revisions, the module was then translated into Malay by an optometrist who is a native speaker.

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The research team developed a training programme comprising theoretical and practical sessions. The Malay language training module was chosen due to the educational backgrounds of the primary eye care providers. Primary eye care providers in Malaysia usually prefer Malay language as the medium of communication. We utilised the Google Classroom platform for the theoretical sessions to enable participants to study outside their working hours and avoid disrupting their work schedules. The training module consisted of seven modules (Table 5.1). The delivery of the theoretical sessions was recorded by invited experts and uploaded to the Google Classroom.

5.3.2 Results

We developed the content of the training module consisted of seven modules (Table 5.1). These modules comprise the overview of glaucoma, ocular anatomy and physiology, signs and symptoms of glaucoma, basic clinical examinations for glaucoma, intraocular pressure (IOP) measurement, fundus camera examination, and management of glaucoma.

Table 5.1 Content of the training module

Module	**Content**
Module 1: Glaucoma: An Overview	Introduction
	Epidemiology
	Health Burden of Glaucoma
	Impact of Glaucoma
	Glaucoma Screening
	Classification of Glaucoma
Module 2: Anatomy & Physiology of the Eye	Anatomy of the Eye
	Fundus Images
	The Visual System
	The Visual Pathway
	Pupillary Light Reflex Pathway
	Ciliary Body
	The Anterior Chamber
	Aqueous Humour Outflow Pathway

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…continuation

	Pathophysiology of Glaucoma
Module 3: Signs & Symptoms of Glaucoma	Symptoms
	Signs
	Risk Factors
Module 4: Basic Clinical Examination Techniques for Glaucoma	History taking
	Visual Acuity Test
	Pupil Examination
	Anterior Chamber Depth Examination
Module 5: Measuring Intraocular Pressure (IOP)	Introduction
	Type of tonometers
	Principles of clinical tonometry
	Non-contact tonometer
	iCare tonometer
Module 6: Examination of the Fundus	Fundus camera examination
	Evaluation of fundus image for glaucoma
	Troubleshooting in fundus photography
	Other abnormal optic disc not related to glaucoma
Module 7: Managing Glaucoma	Workflow of glaucoma screening
	Glaucoma referral pathway
	Referral criteria

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5.3.3 Discussion

Based on our systematic research and semi-structured interviews, we developed a training module for glaucoma screening. The content of this module consisted of an overview of glaucoma, ocular anatomy and physiology, signs and symptoms of glaucoma, basic clinical examinations for glaucoma, IOP measurement, fundus camera examination, and management of glaucoma.

The contents of our training module were similar to an online course conducted in Vietnam to train non-ophthalmic diabetic retinopathy personnel to recognize glaucomatous optic nerves (Olawoye et al. 2023). The training module for the course in Vietnam focused on optic nerve head assessment and comprised of three modules which were an introduction to glaucoma, the characteristics of a standard optic disc, and the

"5 Cs" method for evaluating optic disc photographs for glaucomatous changes (Olawoye et al. 2023). The “5 Cs” method assesses five characteristics such as the **C**up-to-disc ratio (CDR), **C**olour of a neuroretinal rim, **C**omparison of optic nerve heads between the patient’s eyes, **C**ontour of the nerve and **C**oncerns (this includes optic disc haemorrhages, papilloedema and optic disc oedema with blurred nerve head margins) (Olawoye et al. 2023). This method can be accessed through the Orbis Cybersight website (www.cybersight.org). However, our training module offers a broader scope, incorporating basic glaucoma screening procedures such as visual acuity test, pupil examination, oblique flashlight test, fundus camera, tonometry, and management such as referral criteria and follow-up. In our module, we used “5 R” method to evaluate optic nerve head such as **R**ing (scleral), **R**im (neuroretinal rim), **R**etinal nerve fibre layer, **R**egion (presence of parapapillary atrophy), and **R**etinal or optic disc hemorrhages (Fingeret et al. 2005). We also included additional criteria, such as measurement of the cup-to-disc ratio (CDR), comparison of the CDR between the two eyes, and vascular changes such as bayonetting, nasalisation and laminar dot sign.

In contrast, a UK study developed an online education package for optometrists focusing on the Van Herick technique and primary angle-closure glaucoma (Jindal et al. 2025). This package incorporated a recorded lecture on primary angle-closure glaucoma's mechanisms, risk factors, tests, diagnosis, management, referral guidelines, specific instructions on the Van Herick technique, and links to articles (Jindal et al. 2025). Our training module covers all types of glaucoma, including angle-closure glaucoma. However, it does not include the Van Herick technique, as most of our target screeners were nurses, medical assistants, and ophthalmic technicians. These eye care providers were not trained to use a slit lamp, which is required to learn the Van Herrick technique. Some content in the education package, such as risk factors, diagnosis, management, and referral guidelines, was similar to our module.

5.3.4 Conclusion

In conclusion, the content of the training module was developed to ensure comprehensive coverage of glaucoma screening, which integrates theoretical

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knowledge and practical skills. The following section will focus on validation to assess the module's validity before implementation.

5.4 SECTION II: VALIDATION OF TRAINING MODULE

5.4.1 Introduction

A validation process must be conducted to ensure that the content of a training module is accurate, relevant, and suitable for the target participants. Validity is the extent to which an instrument accurately measures the theoretical variables it is intended to assess (Ahmed & Ishtiaq 2021). There were four types of validity such as content validity, face validity, construct validity and criterion validity (Creswell 2005). Face validity was defined as a superficial assessment of whether the items appear to be related to the concept (Holden 2010; Martinez 2017). It determines whether the training module is understandable from the perspectives of experts and potential users (Allen et al. 2023). Content validity is the degree to which the instrument's items represent the content of the concept being measured (Ahmed & Ishtiaq 2021; Rusticus 2023). This process involved evaluation by experts who assessed each module based on relevance, clarity, simplicity, and ambiguity criteria. Construct validity measures the accuracy with which an instrument measures the targeted construct (Ahmed & Ishtiaq 2021). While, criterion validity refers to the degree to which the outcomes of the instrument correlate with other valid measures of the same concept (Ahmed & Ishtiaq 2021). There were two types of criterion validity: concurrent validity and predictive validity (Indu et al. 2025). Concurrent validity assesses how well the new instrument compares with an existing standard instrument when both are administered simultaneously (Mohajan 2017). Predictive validity assesses whether an instrument can predict future performance (Lim 2024; Repke et al. 2024).

In the context of developing a training module, face and content validity are the first steps in establishing the quality of the training module. These evaluations were conducted in the subsequent training evaluation section, following the implementation of the module. Criterion and construct validity were not assessed in this study, as it requires a separate, large-scale testing phase, such as comparing trained versus untrained staff over time, and future performance which was outside the scope of this

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study. Therefore, this section focused on content and face validity to assess the quality of the module. The feedback from content and face validity was used to identify areas requiring improvement, allowing for the revision of the module and thereby increasing its effectiveness for implementation in the next section, which is the training programme.

5.4.2 Methodology

This is a cross-sectional study. The participants were 1) ophthalmologists who are working in teaching hospitals and Ministry of Health hospitals, 2) optometrists who are working at private optometry centres, and 3) nurses, ophthalmic technicians, and assistant medical officers who are working at private and public hospitals in Klang Valley. Two groups of participants were involved in validating the module: the experts and the target users of the training module. The panel of experts evaluated the content and face validity, while the target users evaluated the training module's face validity. Snowball sampling was used to recruit participants for validation of the training modules. Ethics approval was obtained from the Research Ethics Committee Universiti Kebangsaan Malaysia (UKM PP1/111/8/JEP-2020-127) (Appendix A). This study was conducted in accordance with the Declaration of Helsinki and the principles of Good Clinical Practice (GCP).

a. Content and Face Validation by the Expert Panels

This study was conducted over a five-month period from January 2022 to May 2022. The inclusion criteria for expert panels included registered healthcare practitioners who were able to understand Malay and English and comprehend the study's purpose. Participants who were not motivated to participate in the study were excluded from the study. The sample size calculation was based on Yusoff (2019), who recommended six to ten experts for validity.

A list of ophthalmologists and optometrists in the Klang Valley was obtained from the National Specialist Register and the Malaysian Optical Council websites, respectively. Following the initial recruitment of ophthalmologists and optometrists, participants were invited to refer other colleagues who also met the study criteria. Participants were provided with an information sheet about the study (Appendix N) and

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an informed consent form to be signed prior to the commencement of the study (Appendix G). Upon obtaining signed informed consent forms, the English-language version of the module was distributed via email, with the soft copies of the content and face validation instruments, followed by the Malay version after they completed the assessment of the former. Distributing both versions simultaneously risked the Malay translation being based on the English module. This process ensured strict consistency between both language versions.

b. Content Validation Instruments

Two types of content validation instruments were used in this study (Appendix O & P). The first content validation instrument was focused on each module (Appendix O). Each module was rated based on four criteria: relevance, clarity, simplicity and ambiguity, using a Likert 4-point scale. These four criteria of content validity were based on the criteria set by Yaghmaei (2003) for measuring content validity. A comment section was included for each module to allow the expert panels to submit their feedback. Table 5.2 shows the criteria used to measure the instrument's content validity.

Table 5.2 Rating criteria for measuring content validity for each module in the instrument

Criteria	1	2	3	4
Relevance	Not relevant	Items need some revision	Relevant but needs minor revision	Very relevant
Clarity	Not clear	Items need some revision	Clear but needs minor revision	Very clear
Simplicity	Not simple	Items need some revision	Simple but needs minor revision	Very simple
Ambiguity	Doubtful	Items need some revision	No doubt but needs some minor revision	Meaning is clear

Source: Yaghmaei (2003)

The second validity instrument was adopted from an instrument in a study by Castro et al. (2007). This instrument focused on the overall evaluation of the content validity of the training module. There were two components to be evaluated in the training module: scientific accuracy and content. There were six items that required

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evaluation by the expert panels (Appendix P). The expert panels rated each item using a 4-point Likert scale, where 1 = not relevant, 2 = some revision required, 3 = relevant but needs minor revision, and 4 = very relevant. There was a comment section in each item for the expert panels to submit their feedback. Table 5.3 shows the items in the instrument.

Table 5.3 Items in the overall content validity instrument

Criteria	Item
Scientific accuracy	The contents are in agreement with the current knowledge
	Recommendations are necessary and are correctly approached
Content	Objectives are evident
	Recommendations about the desired behaviour (glaucoma screening) are satisfactory
	There is no unnecessary information
	Important points are reviewed

Source: Castro et al. (2007)

i. Face Validation Instrument

We used the face validity instrument by Shuhaimi et al. (2023) who adapted the instrument from Castro et al. (2007) (Appendix Q). There were 27 items, and the criteria included literary presentation, illustrations, legibility, the module's specificity and understandability, and the quality of the information. The participants were asked to rate "yes" or "no" for each item in the face validity form. We used the same rating system as the study by Lau et al. (2019) who also adapted the instrument from Castro et al. (2007) for face validity. A comment section was included at the end of the instrument, allowing participants to comment on any issues that could be improved in the module. Table 5.4 shows the items in the instrument.

Table 5.4 Items in the face validity instrument

Criteria	Item
Literary Presentation	The content is concisely expressed
	Planning and sequence of information is consistent
	Material is reader-friendly

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	Language is explanatory
	The vocabulary is composed of simple words
	The language is suitable
	Identification of headings and subheadings help in the learning process
Illustrations	The illustrations are simple, appropriate, and present an easily understandable outline
	Lists, tables and graphs are self-explanatory
	The illustration has suitable headings
	The illustrations are related to the text (express the desired purpose)
	The illustrations are integrated to the text (Easily located)
Legibility	Size of the letters is adequate
	Style of letters is adequate
	Spacing between letters is adequate
	Spacing between lines is adequate
	Spacing between paragraphs is adequate
	Use of bold characters and bullet points draw attention to specific points or key content
	Adequate use of blank space reduces overcrowded appearance
	Subheadings or the inner margins make reading and memorization easier
	Format of the material is adequate
Module is specific and understandable	Headings and subheadings are clear and informative
	Technical terminology is adequately defined
	Instructions are clear
	Use of words or expressions with double meanings does not occur in the text
Quality of information	Information is updated
	Material helps target users to undertake the desired actions (glaucoma screening)

Source: Castro et al. (2007)

The experts were given a month to evaluate the content and face validity of the training module. The investigator calculated the content validity index (CVI), the agreement percentage for face validity and compiled the experts' suggestions to improve the training module. A review panel comprising two ophthalmologists, three optometrists, and a public health specialist reviewed the tabulated results. The training

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modules were modified after the review panel reached a consensus on each item. The final module was used for face validation in the next study.

c. Face Validation by the Target Users

The target users evaluated the face validity of the training module after it was modified by the experts. They used the same instrument as the experts to assess face validity (Appendix Q). This study was conducted from June to December 2022. The inclusion criteria included healthcare practitioners such as optometrists, nurses, ophthalmic technicians, and assistant medical officers who were able to understand both Malay and English and comprehend the purpose of the study. Participants who were not motivated to participate in the study were excluded from the study. The sample size calculation was based on the recommendation of a minimum of ten target users for face validity (Yusoff 2019).

A snowball sampling method was employed, which eligible participants were asked to refer other participants to join the study. The eligible participants were provided with an information sheet about the study (Appendix N) and an informed consent form to be signed via email prior to the commencement of the study (Appendix G). Upon obtaining a soft copy of the signed informed consent form, the English-language version of the module was distributed via email, with the soft copy of the face validation instrument followed by the Malay version after they completed the assessment of the former. The target users were given a month to evaluate the face validity of the training module.

The investigator calculated the agreement percentage for face validity and compiled the target users' suggestions to improve the training module. A review panel comprising two ophthalmologists, three optometrists, and a public health specialist reviewed the tabulated results. The training modules were modified after the review panel reached a consensus on each item. The final English-language version was accepted, while the final Malay-language version underwent forward-backward translation by four optometrists (two for forward translation and two for backward translation) whose native language was Malay and who were fluent in English.

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5.4.3 Data Analysis

The demographic data was analysed using descriptive statistics in SPSS version 27 (IBM Corp., New York, USA). Data from content and face validity were entered and analysed in Microsoft Excel 2020 (Microsoft Corp., Redmond, Washington, USA). The result of content validity was obtained by calculating CVI. There were two types of CVI: the item-level CVI (I-CVI) and scale-level CVI/Average (S-CVI/Ave) (Polit & Beck 2006; Yusoff 2019). The I-CVI for each item was determined using the following formula (Polit & Beck 2006).

$$\mathrm{I-CVI} = \mathrm{n/N}$$

n= number of experts rate a score of 3 or 4

N= total number of experts

The S-CVI/Ave was the average of all item I-CVIs (Polit & Beck 2006). According to the Polit and Beck (2006), the module has excellent content validity if the minimum I-CVI is 0.78 for six to ten experts and 0.90 for SCVI/Ave.

Each of the item in the face validation instrument was reported using frequencies and percentages. The agreement percentage for experts and target users were calculated for each item for face validation. Items were considered validated if they received 75% positive responses from the evaluators (Teles et al. 2014).

5.4.4 Results

a. Demographic Data

Nine experts (six males and three females) were involved in the content and face validation of the training module. The mean age of the experts was 47.56±5.83 years. Most of the experts were Malays (n=7). The other two experts were Chinese and Indian, respectively. The expert panel comprised five ophthalmologists, two optometry lecturers, a nursing tutor, and an assistant medical officer. Three experts held doctoral

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degrees, two held master's degrees, one a bachelor's, and one a diploma. Five had over twenty years of professional experience, three had ten to twenty years of experience, and one had less than ten years of experience.

Sixteen target users, consisting of seven optometrists, four ophthalmic technicians, three nurses, and two assistant medical officers, were recruited for the face validation study. The majority were females (11) with a mean age of 33.31±4.17 years. Seven participants were Malays, seven were Indian, and two were Chinese. Three participants had over ten years of working experience, nine had five to ten years of working experience, and four had less than five years of experience.

b. Content Validity

Table 5.5 shows the I-CVI values for each module in the Malay language while Table 5.6 shows the SCVI/Ave for each module based on Yaghmaei (2003) instrument. The results showed excellent content validity for all seven modules in Malay language version. Each module achieved an I-CVI of 0.78 or higher across all four criteria (relevance, clarity, simplicity, and ambiguity). S-CVI/Ave was higher than 0.90 for each of the four criteria.

Table 5.5 I-CVI values of each module by experts based on Yaghmaei (2003) instrument

Module	Item Content Validity Index (I-CVI)			
	Relevance	Clarity	Simplicity	Ambiguity
Module 1	1.00	1.00	1.00	1.00
Module 2	0.89	1.00	1.00	1.00
Module 3	1.00	1.00	0.89	0.89
Module 4	1.00	1.00	1.0	1.00
Module 5	1.00	1.00	1.00	1.00
Module 6	1.00	1.00	1.00	1.00
Module 7	1.00	0.89	0.78	0.89

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Table 5.6 Scale Content Validity Index/Average (SCVI/Ave) for each criterion for the module based on Yaghmaei (2003) instrument

Criteria	Scale Content Validity Index/Average (SCVI/Ave)
Relevance	0.98
Clarity	0.98
Simplicity	0.95
Ambiguity	0.97

Table 5.7 shows the results of the overall I-CVI of the module based on Castro et al. (2007). Each module obtained an I-CVI higher than 0.78 for scientific accuracy and content criteria. The module obtained an overall S-CVI/Ave higher than 0.90, which was 0.98.

Table 5.7 Overall I-CVI by experts based on Castro et al. (2007) instrument

Content Validity Criteria	I-CVI
Scientific Accuracy	
Contents agree with the current knowledge	1.00
Recommendations are necessary and are correctly approached	1.00
Content	
Objectives are evident	1.00
Recommendations about the desired behaviour for glaucoma screening are satisfactory	1.00
There is no unnecessary information	0.89
Important points are reviewed	1.00

c. Face Validity by experts

Figure 5.1 shows the level of agreement of the experts. The level of agreement among the experts for each evaluation criterion was higher than 75%, ranging from 83.4% to 97.2% for both the English and Malay language versions of the module. These results indicated that each version of the module possesses adequate face validity.

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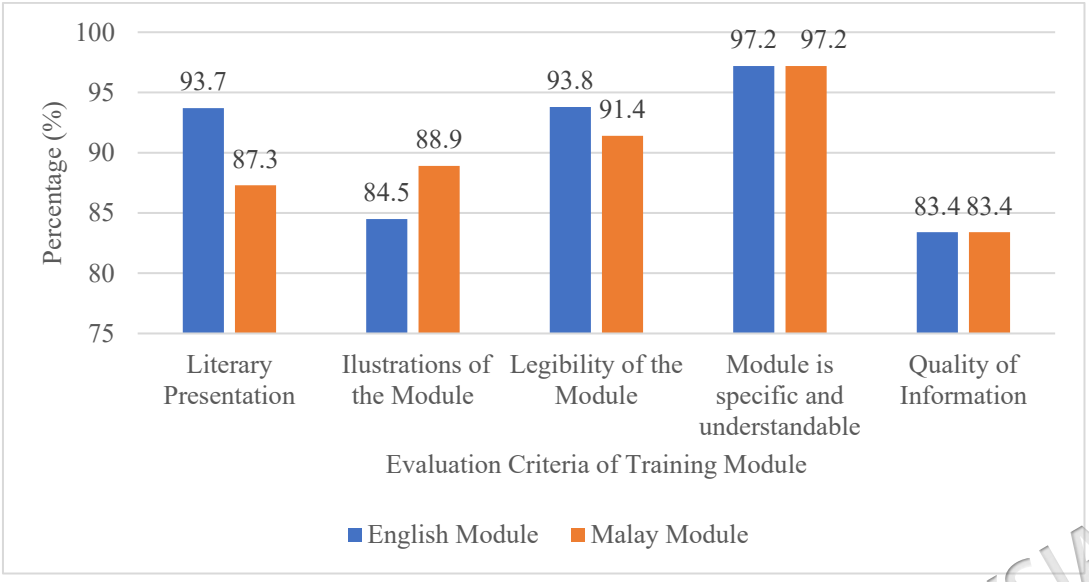

Figure 5.1 Levels of agreement among experts for face validity

i. Face validity by target users

Figure 5.2 shows the level of agreement among target users for the five evaluation criteria for the module's face validity. There was a high level of agreement for all five evaluation criteria, ranging from 93.8% to 100% for the English version and 94.4% to 100% for the Malay version of the module. The results exceeded the minimum 75%, indicating an excellent level of agreement among the target users.

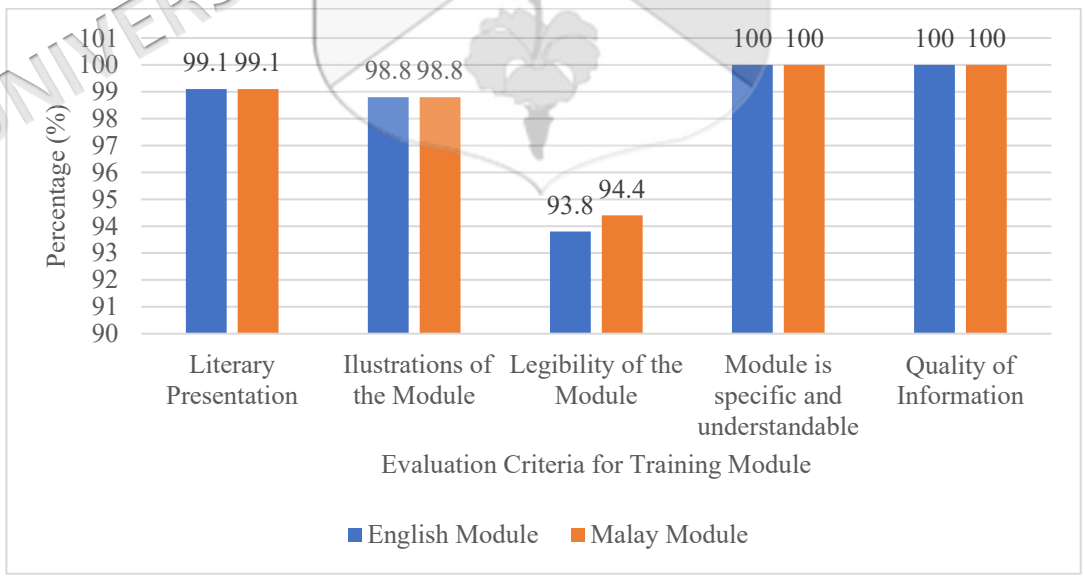

Figure 5.2 Level of agreement by target users for face validity

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ii. Suggestion to improve the training module

Suggestions to improve the module were provided by experts, including changing the font type and size, modifying the illustrations, simplifying the instructions, and adding a summary for each module to make the module more attractive and user-friendly for the target users.

The target users also suggested improvements to the module, such as incorporating a flowchart and a table to present the information, revising the wording, and modifying some illustrations to make the module more visually appealing.

5.4.5 Discussion

The findings showed that both English and Malay language modules have good content and face validity. Our training module is the first training module designed for glaucoma screeners in Malaysia. Other glaucoma training modules such as Olawoye et al. (2023) and Jindal et al. (2025) were focused on specific clinical skills. Olawoye et al. (2023) developed a training module on assessment of glaucomatous optic nerve head, while Jindal et al. (2025) focused on the Van Herick technique and primary angle closure glaucoma. These studies were validated differently (Jindal et al. 2025; Olawoye et al. 2023). Olawoye et al. (2023) module was validated by their own authors. However, their validation process was not clear. Jindal et al. (2025) used two experts to validate their online education package, but they did not report the results of their CVI. Opinions about the number of experts needed for the validation process differ. Davis (1992) suggested a minimum of two subject matter experts, while Almanasreh et al. (2019) recommended five to ten experts to mitigate the risk of chance agreement and ensure sufficient information for effective instrument development.

All suggestions from experts and target users to make the training module more attractive and understandable were incorporated into the final training module. We changed the Times New Roman font size 12 to the Arial font size 11. This change was supported by a survey by Tee et al. (2022), which found that most of their participants preferred Arial font for the training module. The same font type and size were also employed by Arif et al. (2020) in the development of a vocational fuel systems module,

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which utilized 11-point Arial with 1.5 line spacing. Illustrations were added to enhance the readability of our training module, supported by Ksheeraja et al. (2021) who found that most medical students felt pictures in their training module were beneficial for helping them understand both theoretical (60.7%) and clinical knowledge (54.8%) about ophthalmology. A survey by King et al. (2022) also reported that 91% of their participants (n=60) who were pharmacy students felt that the flowcharts in their training module helped improve their knowledge.

A limitation of this study was that the target population was recruited from one locality, Klang Valley. This may introduce sampling bias as it may not accurately represent regional and cultural differences that can influence clinical practices in different parts of Malaysia. Thus, it limits the generalizability of the findings, as the sample may not accurately represent the Malaysian population. Future studies should consider recruiting samples from different geographical locations to enhance the generalizability of these findings.

5.4.6 Conclusion

The study demonstrated that our training module in both languages has good content and face validity. Therefore, it can be used to train primary eye care providers in glaucoma screening. A study should implement this training module to test its effectiveness.

5.5 SECTION III: EFFECTIVENESS OF TRAINING MODULE AND PROGRAMME

5.5.1 Introduction

A validated training module should be evaluated for its effectiveness via a training programme. Assessing effectiveness provides evidence on how well the training module translates theoretical design into actual learning and performance improvement.

Testing the effectiveness of the training module and programme usually involves measuring learning outcomes through pre- and post-tests (Obasanjo & Blackwell 2025), practical assessments (Garba et al. 2026) or surveys (Svistkova et al.

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2025). These assessments help determine whether the training module has the potential to improve knowledge or skills. Pre-and post-tests measure whether the knowledge of participants improved after an educational training module and programme was introduced (Obasanjo & Blackwell 2025). This method was widely used in health training programme to assess its effectiveness (Obasanjo & Blackwell 2025). Practical assessments help evaluate a healthcare professional's ability to perform required skills (Garba et al. 2026). Surveys can be administered following the training to gather feedback on the training (Svistkova et al. 2025). The objective of this study was to determine the effectiveness of the training module in the teleglaucoma screening programme.

5.5.2 Methodology

The study used a pre- and post-test design to assess the effectiveness of the training module and programme. A control group was not included due to the risk of contamination, as participants involved in the validation of the training module may share the training module with non-participants, which could potentially bias results. The study was conducted from January to May 2023. Primary eye care providers such as optometrists, ophthalmic technicians and assistant medical officers who were working at eye clinic Hospital Canselor Tuanku Muhriz (HCTM), Primer Clinic HCTM and private optometry practices in Kuala Lumpur were recruited using convenience sampling. This study was conducted in accordance with the Declaration of Helsinki and the principles of Good Clinical Practice (GCP).

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The inclusion criteria were primary eye care providers who understood the purpose of the study and were fluent in Malay. This language criterion was chosen because Malay is the primary language used by the target participants. Consequently, the Malay-language training module was selected to test the programme’s effectiveness, as it aligns with the educational backgrounds of primary eye care providers. Participants who were not motivated to participate were excluded.

The sample size was calculated using G Power 3.1 software. We used Olawoye et al. (2023), mean score for pre-test of recognizing glaucomatous optic nerve in an

online training course was 33.3%±14.3% and post-test score was 55.8%±12.6% (Olawoye et al. 2023). Based on this study, the sample size was seven participants at a 95% confidence level and a power of 80%. Taking into account a 20% dropout, the final sample size was eight participants. However, Fraenkel et al. (2012) suggested that 15 to 30 participants were needed for conducting experimental research in education. Given the small sample size using Olawoye et al. (2023), we decided to recruit 15 participants according to Fraenkel et al. (2012).

Primary eye care providers who met the eligibility criteria were approached through the heads of the respective clinics' departments. While, private optometrists were invited via the head of a private optometry charity organisation (Our Optometris). An information sheet about the study (Appendix R) and an informed consent form (Appendix G) were provided to all participants. A signed consent form was obtained prior to the study.

The training programme comprised both theory and practical sessions. Theory sessions were conducted online via the Google Classroom platform. Prior to the start of the theory sessions, all learning resources were uploaded to the Google Classroom platform. This included the soft copy of the Malay training module, a series of lecture videos, and links to relevant YouTube videos that demonstrated skills in glaucoma screening, such as using a non-mydriatic fundus camera, iCare tonometer, air puff tonometer, oblique flashlight test, pupil examination, and visual acuity test.

Participants were asked to complete the pre-test multiple-choice questions (MCQs) and a self-assessment questionnaire of their glaucoma screening skills via Google Forms before the online theory session began. Pre-test MCQs were developed by the research committee members, comprising an ophthalmologist and three optometrists, based on the training module content. The MCQs were 31 single-response answers in both Malay and English (Appendix S). The pre-test MCQs were also used as the post-test MCQs. The MCQs underwent peer review by a panel of reviewers comprising an ophthalmologist, two optometrists, and a public health specialist who were not involved in developing the questions. The committee integrated this input and reached a consensus, finalizing the items for online administration via Google Forms.

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All tests were pilot tested with a small group of four target users, comprising three optometrists and an assistant medical officer, who reported no issues. The pilot testing was conducted to assess clarity and comprehensibility of MCQs. Therefore, a small group of representative target users such as four target users was considered sufficient to ensure the clarity and appropriate phrasing of the MCQs (Jørgensen et al. 2019).

Self-assessment of participants' skills in the glaucoma screening questionnaire was adapted from an instrument by O' Carroll et al. (2023) (Appendix T). The questionnaire evaluated eight key skills related to glaucoma screening. We added three items of glaucoma screening skills, which were not included in the questionnaire by O' Carroll et al. (2023) such as history taking, identifying patients with the risk factors of glaucoma, and measurement of intraocular pressure using an iCare tonometer. We used a Likert 4-point scale for rating each item, where "1" is the least competent and "4" is the most competent (Lind et al. 2002). Table 5.8 shows the skills in glaucoma screening in the self-assessment questionnaire.

Table 5.8 Skills in glaucoma screening in the self-assessment questionnaire

No.	Skills in glaucoma screening
1	Conducting a history taking
2	Assessing visual acuity
3	Conducting pupil examination and the oblique flashlight test
4	Measuring intraocular pressure using the iCare tonometer
5	Using a fundus camera
6	Recognising signs and symptoms of glaucoma
7	Identify the patient with risk factors of glaucoma
8	Knowing when to refer a glaucoma patient appropriately

After completing the pre-test and self-assessment questionnaire, participants were given the link to the online learning platform via email. Participants were given two weeks to complete the online theory session.

The one-day training workshop for the practical session was conducted at the Ophthalmology Clinic HCTM. The workshop was led by six trainers, including a glaucoma specialist, two optometry lecturers, and three optometrists. The workshop

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included practical training sessions on glaucoma screening skills such as history taking, visual acuity test, pupil examination, oblique flashlight test, tonometry using an iCare tonometer, non-mydriatic fundus camera, and a lecture on fundus grading for glaucoma diagnosis.

Following the practical session, participants' clinical skills were assessed using six objective structured clinical examination (OSCE) stations. The six stations were history taking, visual acuity test, pupil examination, oblique flashlight test, iCare tonometry, and fundus camera examination. The rubric form for evaluating practical skills in glaucoma screening was obtained from the Optometry Department, Universiti Kebangsaan Malaysia (Appendix U). In the rubrics, the marks for the practical skills were as follows: 20 points for history taking, 20 points for the visual acuity test, 15 points for pupil examination, ten points for the oblique flashlight test, seven points for iCare tonometry, and eight points for the fundus camera examination. The total marks were 80 points. Eighty points were converted to 100 percent after participants completed the OSCE.

The fundus grading test was also used to evaluate their ability to diagnose fundus images and recognize glaucoma signs. The questions for the fundus grading test were developed by the investigators. The fundus images were obtained from the fundus images database in the Ophthalmology Clinic, HCTM. This test comprised 20 fundus images and was delivered to the participants via a Google link. The participants must describe the findings of the fundus images and diagnose each image as either glaucoma, probable glaucoma, normal fundus, or another eye disease (Picture 5.1). Each fundus image carried two points, with a total of 40 points. Forty points were converted to 100 percent after participants completed the test.

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16. 7 a) Nyatakan penemuan tanda-tanda bagi imej fundus berikut (Contoh: nisbah c/d) . *

Please describe the findings for the following fundus image(E.g. c/d ratio).

17. 7 b) Diagnosis bagi imej fundus Soalan 7 ialah: *

The diagnosis for the fundus image in Question 7 is :

Picture 5.1 Fundus grading test

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At the end of the workshop, participants were asked to complete the post-test MCQs, questionnaires evaluating the training module and training programme, and a self-assessment of their glaucoma screening skills using Google Forms. We utilized the instrument developed by Price et al. (2022) to evaluate the training module (Appendix V). The questionnaire consisted of seven items, which included the usefulness of the module, clarity of the content, relevance of the module to the user, likelihood of training module usage in the future, accessibility of the module, how likely the participants would recommend the training module to another colleague and how well the module maintain participant's interest and attention. This questionnaire used a Likert 5-point scale for rating the items, ranging from "not at all" to "very much". Table 5.9 shows the items included in the questionnaire.

Table 5.9 Items included in the evaluation of the training module questionnaire

No	Item
1	How useful did you find the module content?
2	How relevant was the content to your work/profession?
3	How likely do you think you are to utilize this module in the future?
4	How accessible was the module?
5	How well did the module maintain your interest and attention?
6	How clearly was the information in the module presented?
7	How likely would you be to recommend this module to other eye healthcare providers?

Source: Price et al. (2022)

A questionnaire evaluating the training programme was adapted from an instrument developed by Löwe et al. (2008) (Appendix W). This questionnaire consisted of five items, as shown in Table 5.10. A Likert 5-point scale was used for the scoring, where '1' is very poor and '5' is very good. A Likert 5-point scale was used instead of a Likert 6-point scale in the instrument by Löwe et al. (2008), as it was a widely used Likert scale for a questionnaire (Kusmaryono & Wijayanti 2022). Kusmaryono and Wijayanti (2022) recommended using a Likert scale with odd response choices for the questionnaire. In addition, there were two other sections: demographic data and two open-ended questions for participants to write about their perceptions of the training programme's strengths and weaknesses.

Table 5.10 Items included in the evaluation of the training programme questionnaire

No	Item
1	Quality of content
2	Trainers
3	Teaching methodology (Video lectures with the Google Classroom platform)
4	Training workshop
5	Relevance for the training for own job

Source: Löwe et al. (2008)

5.5.3 Data Analysis

SPSS version 27 (IBM Corporation, New York, USA) was used to analyse the data. Demographic data were analysed using descriptive statistics. The Shapiro-Wilk

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test was used to determine whether the data were normally distributed. The numerical data were presented in median and interquartile range. Each item in the self-assessment and evaluation questionnaires for the training module and training programme was reported using median and interquartile range. Answers to the open-ended questions in the training programme evaluation questionnaire were imported into Microsoft Excel 2020 (Microsoft Corp., Redmond, WA, USA) for coding. The Wilcoxon signed-rank test was used to compare the pre- and post-tests, as the data were not normally distributed. p-value ≤ 0.05 was considered significant.

5.5.4 Results

i. Demographic Data

Eighteen participants were recruited for the training programme. Table 5.11 shows the demographic data of the participants. The participants' mean age was 35.00 ± 6.87 years, ranging from 24 to 48 years old. Most participants were mostly females (n=10, 55.56%) and Malay (n=15, 83.33%). They were also mostly comprised of optometrists (n=8, 44.44%). Many participants worked in a hospital (n = 9, 50%). Most of them had ten years or more of working experience (n = 11, 61.11%). They also hold various academic backgrounds, with most participants holding a diploma (n = 10, 55.56%).

Table 5.11 Demographic data of the participants

Characteristics (N=18)		**n (%)**
Age		
	Mean±SD (years)	35.00±6.87
	Range (years)	24-48
Gender		
	Male	8 (44.44)
	Female	10 (55.56)
Race		
	Malay	15 (83.33)
	Chinese	3 (16.67)
Occupation		
	Optometrist	8 (44.44)

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Assistant medical officer	5 (27.78)
Ophthalmic technician	5 (27.78)
Current working place	
Primary health clinic	5 (27.78)
Hospital	9 (50.00)
Optometry Practice	4 (22.22)
Education Level	
Diploma	10 (55.56)
Bachelor's degree	5 (27.78)
Master's degree	3 (16.67)
Years of working experience	
Less than four years	4 (22.22)
Four to nine years	3 (16.67)
Ten years and more	11 (61.11)

ii. Pre and post-test MCQs

Table 5.12 shows the results of the pre- and post-test knowledge assessments before and after training. There was a significant difference in median knowledge pre- and post-training (z = -2.33, p = 0.02).

Table 5.12 Results from pre- and post-test of knowledge before and after training

Score	Median (Interquartile range, IQR)	Wilcoxon Signed Rank Test	
		Z-score	p-value
Pre-test	61.29 (22.58)	-2.33	0.02
Post-test	70.97 (23.39)		

iii. Practical test score

Table 5.13 shows the median scores of skills assessed in the OSCE. The lowest median score was for history taking. The median score for the remaining skills was high. The total median score was high for all skills.

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Table 5.13 Median score of the skills assessed in the OSCE

Skills assessed in the practical test	Median (IQR)
History taking (out of 20 points)	18.50 (3.25)
Visual acuity test (out of 20 points)	20.00 (0.00)
Pupil examination (out of 15 points)	15.00 (1.25)
Oblique flashlight test (out of 10 points)	10.00 (1.00)
iCare tonometry (out of 7 points)	7.00 (0.63)
Fundus camera examination (out of 8 points)	7.00 (0.00)
Total score (100%)	94.38 (8.28)

iv. Fundus grading test

The median score was 55.63% (11.56) for the fundus grading test .

v. Self-assessment of skills in glaucoma screening pre- and post-training

Table 5.14 shows the self-assessment scores for skills in glaucoma screening pre- and post-training. There was a significant difference in self-assessment for all skills before and after training (history taking, p= 0.001; visual acuity test, p=0.011; and the rest of the skills, p<0.001). Pre-training self-assessment revealed that participants' lowest perceived competence was in conducting pupil examinations and oblique flashlight tests, identifying patients with risk factors for glaucoma, and making appropriate referrals for glaucoma patients. All items showed improvement post-training.

Table 5.14 Self-assessment scores for skills in glaucoma screening pre- and post-training

Skills	Pre-Training	Post-Training	Wilcoxon Signed Rank Test	
	Median (IQR)	Median (IQR)	Z-score	p-value
History taking	3.00 (1.30)	4.00 (0.00)	-3.25	0.001
Measurement of Visual Acuity	3.00 (2.00)	4.00 (1.00)	-2.59	0.011
Conducting pupil examination and the oblique flashlight test	2.50 (1.00)	4.00 (1.00)	-3.62	p<0.001

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Measuring intraocular pressure using iCare	3.00 (2.00)	4.00 (0.25)	-3.33	p<0.001
Using a fundus camera	3.00 (1.00)	4.00 (0.00)	-3.32	p<0.001
Able to recognise signs and symptoms of glaucoma	3.00 (1.00)	4.00 (1.00)	-3.48	p<0.001
Able to identify patients with risk factors of glaucoma	2.50 (1.00)	4.00 (1.00)	-3.49	p<0.001
Able to refer a glaucoma patient appropriately	2.50 (2.00)	4.00 (1.00)	-3.58	p<0.001

vi. Evaluation of the training module questionnaire

Table 5.15 shows the median score from the evaluation of the training module questionnaire. The median score for each item in the training module questionnaire was high, indicating that the module was useful, accessible, and presented clear, engaging content relevant to their profession, and can be recommended to other eye healthcare providers.

Table 5.15 Median score from the evaluation of the training module questionnaire

Item	Median (IQR)
How useful did you find the module content?	5.00 (0.00)
How relevant was the content to your work/profession?	5.00 (0.00)
How likely do you think you are to utilize this module in the future?	5.00 (0.00)
How accessible was the module?	5.00 (0.00)
How well did the module maintain your interest and attention?	5.00 (0.00)
How clearly was the information in the module presented?	5.00 (0.00)
How likely would you be to recommend this module to other eye healthcare providers?	5.00 (0.00)

vii. Evaluation of the training programme

Table 5.16 shows the median score of the evaluation of the training programme. The median score for each item in the training programme evaluation questionnaire was high, indicating that the training programme was of high quality, with good trainers, teaching methodology, training workshops, and relevance to their current jobs.

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Table 5.16 Median score of the evaluation of the training programme

Aspects of the training programme	Median (IQR)
Quality of content	5.00 (1.00)
Trainers	5.00 (1.00)
Teaching methodology (Video lectures with the Google platform)	5.00 (1.00)
Training workshop	5.00 (1.00)
Relevance for the training for own job	5.00 (1.00)

Most participants (n=15, 83.33%) felt the training programme helped improve their knowledge of glaucoma screening. Some participants (n=4, 22.22%) felt that the training improved their skills and confidence and refreshed their memory of glaucoma screening. A participant said the training content was clear, while another said the online module was compact and easy to understand. However, some participants (n =3, 16.67%) did not prefer the online learning platform, while others (n =3, 16.67%) disliked that the workshop was held on the weekend.

5.5.5 Discussion

The findings indicated that the training programme improved markedly the participants' knowledge. The participants acquired a high score in practical skills but acceptable score for fundus grading test. Additionally, participants reported they felt their skills had increased after training. They also rated a high score in performance for both the training module and programme. Qualitative feedback indicated that most participants felt the training programme improved their knowledge, skills, and confidence in glaucoma screening, while the weakness of the training programme was the online learning platform and workshop conducted on the weekend.

The findings suggest that the training module enhanced primary eye healthcare providers' knowledge of glaucoma screening. This result aligns with other studies that have utilised training for healthcare providers in glaucoma. A training programme that trained community health workers in Nigeria to use portable glaucoma screening instruments found that scores on the glaucoma knowledge assessment test improved from 0% to 45% pre-test to 50% to 100% post-test (Garba et al. 2026). Olawoye et al. (2023) successfully trained non-ophthalmic diabetic screening graders in Vietnam to

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recognize glaucomatous optic nerve heads using a short online course. Their mean score improved from 33.3±14.3% pre-training to 55.8% ± 12.6% post-training ($p<0.001$) (Olawoye et al. 2023). Another study, which trained ophthalmology residents in glaucoma diagnosis using optic disc photographs, also demonstrated significant improvement in scores from 18% in the pre-test to 57% in the post-test after training ($p< 0.001$) (Tanjirawatana et al. 2025). Myint et al. (2014) similarly reported a significant improvement in the median knowledge score about characteristics of the glaucomatous optic nerve head from two to five pre- and post-training respectively ($p < 0.001$). Myint et al. (2014) postulated that the score improvement to the module's lecture-based mode of delivery. Our study similarly utilised lectures as the primary instructional method. Previous studies indicated that a key factor in increased performance on the theoretical examination was the ability to recall information (Huang et al. 2018; Myint et al. 2014). MCQs were developed based on the training module. Thus, the participants in our study may have achieved higher scores due to their ability to memorise the knowledge in the training module.

The theoretical component of our training module was delivered entirely online. This online modality offers several advantages, including increased accessibility and flexibility. Our findings showed that the online training course was sufficient to deliver the knowledge to the participants. This result aligns with other studies that have used online training courses for glaucoma screening. Jindal et al. (2025) who incorporated an online education package to train optometrists in the Van Herick technique, reported improved interobserver agreement between optometrists and ophthalmologists in interpreting results (Jindal et al. 2025). Another online training programme in Australia also demonstrated improvements in glaucoma diagnosis among 46 orthoptists (Scheetz et al. 2019). These findings underscore the efficacy of online educational interventions for delivering theoretical knowledge in glaucoma screening.

Our participants achieved high scores across all required skills for glaucoma screening using online lectures and practical sessions. Similarly, 16 community health workers were trained in using portable glaucoma screening tools through lectures, practical demonstrations, and hands-on training sessions in a study by Garba et al. (2026). Their participants achieved scores of 80% or higher on a practical assessment

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covering instrument operation, scoring, and referral protocols after the training (Garba et al. 2026). They observed that their participants were more engaged with practical sessions than lectures (Garba et al. 2026). These findings indicate that the lectures and practical sessions were effective in training primary eye care providers to perform glaucoma screening.

The performance in fundus grading of the glaucomatous optic nerve was lower compared to other assessments. This finding suggests a potential need for more training hours in fundus grading. Olawoye et al. (2023) demonstrated that non-ophthalmic graders significantly improved recognition of glaucomatous optic nerve heads after five hours of online training with an additional 20 to 30 minutes of face-to-face training with a glaucoma specialist. The online lecture for our fundus examination module was only 36 minutes, supplemented by 20 to 30 minutes of face-to-face training with a glaucoma specialist, which was a shorter duration than the training hours provided in the study by Olawoye et al. (2023). However, our training programme was not entirely focused on recognising glaucomatous optic discs. It also incorporated additional skills required for glaucoma screening, resulting in fewer training hours for fundus grading of the glaucomatous optic nerve.

Participants perceived their competency in glaucoma screening improved after training. This finding was consistent with a study by O' Carroll et al. (2023) that reported a statistically significant increase in participants' self-reported confidence in their ophthalmic skills, from 59.6% to 85.0% ($p < 0.001$), after their training workshop. Another study demonstrated that small-group hands-on sessions increased medical students' confidence in eye examination skills from 2.80 to 4.52 on a 5-point Likert scale (Lee et al. 2020). This high self-assessment score in glaucoma screening competence may stem from participants' prior workplace experience. Most participants were trained to conduct a visual acuity test and use a fundus camera in their workplace. Our findings also align with a study by Srikanth (2019), which reported that 98.6% of medical undergraduate students were confident in visual acuity testing due to frequent exposure to this skill.

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Participants in our study provided a good evaluation of the training module. They felt that the training module and programme were good in terms of content, usefulness, accessibility, and relevance to their jobs. Malik et al. (2020) reported that most primary health care workers (n=35, 87.5%) in a training programme found the primary child eye care training module easy to understand. This suggests that well-developed modules tailored to the target audience are essential for effective teaching.

Participants gave a good evaluation of the training programme. Overall, they felt that the training programme was good in terms of content, training methodology, trainers, workshop, and relevance to their jobs. These findings were similar to a survey by Abdulaziz Hawi Hassan et al. (2024) which reported that 73% (n=37) of 51 hospital healthcare workers viewed their hospital-based training methodology was effective in improving their skills in health delivery, while 59.5% felt the training was relevant to their job. Their training methodology was lectures, presentations, discussions, demonstrations, and seminars (Abdulaziz Hawi Hassan et al. 2024) , whereas our study consisted solely of lectures and practical sessions. However, our participants rated the teaching methodology as good, suggesting it was effective. The trainers in our training programme were rated as good by our participants. This result was similar to feedback from a diabetes education training programme, which reported that their healthcare workers found the facilitators effective and satisfactory (Hall et al. 2025). Their teaching methodology was more varied, such as presentations, interactive group work, and case-based learning using a virtual patient scenario (Hall et al. 2025). The quality and delivery style of the trainers are important to the success of a training programme, as confirmed by positive feedback from our participants.

Most participants also reported that our training programme improved their knowledge, skills, and confidence in conducting glaucoma screening. This finding was aligned with a study that found that healthcare workers involved in a vision screening training programme in India reported improved confidence and knowledge post-training (Sodani et al. 2025).

Most participants were satisfied with the online theory sessions and weekend practical sessions. This result was similar to that of the study by Abdulaziz Hawi Hassan

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et al. (2024) who reported that 70% of healthcare workers found the scheduling of training programmes convenient. Bhagya Lakshmi and Nanjunda Swamy (2025) reported that 82% of medical students preferred online learning because they could study from home, while 50% preferred the flexibility of a self-paced schedule offered by online learning.

The strength of the present study was that the training module was specifically developed to train eye care providers in glaucoma screening in the Malaysian healthcare setting. Although this module was developed to train eye care providers in glaucoma screening in Malaysia, it may be used or adapted to train eye care providers in other countries.

One limitation was the absence of a pre-training assessment for online fundus grading and of practical tests for comparison. Therefore, future research should investigate the "real-world" impact of the training programme on primary eye healthcare providers in glaucoma screening.

5.5.6 Conclusion

In conclusion, this training module and programme improved the knowledge and skills of primary eye health care providers in glaucoma screening. Therefore, it can be used to train eye care providers in glaucoma screening in Malaysia. Further research is needed to determine how this training programme translates into practice for primary eye healthcare providers during glaucoma screening. Glaucoma screening can be classified into opportunistic case finding and population screening. However, both strategies have advantages and disadvantages, which can be addressed through the teleglaucoma screening programme. Once a competent workforce is established, it is equally essential to evaluate the technological aspects of teleglaucoma. Therefore, the following chapter focuses on analysing the system's functionality and usability.

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CHAPTER VI

PHASE IV: EVALUATION OF FUNCTIONALITY AND USABILITY OF TELEGLAUCOMA SYSTEM

6.1 INTRODUCTION

One of the key components of the teleglaucoma screening programme is a system that allows the screeners to upload the clinical results and enables the specialist to evaluate the clinical results for diagnosis and management of glaucoma (Gan et al. 2020). The components required for an efficient teleglaucoma system were the ability to register the patient's data and history, upload clinical examination results, enable specialists to view the results, support their diagnosis and management, and refer patients for follow-up. It is important to have a system that works efficiently for the teleglaucoma screening programme. In our study, we used a web-based store-and-forward system as found in Phase I, which had previously identified this modality as one of the components of the teleglaucoma program. We adapted a system from the Electronic Medical Record Standard Template (EMRST), C-HEtS (Caring Hospital Enterprise System) Hospital Canselor Tuanku Muhriz (HCTM), as the new teleglaucoma system. A functional and usability study is an essential component of the system's evaluation before it is used in the teleglaucoma programme. Therefore, this chapter showed the functional and usability study of the teleglaucoma system.

6.2 OBJECTIVE

The objective of this phase was to evaluate the functionality and usability of an adapted teleglaucoma system from a ready-to-use electronic medical record (EMR).

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6.3 METHODOLOGY

This was a cross-sectional study. The participants were recruited from eye healthcare professionals such as optometrists, ophthalmic technicians, assistant medical officers, and ophthalmologists, who were currently working at the Ophthalmology Clinic and Primer Clinic HCTM. Participants were recruited using purposive sampling. There were two study locations: the Ophthalmology Clinic and the Primer Clinic HCTM. The study was conducted from 3 July to 23 July 2023. This study was conducted in accordance with the Declaration of Helsinki and the principles of Good Clinical Practice (GCP).

The inclusion criteria included eye healthcare professionals who could understand English and the purpose of the study. Although Phase III focused on content validation of the training materials in both Malay and English, the standardized usability assessment tool used in this phase which was the IBM Computer System Usability Questionnaire (CSUQ), was only available in English. Therefore, English proficiency was mandatory for the usability data collection. Exclusion criteria included participants who were not motivated to participate in the study.

The sample size was based on Hwang and Salvendy (2010), who recommended using the rule of thumb of 10±2 to recruit participants for usability testing of a system. Whereas, A'bas et al. (2021a) recommended ten participants for a functionality and a usability study of a tele diabetic system. Therefore, we recruited ten participants.

Participants who met the eligibility criteria for this phase were approached and informed about the study. If the participants agreed to participate, the participant information sheet (Appendix X) and the informed consent form (Appendix G) were sent to them in hard copy. A signed consent form was obtained prior to the study.

Participants received an instruction manual that explained how to use the teleglaucoma system. In this study, there were two types of users: ophthalmologists and primary eye care providers. Two separate English versions of instruction manuals were given, one for primary eye care providers (Appendix Y) and another for ophthalmologists (Appendix Z). The instruction manuals were tailored to each user

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group, as each group was assigned specific tasks within the teleglaucoma system (Table 6.1). After participants read the manual, they need to complete all required tasks listed in Table 6.1 according to their user type to test the system.

Primary eye care providers were tasked with registering patients, recording habitual visual acuity for each eye, and uploading the clinical results from the teleglaucoma screening including history-taking, intraocular pressure (IOP), and assessment of pupil reflex to the nurse's sheet (Picture 6.1). They also uploaded the images from the fundus camera examination (Picture 6.2) and the Melbourne Rapid Field (MRF) visual field test in PNG, JPEG, or PDF format (Picture 6.3). The Melbourne Rapid Field (MRF) visual field test is a tablet-based test described in Chapter II. Ophthalmologists can view the clinical data and images uploaded by primary eye care providers. They can record the findings, diagnosis, and management in the patient's clinical sheet and refer the patient if they suspect the patient of having glaucoma or probable glaucoma in the system.

Table 6.1 User's Tasks for Teleglaucoma System

User Type	Tasks
Primary eye care providers	Registration of the patient View patient list Recording the visual acuity of the patient Upload file images Upload nurse sheet
Ophthalmologists	View patient list View the file images and the nurse's sheet Submit clinical sheets with diagnosis and management Submit a referral letter

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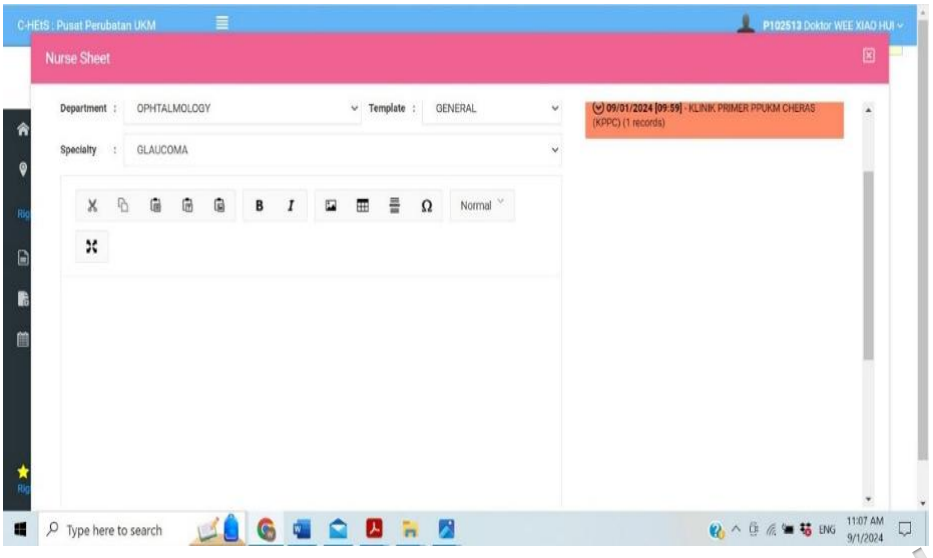
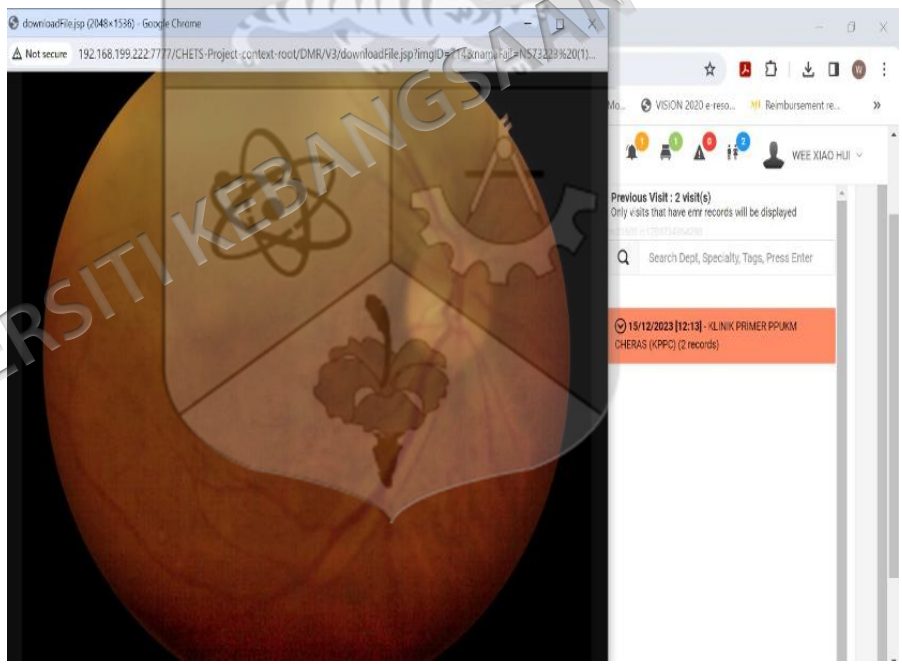


Picture 6.1 Nurse Sheet



Picture 6.2 Fundus image

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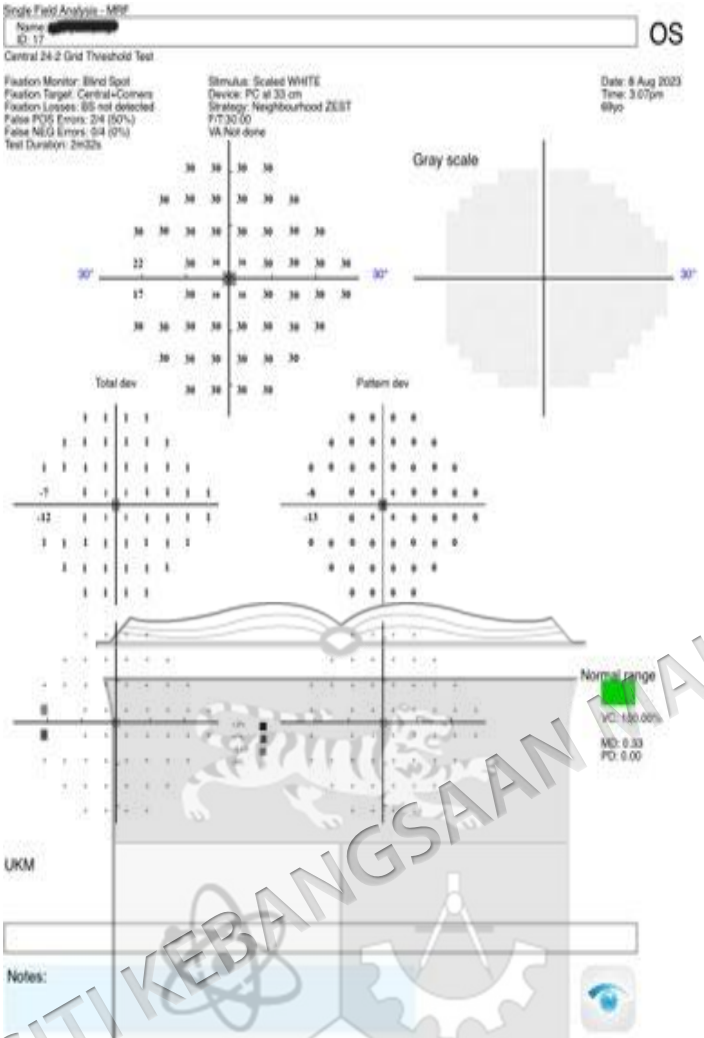

Picture 6.3 Melbourne Rapid Field

The participants were provided with the link http://newhis.hukm.ukm.my:7777/CHETS-Project-context-root/inclogin.jsp. to access the system. The teleglaucoma system was adapted from a web-based system, which was the Electronic Medical Record Standard Template (EMRST), C-HEtS Hospital Canselor Tuanku Muhriz (Caring Hospital Enterprise System). The Information Technology Center of Universiti Kebangsaan Malaysia developed this system using JDeveloper 10g. The database was Oracle database. The system was incorporated with several security features. All data transmissions were confined to the designated working sites, such as the Primer and Ophthalmology Clinic HCTM. Another security feature required users to log in with a username and an encrypted password.

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Furthermore, access to private and confidential records was granted to selected personnel. Lastly, this web-based system can only be accessed via the HCTM intranet.

The tasks were completed at the participants' workplace, either the Primer Clinic or the Ophthalmology Clinic HCTM, using the researcher's laptop, a HP 15 FC0402AU (Hewlett-Packard, USA), and the HCTM intranet connection to access the system. They were given 20 minutes to complete the tasks. Two online Google Forms consisting of two questionnaires were administered to participants after they completed the tasks on the same day. The first Google Form was a functionality questionnaire adapted from A'bas et al. (2021a). The second online Google Form questionnaire was the evaluation of the usability of the system using the IBM Computer System Usability Questionnaire (CSUQ) (Lewis 1995) .

The newly adapted functionality questionnaire was assessed for content validity and reliability. Six experts comprising of two ophthalmologists, three optometrists, and an assistant medical officer assessed the content validity of the functionality questionnaire. The overall item content validity index (I-CVI) was 0.95, indicating good content validity. Each item obtained an I-CVI of 0.78 or higher for each of the four criteria (relevance, clarity, simplicity, and ambiguity). A good questionnaire has good content validity when an I-CVI was 0.78 or higher for a minimum of three experts (Polit et al. 2007). For S-CVI/Average (SCVI/Ave), the scores for clarity and ambiguity were 0.98, and for relevance and simplicity, they were 0.95. Items with an S-CVI/Ave above 0.90 were considered to have good content validity (Polit et al. 2007). The reliability coefficient using The Kuder-Richardson Formula 21 (KR-21) (Kuder & Richardson 1937)was 0.82 which showed good reliability (Ekolu & Quainoo 2019). This reliability was tested with ten primary eye care providers who were not the study participants.

The functionality questionnaire consists of three sections (Appendix AA). The first section of the form included demographic data, such as age, gender, race, occupation, current workplace, years of work experience, and the highest level of education. The second section was the evaluation of the functionality of the system, and the final section was suggestions for system improvement. Participants were asked to answer two different sets of items based on their occupation in the second section due

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to primary eye care providers and ophthalmologists performed different tasks. When participants reported their occupation as either "primary eye care provider" or "ophthalmologist," they were directed to the corresponding sets of ten items for primary eye care providers and six items for ophthalmologists. Participants were required to answer "yes" or "no" to each item. Table 6.2 shows the items for primary eye care providers and ophthalmologists in the second section.

Table 6.2 The second section of the functionality questionnaire

Type of Users	Items
Primary eye care provider	I was able to register a new case
	I was able to view the patient list for the current day
	I was able to view details of a new patient.
	I was able to edit the details of a new patient.
	I was able to delete patient details if necessary.
	I was able to make comments in the nurse's sheet.
	I was able to upload file images.
	I was able to change or re-upload another file images.
	I was able to delete the uploaded images.
	I was able to view the uploaded file images.
Ophthalmologists	I was able to view the patient list for the day.
	I was able to view the details of a new patient
	I was able to view the uploaded file images.
	I was able to make comments, diagnoses, and management in the patient's clinical sheet.
	I was able to successfully submit the patient's clinical sheet.
	I was able to issue a referral letter to a patient if necessary

IBM Computer System Usability Questionnaire (CSUQ) measured users' satisfaction using a system (Lewis 1995). It was one of the most effective questionnaires to measure the usability of a system (Tullis & Stetson 2004). The questionnaire consisted of nineteen items (Appendix BB). There were four categories in the IBM CSUQ, which were the usefulness of the system section (SYSUSE) (Items 1-8), the quality of the information section (INFOQUAL) (Item 9-15), the quality of the interface section (INTERQUAL) (Item 16-18) and the overall satisfaction section (OVERALL) (Item 19) (Lewis 1995). The items were assessed with a Likert-7 point scale in which

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1= strongly disagree, 2= largely disagree, 3 = disagree, 4 = neutral, 5= agree, 6= largely agree, and 7= strongly agree (Medina et al. 2019). Table 6.3 shows the items in the IBM CSUQ in four sections.

Table 6.3 IBM Computer System Usability Questionnaire (IBM CSUQ)

Category	No	Item
SYSUSE	1	Overall, I am satisfied with how easy it is to use this system
	2	It was simple to use this system
	3	I could effectively complete my work using this system
	4	I was able to complete my work quickly using this system
	5	I was able to efficiently complete my work quickly using this system
	6	I feel comfortable using this system
	7	It was easy to learn to use this system
	8	I believe I could be productive quickly using this system
INFOQUAL	9	The system gives error message that clearly tell me to fix the problem
	10	Whenever I made a mistake using the system, I could recover easily and quickly
	11	The information provided in the system (user manual) provided with this system was clear
	12	It was easy to find information I needed in the system
	13	The information provided in the system was easy to understand
	14	The information was effective in helping me complete the tasks and scenarios
	15	The organization of information on the system screens was clear
INTERQUAL	16	The interface of this system was pleasant
	17	I liked using the interface of this system
	18	This system has all the functions and capabilities I expect it to have
OVERALL	19	Overall, I am satisfied with this system

Source: Lewis (1995)

6.4 DATA ANALYSIS

Data was analysed using SPSS version 27 (IBM Corp., New York, USA). Descriptive analysis was used to analyse the data. Data normality was assessed using the Shapiro-Wilk test. The data was not normally distributed. Therefore, a non-parametric test was used for data analysis. Each item in the functionality questionnaire was reported using frequency and percentages. The suggestions for improvement were input into Microsoft Excel 2020 (Microsoft Corp., Redmond, Washington, USA) for analysis. The average

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for each CSUQ category was calculated in Microsoft Excel 2020 (Microsoft Corp., Redmond, Washington, USA) and later entered into SPSS version 27 (IBM Corp., New York, USA). The Mann-Whitney U test was used to compare the mean ranks of the CSUQ categories between primary eye care providers and ophthalmologists. This comparison evaluation helps identify role-specific software limitations, providing insights to refine the interface and improve the system for all user groups. p-value ≤ 0.05 was considered significant.

6.5 RESULTS

6.5.1 Demographic Data

Ten eye healthcare professionals participated in this phase. Table 6.4 shows the participants' demographic data. The participants' mean age was 36.40 ± 6.96 years, ranging from 24 to 52 years old. Most participants were males (n=7, 70%) and Malay (n=8, 80%). They were also mostly comprised of assistant medical officers (n=4, 40%). Many participants worked in a hospital (n = 6, 60%). Most of them had more than 10 years of work experience (n=5, 50%). They also hold various academic backgrounds, with most participants holding a diploma (n = 4, 40%).

Table 6.4 Demographic data of the participants

Characteristics (N=18)	**n (%)**
Age	
Mean±SD (years)	36.40±6.96
Range	24-52
Gender	
Male	7 (70)
Female	3 (30)
Race	
Malay	8 (80)
Chinese	1 (10)
Indian	1 (10)
Occupation	
Assistant medical officer	4 (40)

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Ophthalmologist	3 (30)
Optometrist	2 (20)
Ophthalmic technician	1 (10)
Current working place	
Hospital	6 (60)
Primary health clinic	4 (40)
Education Level	
Diploma	4 (40)
Degree	2 (20)
Master	3 (30)
PhD	1 (10)
Years of working experience	
Less than 3 years	1 (10)
3-5 years	1 (10)
6-8 years	1 (10)
8-10 years	2 (20)
More than 10 years	5 (50)

6.5.2 Result from the Functionality Questionnaire

Figure 6.1 shows the results of the functionality questionnaire for primary eye care providers. All primary eye care providers completed the task, except for two participants (28.57%) who were unable to delete patient details. All primary eye care providers were unable to delete file images uploaded to the system. Figure 6.2 shows the result from the functionality questionnaire for ophthalmologists. All ophthalmologists were able to complete the tasks.

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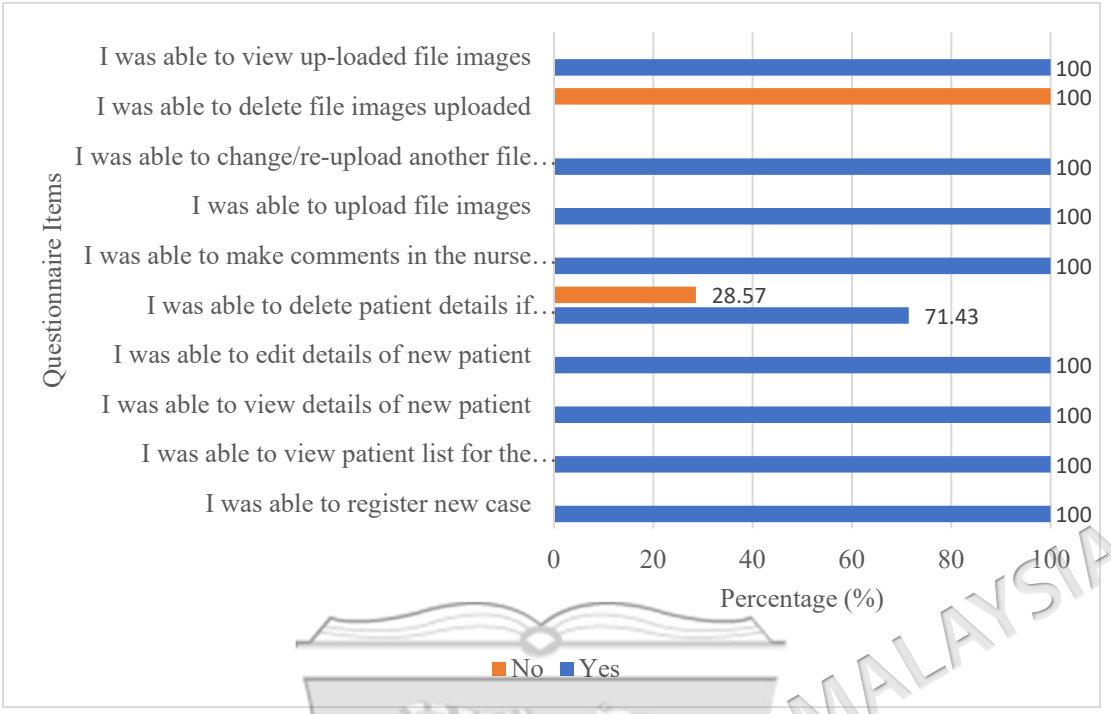

Figure 6.1 Results from the functionality questionnaire for primary eye care providers

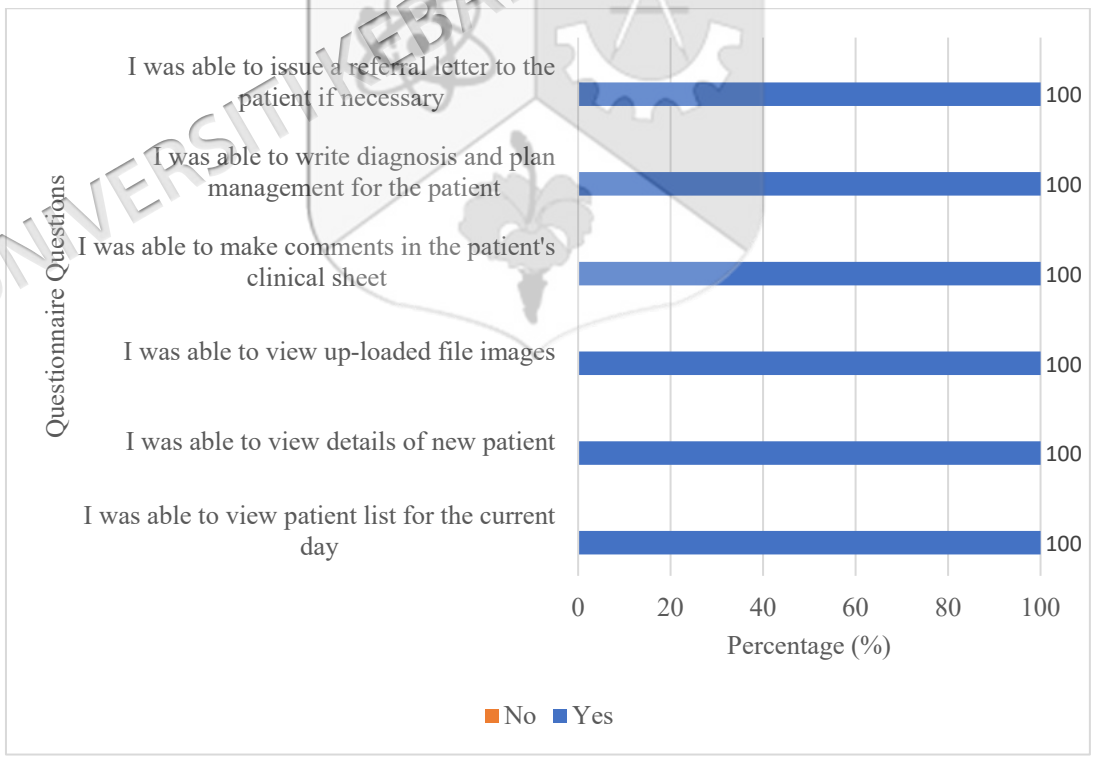

Figure 6.2 Results from the functionality questionnaire for ophthalmologists

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6.5.3 Results from the Usability Questionnaire

Table 6.5 shows the median and interquartile range (IQR) for each item in the usability questionnaire. All items showed a high median score ranging from 5.50 to 7.00.

Table 6.5 Results from the Usability Questionnaire

Category	No	Items	Median (IQR)
SYSUSE	1	Overall, I am satisfied with how easy it is to use this system	6.00 (2.00)
	2	It was simple to use this system	6.50 (1.25)
	3	I could effectively complete my work using this system	7.00 (1.00)
	4	I was able to complete my work quickly using this system	7.00 (1.00)
	5	I was able to efficiently complete my work quickly using this system	7.00 (1.00)
	6	I feel comfortable using this system	7.00 (1.00)
	7	It was easy to learn to use this system	7.00 (1.00)
	8	I believe I could become productive quickly using this system	6.50 (1.00)
INFOQUAL	9	The system gives error message that clearly tell me to fix the problem	6.00 (2.00)
	10	Whenever I made a mistake using the system, I could recover easily and quickly.	5.50 (2.25)
	11	The information provided in the system (user manual) provided with this system was clear	6.00 (1.25)
	12	It was easy to find the information I needed in the system	6.50 (1.00)
	13	The information provided in the system was easy to understand	6.50 (1.00)

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	14	The information was effective in helping me complete the tasks and scenarios	6.50 (1.00)
	15	The organization of information on the system screens was clear	6.50 (1.00)
INTERQUAL	16	The interface of this system was pleasant	6.00 (1.00)
	17	I liked using the interface of this system	6.00 (1.00)
	18	This system has all the functions and capabilities I expect it to have	6.50 (1.00)
OVERALL	19	Overall, I am satisfied with this system	6.00 (1.00)

Table 6.6 shows the median and interquartile range (IQR) of each category in the usability questionnaire. Each category showed a high median score ranging from 6.00 to 6.38.

Table 6.6 Results from each category in the usability questionnaire

Category	**Median (IQR)**
SYSUSE	6.38 (0.91)
INFOQUAL	6.29 (1.46)
INTERQUAL	6.17 (1.00)
OVERALL	6.00 (1.00)

Table 6.7 showed a comparison of each category of the usability section of the questionnaire according to occupation. The results indicated that INFOQUAL and INTERQUAL categories were significantly higher in primary eye care providers than in ophthalmologists (INFOQUAL, $U = 6.86$, $p = 0.028$, INTERQUAL, $U = 6.71$, $p = 0.039$).

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Table 6.7 Comparison of each category of the usability section of the questionnaire according to occupation

Category	Occupation	N	Mean Rank	Mann-Whitney U	Z	p-value
SYSUSE	Primary eye care providers	7	6.14	6.00	-1.065	0.287
	Ophthalmologists	3	4.00			
INFOQUAL	Primary eye care providers	7	6.86	1.00	-2.199	0.028*
	Ophthalmologists	3	2.33			
INTERQUAL	Primary eye care providers	7	6.71	2.00	-2.067	0.039*
	Ophthalmologists	3	2.67			
OVERALL	Primary eye care providers	7	6.14	6.00	-1.134	0.257
	Ophthalmologists	3	4.00			

*p<0.05

6.5.4 Feedback from Participants about Suggestions for Improvement of the System

Some participants described the system as 'easy to navigate,' and they perceived it could save time during clinical tasks. However, some participants suggested that a side-by-side display of images from both eyes would facilitate easier comparison and interpretation of the findings. Another suggestion was a more user-friendly interface, such as a standardized template for entering data for clinical sheets, particularly for history, clinical examination, and management. Additional recommendations included the ability to upload multiple images and an 'edit' function that allows users to update clinical sheets after submission.

6.6 DISCUSSION

Based on the results from the functionality questionnaire, eye healthcare professionals, particularly ophthalmologists, can utilize the functions in the teleglaucoma database management system. Our findings aligned with another study in Malaysia, which reported that the majority of their participants could effectively use the functions in their tele diabetic system (A'bas et al. 2021a, 2021b). However, participants in our study were unable to delete the images they had uploaded to the system. In contrast, another telemedicine system enabled users to delete fundus images after uploading, which is a

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feature supported by a specific deletion interface not present in this study (A'bas et al. 2021a, 2021b). Therefore, primary eye healthcare providers in our study must carefully upload the correct images to the system. The next improvement for the system involves implementing a function to delete uploaded images.

The results from the usability questionnaire showed that participants mostly agreed that the system was user-friendly, with means greater than 6 for all CSUQ categories. Our findings are consistent with a study by Ayatollahi et al. (2017), which reported mean usability scores for a web-based teleophthalmology system in Iran. Their research indicated mean usability scores of 8.2 ± 0.4 out of 10 from optometrists and 7.7 ± 1.1 out of 10 from ophthalmologists (Ayatollahi et al. 2017). Other studies also highlight the usability of teleophthalmology and related systems. In another study by Safdari et al. (2018) which evaluated the usability of a web-based tele diabetic screening developed by their team, they reported a mean score of 7.3 and 7.1 out of 9.0 among eye specialists and optometrists respectively (Safdari et al. 2018). In Malaysia, a study by A'bas et al. (2021b) reported that their tele diabetic retinopathy system was perceived as user-friendly by their participants. Similarly, in the Philippines, a study that combined web applications with electronic medical record (EMR) management systems and medical teleconsultation reported that medical professionals gave a high usability score of 82.5 out of 100 (Day et al. 2018).

The SYUSUSE domain of the CSUQ showed the highest score. This result suggests the participants perceived the system as easy to learn and operate. Our findings align with other studies, which showed that similar telemedicine systems are easy to use and learn such as a study by A'bas et al. (2021b) which reported that 27 primary health care doctors were satisfied with their tele-diabetic retinopathy system, as it was easy to use. Ayatollahi et al. (2017) reported that their teleophthalmology system was easy to learn, with mean scores of 8.7±0.3 (Ayatollahi et al. 2017). Another study in Iran also found that healthcare professionals perceived that telemedicine for diabetes management was easy to use, with a mean score of 4.40 ± 0.77 and 4.14 ± 0.86 for physicians and nurses, respectively (Ayatollahi et al. 2018). The perceived ease of use of a system was a major factor in healthcare providers' acceptance of a telemedicine system (Shiferaw et al. 2021).

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The interface quality (INTERQUAL) category has the lowest median score among the other categories. This finding suggests that the system's interface still needs improvement. Furthermore, ophthalmologists rated significantly lower median scores for INFOQUAL and INTERQUAL than primary eye care providers. This finding was consistent with a previous study, which reported that 'terminology and system information' had the lowest mean usability score among ophthalmologists (6.5 ± 0.6) compared to optometrists (7.3 ± 1.7) (Ayatollahi et al. 2017). This study found that the users were interested in interacting more and received feedback regarding their interactions with the system (Ayatollahi et al. 2017). However, their ophthalmologists gave a higher mean score to interface design (8.8 ± 0.1) than optometrists (8.3 ± 0.9) (Ayatollahi et al. 2017). Their interface design may be more interesting than ours. Future research should address improvements in these areas.

Our system currently allows ophthalmologists to view a single image on the screen while reviewing the patient's case. The suggestion by some participants to display images of both eyes side by side could help clinicians compare key clinical parameters, especially the cup-disc ratio between the two eyes. Other suggestions proposed by some participants were a multi-image upload feature, standardizing data entry fields, and adding an 'edit' function for submitted information. Kassam et al. (2013) proposed to have an efficient user interface, such as displaying all patient information on multiple screens and a drop-down menu to reduce teleglaucoma consultation times (Kassam et al. 2013). These suggestions will be proposed to the system designers to enhance the system's functionality and improve workflow efficiency.

Current teleophthalmology platforms generally fall into three categories: those integrated directly into electronic medical record (EMR) systems (Grau et al. 2019; Newman-Casey et al. 2023; Polat et al. 2021), standalone software applications (A'bas et al. 2021a; 2021b), or mobile applications (Das et al. 2022; Guo et al. 2018). An EMR system integrated with a telemedicine platform enables seamless integration with established clinical workflows and provides access to patients' medical history (Tupsakhare 2020). Standalone teleophthalmology software applications, such as the EyePACS system, allow ophthalmologists from other organisations to review clinical

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data from anywhere and anytime (Cuadros & Bresnick 2009). However, one of the disadvantages of these standalone applications was that they could disrupt clinical workflows by providing incomplete patient data, which may hinder ophthalmologists from providing accurate interpretations (Fish et al. 2011). Mobile applications provide the flexibility to conduct screenings at any location and time (Guo et al. 2018). However, mobile systems also introduce heightened cybersecurity risks, as these applications are more susceptible to hacking (Aliasgari et al. 2018). Thus, our system is integrated with the EMR system.

A limitation of this study was that its findings may not be applicable to real-world situations, as it utilised simulated tasks.

Future research should consider integrating artificial intelligence (AI) into the teleglaucoma system to assist with interpreting clinical data and fundus images.

6.7 CONCLUSION

In conclusion, our study showed that eye healthcare professionals found the teleglaucoma system incorporated into the EMR system was functional and usable. Future research should examine the effectiveness of implementing this teleglaucoma system.

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CHAPTER VII

PHASE V: COMPARISON OF THE DETECTION RATE OF GLAUCOMA AND PROBABLE GLAUCOMA BETWEEN OPPORTUNISTIC CASE FINDING AND TELEGLAUCOMA PROGRAMME

7.1 INTRODUCTION

The teleglaucoma screening programme uses the teleglaucoma platform, which integrates digital imaging and remote diagnostics by glaucoma specialists (Gan et al. 2020). It aims to overcome the barriers to traditional screening methods by detecting glaucoma earlier (Brandão-De-Resende et al. 2023) which will improve access to eye care services, especially for patients who live in remote areas (Ertel et al. 2021).

Our teleglaucoma programme utilises a web-based system (EMRST CHEtS) to remotely screen for glaucoma between primary health clinics and a tertiary hospital with glaucoma services. A comparative analysis of glaucoma and probable glaucoma detection rates was essential to assess the effectiveness of the teleglaucoma programme compared to the conventional pathway. The conventional pathway in Malaysia is opportunistic case finding, which detects glaucoma in patients who undergo eye examinations for any complaints or routine eye examination (Doozandeh et al. 2022; Founti et al. 2024).

The integration of findings from Phase I identified seven essential components of a teleglaucoma screening programme: (1) accessible screening locations, (2) high-risk screening participants, (3) examinations such as history taking, visual acuity assessment, tonometry, fundus photography, and visual field testing, (4) trained personnel, (5) clear referral criteria, and (6) a store-and-forward telemedicine modality. In line with these findings, we conducted our programme at a primary care clinic targeting high-risk patients. Data collection, including history-taking, visual acuity

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assessment, tonometry, fundus photography, and visual field testing, was conducted by trained primary eye care providers and uploaded to the Electronic Medical Record Standard Template (EMRST) for diagnosis and management in accordance with referral criteria.

This phase aimed to determine the effectiveness of the teleglaucoma programme in detecting cases of glaucoma and probable glaucoma in the local population to evaluate whether teleglaucoma is a viable glaucoma screening modality in our local population.

7.2 OBJECTIVE

The objective of this phase was to compare the detection rates of glaucoma and probable glaucoma between the conventional pathway and the teleglaucoma screening programme in the local population.

7.3 METHODOLOGY

This study was a comparative cross-sectional study. In the teleglaucoma screening programme, participants were recruited from patients attending the Primer Clinic Hospital Canselor Tuanku Muhriz (HCTM). In the conventional pathway, participants consisted of all patients who visited Sentul Health Clinic for any eye complaints during the study period. The number of patients visiting Sentul Health Clinic is almost the same as that of Primer Clinic HCTM, with Sentul Health Clinic receiving approximately 300 patients per day and Primer Clinic HCTM receiving about 250. A potential source of bias may arise when a single clinic is used for both the teleglaucoma programme and opportunistic case finding, as healthcare providers, such as nurses and optometrists at Primer Clinic HCTM, may apply similar eligibility criteria to patients in both pathways.

Participants were recruited using convenience sampling. The study was conducted from August to December 2023. Ethics approval was obtained from the Research Ethics Committee Universiti Kebangsaan Malaysia (UKM PP1/111/8/JEP-2020-127) (Appendix A) and the Medical Research and Ethics Committee under the Ministry of Health Malaysia (NMMR-22-02206-RRK) (Appendix CC). This study was

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conducted in accordance with the Declaration of Helsinki and in compliance with the principles of Good Clinical Practice (GCP) guideline.

The inclusion criteria for the teleglaucoma and conventional (opportunistic case-finding) pathways differ because they reflect different clinical approaches: active versus passive screening. Teleglaucoma targets a specific high-risk population, while the conventional pathway reflects standard opportunistic practice, in which cases are identified among people already seeking help for eye problems. For the teleglaucoma screening programme, the inclusion criteria were patients aged 40 years and above, who had risk factors for glaucoma such as family history of glaucoma, diabetes, hypertension, allergy, history of eye trauma, migraine, Raynaud's phenomenon, obstructive sleep apnea, myopia, hyperopia, history of taking steroids, and had undergone eye surgery, have the ability to understand the purpose of the study and give informed consent to join the study. Patients with eye diseases that obscure the fundus view, corneal diseases that interfere with the measurement of intraocular pressure (IOP), patients with existing glaucoma or probable glaucoma, vulnerable patients such as cognitively impaired, pregnant women, terminally ill patients, AIDS or HIV patients, and non-citizens of Malaysia were excluded from the study.

The inclusion criteria for the conventional pathway were patients aged 18 years and above who presented with eye complaints. Patients with existing glaucoma, or probable glaucoma, non-citizens of Malaysia, and vulnerable subjects such as the cognitively impaired, pregnant women, terminally ill patients, and AIDS or HIV patients were excluded from the study.

Sample size was calculated from Kiage et al. (2013) where 14% was diagnosed as glaucoma through the teleglaucoma programme compared with 26% in the conventional pathway (Kiage et al. 2013). In their study, conventional pathways yielded significantly better outcomes than teleglaucoma. Using a baseline in which the conventional pathway performs better gives a wider effect size which. yields a larger, sample size target. This will prevent the study from being underpowered and ensures we can statistically detect whether our teleglaucoma programme performs well against a conventional pathway. Using PS software, the sample size was 173 per group at a

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95% confidence level and 80% power (Figure 7.1). Therefore, the final sample size was 190 per group, accounting for a 10% dropout rate.

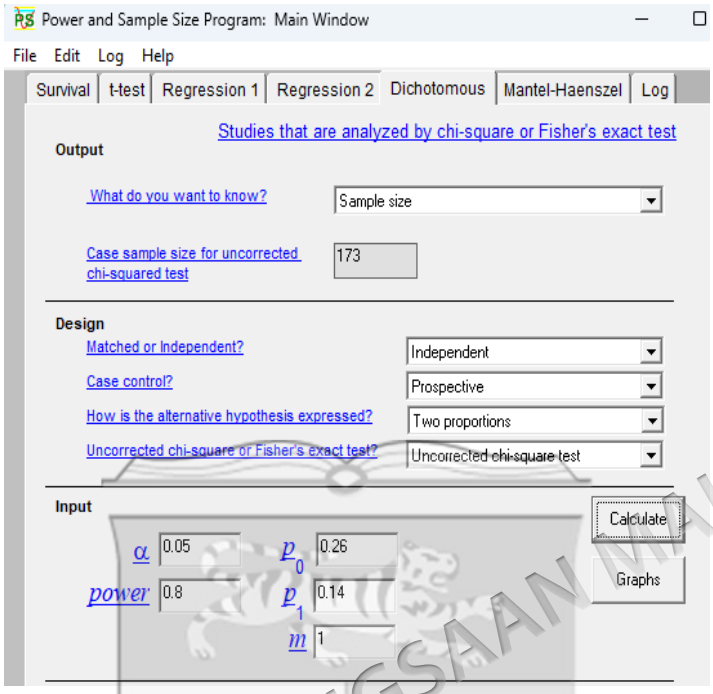

Figure 7.1 Sample size calculation

Eligible participants in Primer Clinic HCTM were approached from 1 August 2023 to 26 December 2023. Upon being approached, they were informed of the study's purpose. After participants agreed to participate, the participant information sheet (Appendix DD) and the informed consent form (Appendix EE) were provided. A signed consent form was obtained prior to the study. The screening programme was conducted by a team of glaucoma screeners comprising a nurse, a medical assistant, and an optometrist.

Participants underwent the screening protocol on the same day. A history taking was taken for each patient before they underwent the following screening procedure. The patients were asked questions about their main complaints, medical conditions, previous ocular history, previous surgery, allergy, history of taking steroids, and family history of glaucoma.

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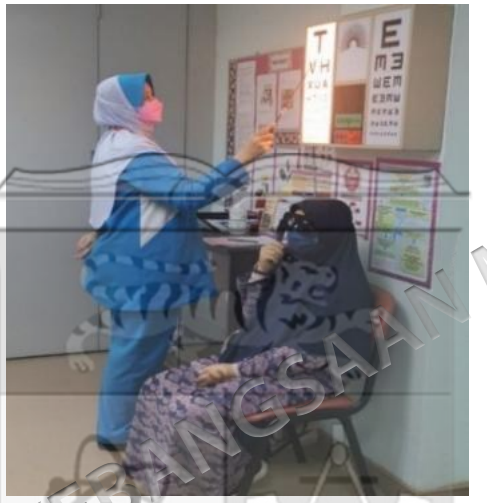
Participants underwent a visual acuity test using a Snellen chart. In the distance visual acuity test, participants were instructed to wear spectacles if they had a refractive error. Only one eye was being tested at a time. Another eye was occluded. Participants were instructed to read the smallest line of letters they could see on the Snellen Chart. The measurement was recorded for each eye. If their visual acuity was the same or worse than 6/9, a pinhole was held in front of their eyes to measure visual acuity with a pinhole. Picture 7.1 shows the visual acuity test.



Picture 7.1 Visual acuity test

Pupil examination was performed with a pen torch to detect relative afferent pupillary. Participants were instructed to look at the distance in a dark room. The light was shone into the participant's eye for three seconds.

Tonometry was performed using the iCare HOME (Icare Ltd, Vantaa, Finland) tonometer. This tonometer was positioned 4–8 mm away from the patient's corneal surface, and six readings were taken (Jemaima et al. 2020). It has an LED probe base light, which will illuminate red when the tonometer was held incorrectly and green when it was held correctly (Liu et al. 2020). The final recorded measurement is the average of four measurements, excluding the highest and lowest readings among the six readings. All readings were recorded in a cloud-based software, which was Icare LINK or Icare CLINIC, in a HP 15 FC0402AU laptop (Hewlett-Packard, USA), (Liu et al. 2020). Picture 7.2 shows the iCare HOME tonometer while Picture 7.3 shows the IOP measurement using the iCare HOME tonometer.

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Picture 7.2 iCare HOME tonometer

Picture 7.3 Measuring IOP using iCare HOME tonometer

The visual field test was conducted using the Melbourne Rapid Field (MRF) (Glance Optical Ltd, Melbourne, Australia) test. It is a perimeter application that measures the visual field (Ichhpujani & Dhillon 2022) using a web-based version of the MRF perimeter (www.visioninhome.com.). This MRF online was conducted on an iPad 10.2-inch (Apple Inc., Cupertino, CA, USA) running iPadOS 18.7.14, with a Bluetooth keyboard, in a quiet, dimly lit room at Primer Clinic HCTM. The test conducted was 24-2, which tests 66 points, which test the visual field of 30 degrees horizontally and 20 degrees vertically (Kumar & Thulasidas 2020). Picture 7.4 shows MRF Online running on an iPad with a Bluetooth keyboard. A dark covering is placed over the iPad to reduce ambient room light and glare (Harris et al. 2022). Maximum screen brightness and screen calibration were performed before initiating the procedure (Jemaima et al. 2020). An English voice prompt was used in the study. Participants were asked to sit comfortably at a viewing distance of 33cm while wearing their habitual correction. Monocular testing was conducted with the non-tested eye occluded using an eye patch. A demonstration test was conducted to ensure participants understood the test

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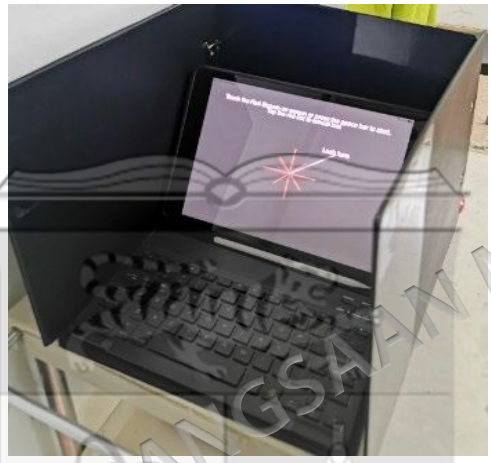
procedures. They were asked to fixate on the red cross and press the spacebar when a grey or white dot appeared on the screen. This method of pressing the spacebar on the keyboard was used instead of touching the iPad screen to prevent fingerprints, which can cause the screen to become dirty (Jemaima et al. 2020; Kumar & Thulasidas 2020). The optometrist ensured that the patient's viewing distance was 33cm and consistently reminded participants to maintain fixation on the red cross target throughout the test. Picture 7.5 shows a participant who underwent the MRF test.



Picture 7.4 Melbourne Rapid Field (MRF) test

Picture 7.5 Participant underwent the MRF test

Reliability criteria for the MRF test required that both false-positive (FP) and fixation-loss (FL) rates be less than 33% (Prea et al. 2022). If the first test showed unreliable results, the screener repeated the procedure for a second test. We included

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data from the Melbourne Rapid Field test, which was reliable for data analysis. Four parameters from the MRF results were collected for data analysis: Mean Deviation (MD), Pattern Deviation (PD), Visual Capacity (VC), and test duration. MD is the average difference between recorded thresholds and age-corrected normative data (Sugihara et al. 2025). It measures diffuse visual field loss, whereas PSD measures focal visual field loss by removing the general depression or elevation in sensitivity (Sugihara et al. 2025). Visual capacity (VC) was similar to the visual field index in the Humphrey Field Analyser (Kumar & Thulasidas 2020). It quantifies overall visual field function as a percentage of age-adjusted norms, with 100% representing a standard field and 0% indicating total blindness (Li et al. 2020).

Fundus photography was conducted by using a non-mydriatic fundus camera, Forus 3nethra Classic (Forus Health Pvt. Ltd., Bengaluru, India) (Picture 7.6). It is mounted on a tabletop and connected to a Levono Ideapad 320 laptop. It captures images with a 40 ° to 45 ° field of view (Patel et al. 2020). Picture 7.7 shows the fundus photograph with the Forus 3nethra Classic fundus camera.

Picture 7.6 Forus 3nethra Classic fundus camera

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Picture 7.7 Fundus photography

The test results and images were uploaded to the system by glaucoma screeners and reviewed virtually by two ophthalmologists: a 52-year-old Malay female with 23 years of experience, and a 36-year-old Chinese male with 8 years of experience. Reviews were completed within one to two weeks. The review was performed in a masked evaluation, with the ophthalmologist unaware of the other's diagnosis and management. The optometrist sought consensus from the ophthalmologists for any diagnostic disagreements. The ophthalmologists diagnosed the participants into three groups, which were glaucoma, probable glaucoma, and no glaucoma, based on referral criteria in Table 7.1. Participants diagnosed as glaucoma or probable glaucoma were referred to the Ophthalmology Clinic HCTM for a comprehensive eye examination to confirm the diagnosis. The final diagnoses were subsequently retrieved from the HCTM's Electronic Medical Record (EMR) following the comprehensive examinations. Those without glaucoma were discharged from the screening programme. Figure 7.2 shows the flowchart for the teleglaucoma programme.

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Table 7.1 Referral criteria for teleglaucoma screening programme

Disease	Referral Criteria
Glaucoma	large vertical cup-disc ratio (VCDR) more than 0.6
	asymmetry of VCDR more than 0.2
	notching, neuroretinal rim thinning
	optic disc haemorrhage
	retinal nerve fibre loss
	peripapillary atrophy
	Intraocular pressure (IOP) more than 21mmHg
	Abnormal visual field
Probable glaucoma	Either IOP more than 21mmHg with or without the presence of a suspicious optic nerve head and visual field defect.

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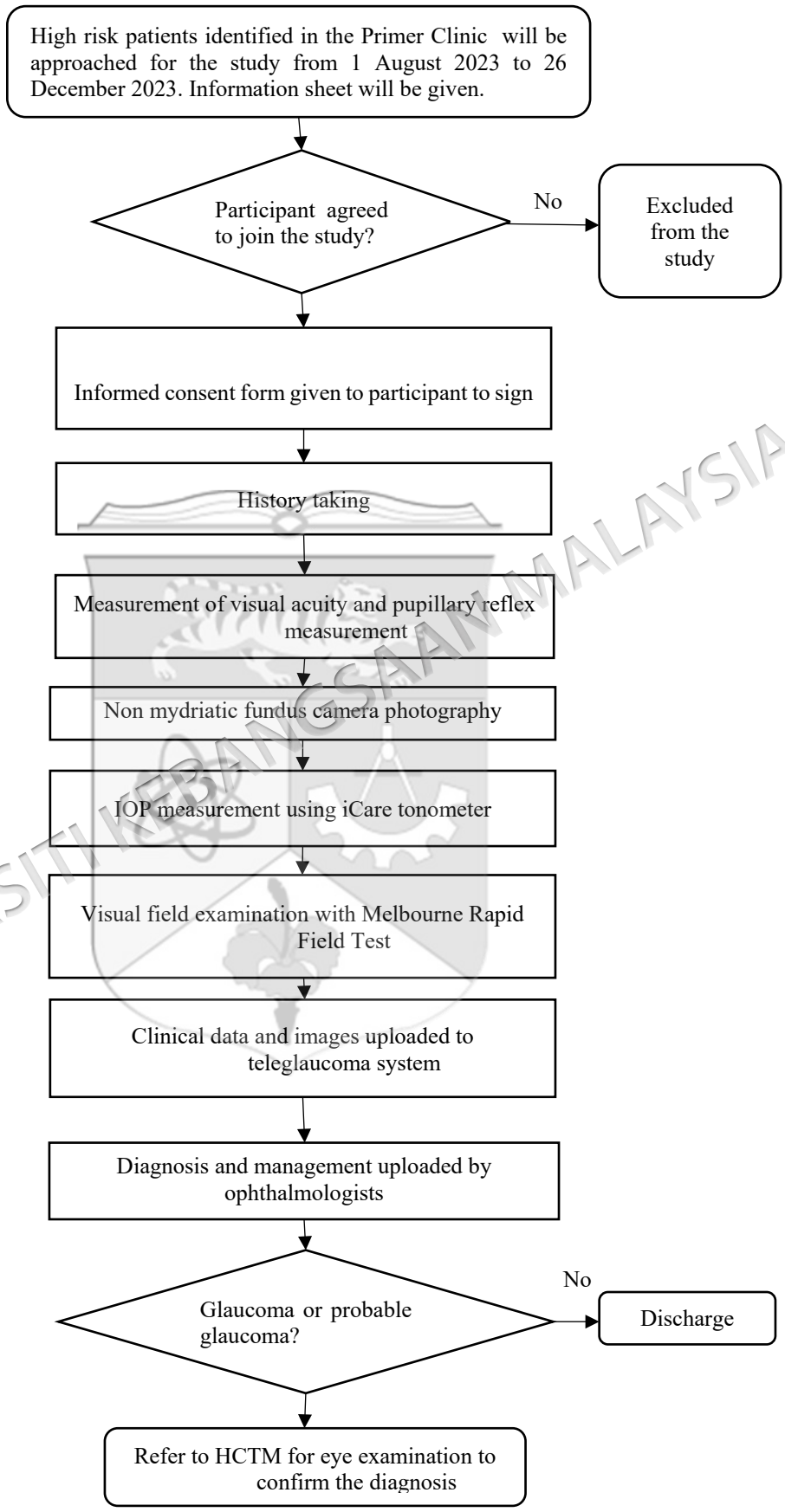

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Figure 7.2 Flow chart of the procedure in the teleglaucoma screening programme

In the conventional pathway, participants were identified from the Sentul Health Clinic registry which includes records of patients who underwent fundus examinations from 1 August 2023 to 26 December 2023. Data such as age, gender, ethnicity, medical conditions, and signs of glaucoma, such as cup-to-disc ratio, were collected from medical records. The patients diagnosed with glaucoma or probable glaucoma in the conventional pathway were contacted by the assistant medical officers by telephone to determine their willingness to participate in the study. They were informed of the study's purpose. If the participants agreed to participate, the participant information sheet (Appendix DD) and the informed consent form (Appendix EE) were provided to them in soft copy. A signed consent form was obtained prior to the study. Participants were asked to provide their diagnosis at the hospital where they attended eye examination. Figure 7.3 shows the flowchart of the procedure in the opportunistic case finding.

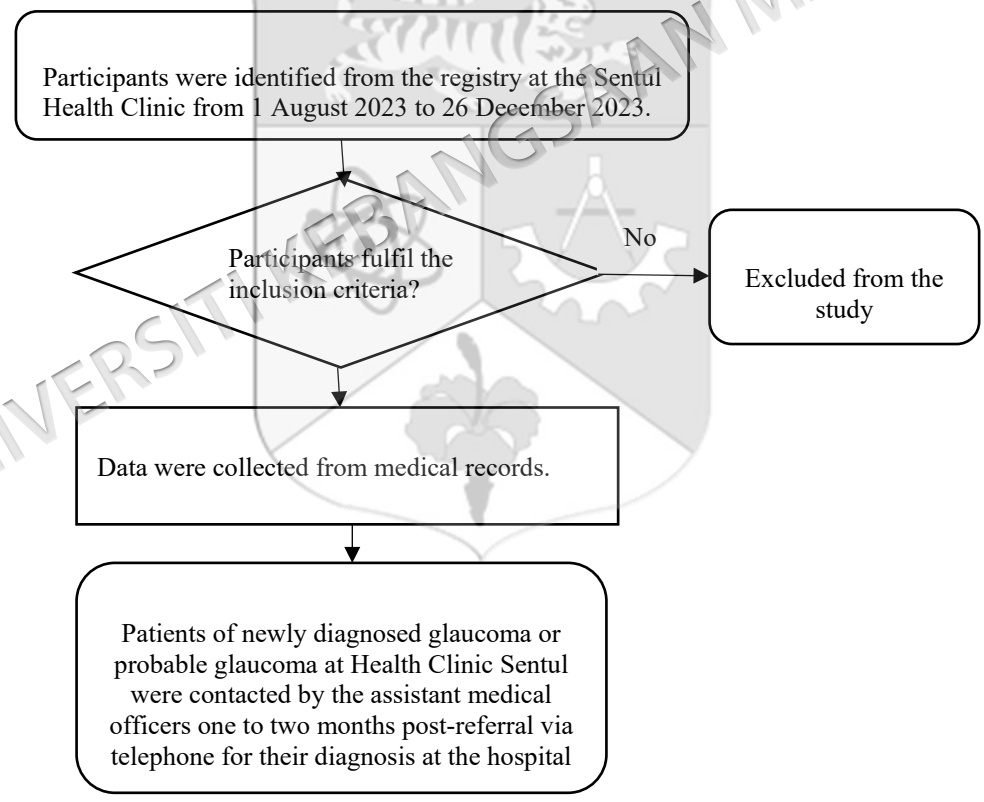

Figure 7.3 Flowchart of the procedure in the conventional pathway

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7.4 DATA ANALYSIS

SPSS version 27 (SPSS Inc., Chicago, IL) was used for data analysis. Descriptive analysis was used for the demographic and clinical data. Data on medical conditions were unavailable for 20 participants in the conventional pathway due to the lack of accessible medical records. Therefore, the demographic data for medical conditions in the conventional pathway were calculated by excluding records with missing values. Data normality was assessed using the Shapiro-Wilk test. If the data were normally distributed, the student's t-test was used to compare continuous variables. If the data were not normally distributed, the Mann-Whitney test was used to compare continuous variables. Inter-rater agreement for glaucoma diagnosis within the teleglaucoma screening programme was evaluated using Cohen's Kappa statistics. Participants were classified as having glaucoma or probable glaucoma if at least one eye met the diagnostic criteria (Marco et al. 2021). According to Landis and Koch (1977), they proposed six levels of scale to interpret Cohen's Kappa coefficients: slight (0–0.20), fair (0.21–0.40), moderate (0.41–0.60), substantial (0.61–0.80), and almost perfect agreement (0.81–1.00). Categorical variables were compared between the teleglaucoma screening programme and the conventional pathway using either Chi-square or Fisher's exact tests. p-value ≤ 0.05 was considered significant.

7.5 RESULTS

7.5.1 Demographic Data

A total of 203 participants were recruited for the teleglaucoma screening programme of whom 200 participants completed the screening protocols. In the conventional pathway, 414 participants were included. The demographic data is shown in Table 7.2 and Table 7.3.

The participants' median age in the teleglaucoma screening programme was 63.00 (55-69). Most participants were females (n=105, 52.5%) and Malay (n=113, 56.5%). In the conventional pathway, participants' median age was 62.50 (57-67). Most participants were females (n=225, 54.35%) and Malay (n=230, 55.56%). There was a statistically significant difference in the distribution of races between the teleglaucoma

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screening programme and the conventional pathway ($p<0.001$). In both pathways, most participants were Malays, followed by Chinese. However, there was a higher proportion of Chinese and a lower proportion of Indian and others in the teleglaucoma screening programme than in the conventional pathway.

Nearly all patients in the conventional group had diabetes mellitus, hypertension, and dyslipidemia, whereas approximately 73.5 to 80.5% of patients in the teleglaucoma group reported the same medial condition. Other medical conditions, such as ischemic heart disease, chronic kidney disease, asthma, migraine, thyroid, and cancer, were reported in both groups. Five healthy individuals were screened in the teleglaucoma screening programme, while all participants in the conventional pathway had at least one known medical condition. This indicates that the prevalence of systemic comorbidities was greater among patients screened through the conventional pathway.

Table 7.2 Demographic data of age, gender and race

Characteristics	**Teleglaucoma screening programme (N=200),**	**Conventional pathway (N=414)**	**p-value**
Age (Median, IQR)	63.00 (14)	62.50 (10)	0.556[a]
Gender (n,%)			
Male	95 (47.50)	189 (45.65)	0.667[b]
Female	105 (52.50)	225 (54.35)	
Race (n,%)			
Malay	113 (56.50)	230 (55.56)	p<0.001[b] *
Chinese	72 (36.00)	102 (24.64)	
Indian & Others	15 (7.50)	82 (19.81)	

[a]Mann-Whitney test, [b]Chi-square test, *p<0.05

Table 7.3 Demographic data of the medical condition

Medical Condition (n)	**Teleglaucoma screening programme (N=200) Frequency (Percentage)**	**Conventional pathway (N=394) Frequency (Percentage)**
Diabetes mellitus	150 (75.00)	384 (97.46)
Hypertension	147 (73.50)	394 (100.00)

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Dyslipidemia	161 (80.50)	394 (100.00)
Others	49 (24.50)	35 (8.88)
No medical condition	5 (25.00)	0 (0.00)

7.5.2 Results from the Teleglaucoma Programme and the Conventional Pathway

Table 7.4 shows the comparison of results from the screening tests between the teleglaucoma screening programme and the conventional pathway. In the conventional pathway, six participants were blind in both eyes, while one participant was blind in one eye. There was a statistically significant difference in the vertical cup-to-disc ratio between the teleglaucoma screening programme and the conventional pathway in both the right ($p < 0.01$) and left ($p < 0.01$) eyes.

Table 7.4 Comparison of screening tests results between the teleglaucoma screening programme and the conventional pathway

Measurement	**Teleglaucoma screening programme (n=200)**	**Conventional pathway (n=414)**	**p-value**
Visual acuity on Right Eye (n,%)			
No visual impairment or mild visual impairment (≥ 6/18)	198 (99.0%)	399 (96.4)	0.16[b]
Moderate visual impairment < 6/18-6/60	2 (1.0%)	9 (2.2)	
Blindness <3/60	0 (0%)	6 (1.4)	
Visual acuity on Left eye (n,%)			
Mild visual impairment or no visual impairment ≥ 6/18	198 (99.0)	396 (95.7)	
Moderate visual impairment < 6/18-6/60	2 (1.0)	12 (2.9)	0.14[b]
Severe visual impairment <6/60-3/60	0 (0)	1 (0.2)	
Blindness <3/60	0 (0)	5 (1.2)	

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Vertical cup-to-disc ratio for right eye, Median (IQR)	0.4 (0.2)	0.3 (0.0)	<0.01[a]*
Vertical cup-to-disc ratio for left eye, Median (IQR)	0.4 (0.2)	0.3 (0.1)	<0.01[a]*

[a]Mann-Whitney,[b]Fisher's exact test, *p<0.05

Table 7.5 shows the results of the screening tests (tonometry and Melbourne Rapid Field Test) conducted in the teleglaucoma screening programme. These screening tests were not administered in the conventional pathway. Therefore, no data on these screening tests for the conventional pathway. Results showed a median intraocular pressure within the normal range, a high median visual capacity. The median results for mean deviation, pattern deviation and test duration were higher in the right eye than left eye.

Table 7.5 Results of the screening tests conducted in the teleglaucoma screening programme

Tests	**Median (IQR)**
Intraocular pressure (mmHg)	
Right eye	13 (5.00)
Left eye	13 (6.00)
Melbourne Rapid Field Test	
Mean deviation (dB) for the right eye	-1.23 (2.99)
Mean deviation (dB) for the left eye	-0.84 (2.29)
Pattern deviation (dB) for the right eye	3.88 (3.60)
Pattern deviation (dB) for the left eye	2.83 (3.28)
Visual capacity (%) for the right eye	98.06 (8.25)
Visual capacity (%) for the left eye	99.14 (5.80)
Test duration	
Right eye	3 min 18 sec (57 sec)
Left eye	3 min 8 sec (53 sec)

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7.5.3 Inter-rater agreement between two ophthalmologists in glaucoma diagnosis

Table 7.6 shows the inter-rater agreement between two ophthalmologists in glaucoma diagnosis. The agreement between two ophthalmologists was moderate, with a Cohen's kappa statistic of 0.526 (95% CI [0.34, 0.71]).

Table 7.6 Inter-rater agreement between two ophthalmologists in glaucoma diagnosis

	Rater 1	Rater 2	Cohen's kappa coefficient (95% CI)
Diagnosis	Ophthalmologist 1	Ophthalmologist 2	0.526 (0.34,0.71)

7.5.4 Referral, Accuracy and Detection Rate of Glaucoma or Probable Glaucoma Cases for the Teleglaucoma Screening Programme and Conventional Pathway

Table 7.7 shows the referral, accuracy and detection rates for glaucoma or probable glaucoma, as detected by the teleglaucoma screening programme and the conventional pathway. This study intentionally utilized two separate groups of patients to mirror a real-world clinical setting. In practice, these pathways serve fundamentally different populations: the teleglaucoma programme functions as a community-based screening targeting high-risk individuals, whereas conventional clinics primarily manage patients who are already symptomatic. This design enabled the study to evaluate the effectiveness of the teleglaucoma programme in detecting glaucoma or probable glaucoma in a real-world context.

Referral and detection rates for glaucoma or probable glaucoma in the teleglaucoma screening programme were 13% and 6%, respectively, compared with the conventional pathway, which were 3.14% and 1.45%, respectively. The accuracy rates for teleglaucoma and the conventional pathway were similar, at 46.15%. There were statistically significant differences in the referral and detection rates of glaucoma or probable glaucoma between the teleglaucoma screening programme and the conventional pathway ($p<0.001$ and $p=0.001$, respectively).

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Table 7.7 Referral, accuracy and detection rate of glaucoma or probable glaucoma cases

	Teleglaucoma (n=200)	**Conventional pathway (n=414)**	**p-value**
Number of glaucoma or probable glaucoma cases detected by screening (A)	26	13	p<0.001*
Referral rate (A/N x100%)	13.00%	3.14%	
Number of glaucoma or probable glaucoma cases confirmed at the hospital (B)	12	6	
Accuracy rate (B/A x100%)	46.15%	46.15%	
Detection rate of glaucoma (B/N x100%)	6.00%	1.45%	0.001*

* Chi-square test, *p<0.05

Figure 7.4 shows the flowchart of the distribution of patients for the teleglaucoma screening programme and the conventional pathway. The teleglaucoma screening programme identified 26 probable glaucoma cases, while the conventional pathway identified 13. Among those identified in the teleglaucoma group, 18 patients accepted a hospital referral, while the remainder declined. The patients who refused the referral cited busy schedules, their older age, and disbelief in their diagnosis as their reasons for refusal. Of those referred, 15 attended their eye examinations, resulting in twelve confirmed diagnoses of probable glaucoma: ten cases of primary open-angle suspect (POAGS) and two cases of primary angle-closure suspect (PACS).

In the conventional pathway, ten of the thirteen identified probable glaucoma patients attended their hospital eye examinations. Of the remaining three, two declined referrals, and one could not be contacted. Among those who attended their appointments, the examinations confirmed four cases of glaucoma and two cases of probable glaucoma.

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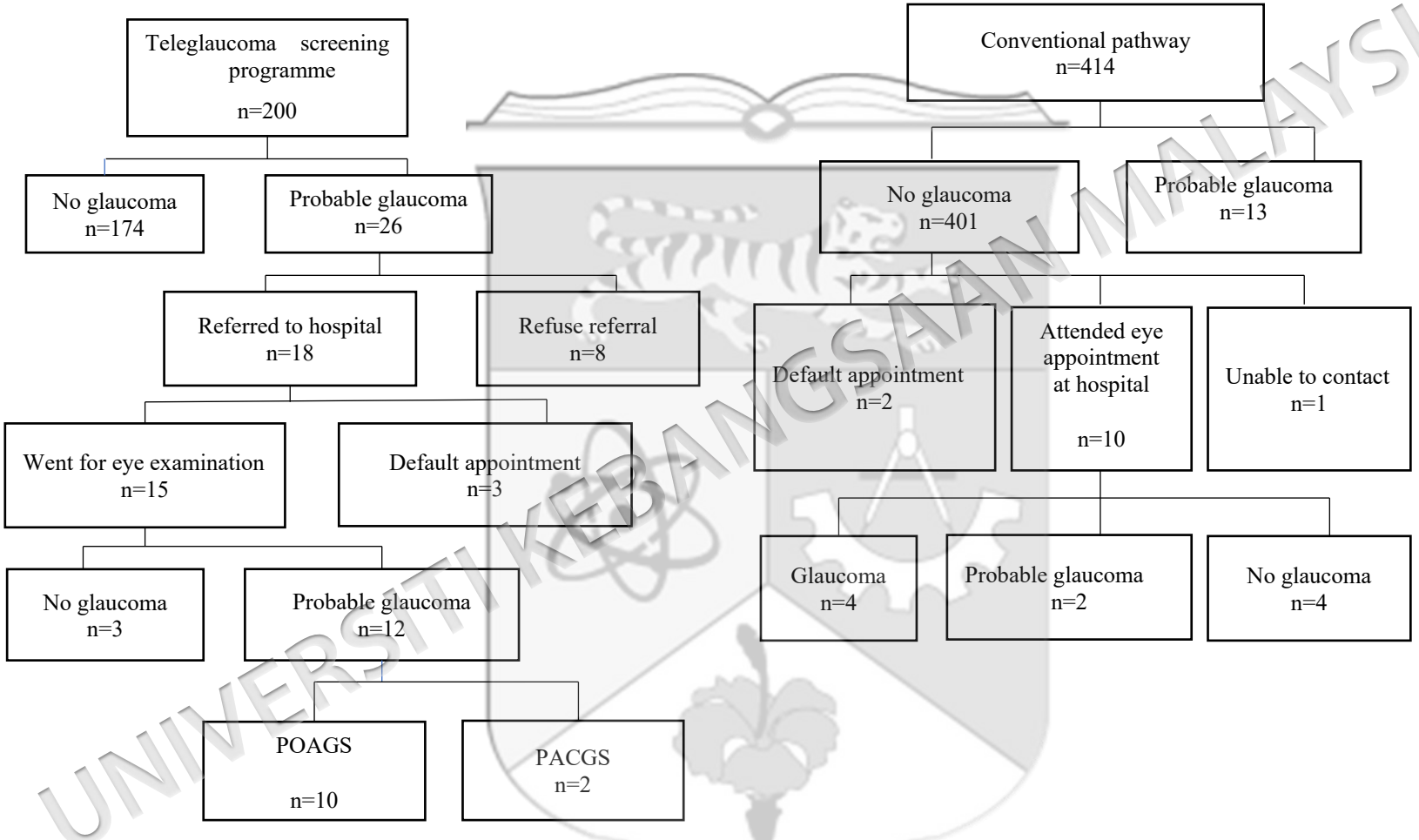

Figure 7.4 Flowchart of the distribution of patients in the teleglaucoma programme and conventional pathway

POAGS= Primary Open-Angle Glaucoma Suspect, Primary Angle-Closure Glaucoma Suspect

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7.5.5 Results of Confirmed Diagnosis of Glaucoma and Probable Glaucoma Patients in the Teleglaucoma Screening Programme and Conventional Pathway

This analysis was performed to determine whether the confirmed glaucoma and probable cases detected through each pathway differed in terms of demographic data such as age, race, gender, medical history and cup-to-disc ratio. This comparison provides additional information regarding the profiles of glaucoma and probable glaucoma patients identified through the two screening approaches.

Table 7.8 shows the demographic data and findings of confirmed glaucoma and probable glaucoma patients in the teleglaucoma screening programme and the conventional pathway. The mean age of confirmed glaucoma or probable patients in the teleglaucoma screening programme was 66.33±5.25 years, ranging from 60 to 77 years old. While in the conventional pathway, their mean age was 61.00±14.04 years, ranging from 39 to 80 years. Most confirmed or probable glaucoma patients were female (n=7, 58.7%) in the teleglaucoma screening programme and 66.7% (n=4) in the conventional pathway.

Table 7.8 Results of confirmed glaucoma and probable glaucoma patients in the teleglaucoma screening programme and conventional pathway

	Teleglaucoma Screening Programme (n=12)	**Conventional pathway (n=6)**	**t-statistic**	**df**	**p value**
Age,mean±SD (years)	66.33±5.25	61.00±14.04	1.19	16	0.25[a]
Range	60-77	39-80			
Gender (n,%)					
Male	5 (41.70)	2 (33.33)			0.57[b]
Female	7 (58.70)	4 (66.67)			
Race (n,%)					
Malay	4 (33.33)	3 (50)			0.76[b]
Chinese	7 (58.30)	3 (50)			
Indian	1 (8.30)	0 (0.00)			

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Medical Condition (n)					
Diabetes mellitus	9	4			0.56[b]
Hypertension	10	6			0.43[b]
Others	12	4			0.10[b]
Family history of glaucoma	1 (8.33)	NA			
Vertical C/D ratio for the right eye	0.56±0.13	0.68±0.13	-1.78	16	0.10[a]
Vertical C/D ratio for the left eye	0.56±0.13	0.67±0.12	-1.69	16	0.11[a]
Intraocular pressure right eye (mean±SD)	14.25±4.14	NA			
Intraocular pressure left eye (mean±SD)	13.83±4.20	NA			

[a] Independent t test, [b] Fischer Exact test , NA: Non applicable

7.5.6 Detection of Other Ocular Diseases in Teleglaucoma Screening Programme and Conventional Pathway

Table 7.9 shows the number of confirmed or probable glaucoma cases with other ocular diseases detected in the teleglaucoma screening programme and conventional pathway. The most commonly detected ocular disease in the teleglaucoma programme and the conventional pathway was cataract.

Table 7.9 Number of confirmed or probable glaucoma cases with other ocular diseases detected in the teleglaucoma screening programme and conventional pathway

Ocular Diseases	Teleglaucoma Screening Programme (N=12), (n,%)	Conventional pathway (N=10),(n,%)
Cataract	7 (58.33)	3 (30.00)
Age-related macular degeneration	1 (8.33)	0 (0.00)
Non-proliferative diabetic retinopathy	0 (0.00)	1(10.00)

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7.6 DISCUSSION

In our study, the detection rate of glaucoma or probable glaucoma in teleglaucoma was significantly higher (6%) than the opportunistic case finding (1.4%) (p=0.001). Medical officers reviewed fundus images in the conventional pathway at the Sentul health clinic which reflects the current standard of care available in many primary care settings,. In contrast, the teleglaucoma programme was specifically designed to extend specialist glaucoma expertise to the primary care setting through telemedicine. Therefore, fundus images were reviewed by an experienced glaucoma specialist, as specialist interpretation is a key component of the teleglaucoma model and one of the anticipated advantages of the programme. The purpose of the study was not to compare the diagnostic abilities of glaucoma specialists and medical officers, but rather to evaluate whether a teleglaucoma programme could improve glaucoma detection compared with the existing conventional pathway. Therefore, the use of varying levels of expertise reflects the intended design of each service model. This difference may cause a higher detection rate of glaucoma in the teleglaucoma screening programme. Our findings were supported by a study showing that the diagnostic accuracy of ophthalmology specialists was higher than that of other groups (non-ophthalmologists and non-specialists), with a sensitivity of 0.68 (Wada-Koike et al. 2024). They concluded that specialized ophthalmological knowledge could improve glaucoma detection (Wada-Koike et al. 2024).

In our study, the teleglaucoma screening programme included four tests: visual acuity, fundus photograph, tonometry, and visual field testing. While in opportunistic case finding, only two tests were used: the visual acuity test and fundus photography. These differences in screening instruments reflected the design of the teleglaucoma programme developed through the earlier phases of this research as the objective of the study was to evaluate the effectiveness of the tele-glaucoma programme as a comprehensive screening model compared with the existing opportunistic case-finding pathway. These limited tests in opportunistic case finding may lead to a lower detection rate, as more tests are typically required for an accurate glaucoma diagnosis. Structural tests, such as fundus photography and visual field test, have the highest chance of detecting glaucoma (Mangione et al. 2022; Tan et al. 2020).

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Our findings showed a lower detection rate of glaucoma or probable glaucoma (6%) than the 9.2% reported in a teleglaucoma programme in Spain (Anton et al. 2021). This may be due to the usage of ocular coherence tomography (OCT) in that study. They reported that combining fundus photography and optical coherence tomography (OCT) achieved 100% sensitivity for detecting advanced glaucoma cases and 69% and 95% specificity for identifying glaucoma or probable glaucoma (Anton et al. 2021). Another study found that using OCT significantly improved the accuracy of glaucoma screening (Watanabe et al. 2022). The sensitivity of diagnostic accuracy of OCT and fundus images was 80% compared with fundus photography alone, which had a sensitivity of 55.4% (Watanabe et al. 2022). Therefore, using OCT in combination with other tests may improve glaucoma detection.

We observed that the visual field test was less practical in a screening setting than the other tests. The main reasons were patient impatience and a lack of attention, as many participants were eager to see a doctor, resulting in unreliable results. Consequently, repeated testing was required to achieve reliable data results. This approach is supported by the teleglaucoma programmes, which excluded visual field tests due to the time-consuming nature of obtaining accurate results (Anton et al. 2021; Chandrasekaran et al. 2019) and the unreliable results from frequency-doubling technology (Marco et al. 2021). Therefore, we suggest that future teleglaucoma programmes do not include visual field testing.

The referral rate for glaucoma or probable glaucoma in teleglaucoma was significantly higher (13%) than in opportunistic case finding (3.14%). This was primarily due to the teleglaucoma's targeted approach to high-risk groups. However, our referral rate was lower than that of a teleglaucoma programme in Kenya, which was 28.2% (Marco et al. 2021). This was likely due to the higher glaucoma risk in African populations (Cole et al. 2021). Furthermore, cases in Africa often present at an advanced stage due to limited access to ophthalmic care, leading to a higher referral rate. Marco et al. (2021) reported that out of 42 glaucoma cases, 33.3% (n=14) were moderate and 52.4% (n=22) were advanced glaucoma.

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There was a significant difference in the distribution of races between the conventional pathway and the teleglaucoma screening programme, with a higher proportion of Indians and Others in the conventional pathway and Chinese in the teleglaucoma screening programme. Sentul Health Clinic was one of the Ministry of Health's primary health clinics, and eye screening is usually conducted for all diabetic patients in primary health clinics under the Ministry of Health to detect diabetic retinopathy (Ngah et al. 2020). The prevalence of diabetes mellitus was the highest among Indians (31.4%) than other races, Malays (21.6%), and Chinese (15.4%) in Malaysia (Kazlauskaite et al. 2023). Therefore, this suggests that the higher proportion of Indians in the conventional pathway was due to the higher prevalence of diabetes mellitus being highest among them.

The higher participation of Chinese ethnicity in the teleglaucoma screening programme compared to the conventional pathway may be due to the teleglaucoma recruitment strategy, which emphasized the need for screening. This was supported by a study that reported direct engagement via email, mail, telephone, or in-person contact proved to be the most effective recruitment strategy during the Screening and Intervention for Glaucoma and Eye Health through Telemedicine (SIGHT) studies in the USA (Sapru et al. 2024). This contrasts with opportunistic approaches, which rely on passive patient attendance. Previous research demonstrated that Chinese diabetic adults had significantly adjusted lower odds of attending annual eye examinations than Malays (aOR=0.50, 95% CI [0.29, 0.87]) (Yap et al. 2025). This finding supported our report of a lower proportion of Chinese participants in the conventional pathway.

In the conventional pathway, some cases of blindness were observed, whereas none were found in our teleglaucoma programme. Similarly, a previous study in China, which compared a glaucoma screening programme with opportunistic case finding, found that the glaucoma screening programme detected less visual impairment (6.6%) than opportunistic case finding (38.6%) (Xie et al. 2023). This result was likely due to differences in the causes of blindness in opportunistic case finding, which may be caused by other eye conditions such as cataract. The teleglaucoma programme was specifically designed to screen for glaucoma and excluded unclear fundus images due to media opacity. Thus, this criterion excludes patients with severe visual impairment

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and blindness from our study, leading to no such cases being identified within the programme itself.

In this study, participants in the teleglaucoma screening programme had a significantly higher vertical cup-to-disc ratio in both eyes than those assessed via the conventional pathway. This finding suggests that participants with teleglaucoma may exhibit larger optic nerve cupping, potentially reflecting a higher likelihood of glaucomatous damage in this pathway. Teleglaucoma programmes often function as targeted screening, which may detect patients with more suspicious optic nerve findings. This was supported by Giorgis et al. (2019) who suggested that their programme's high glaucoma detection rate (7.9%) was due to screening high-risk participants. Thus, these findings support the role of teleglaucoma as an effective screening tool for detecting glaucoma or probable glaucoma.

The agreement between the two ophthalmologists in teleglaucoma programme was moderate, both in diagnosis and management. These findings aligned with a study comparing teleglaucoma to in-person diagnosis, which reported moderate agreement between two ophthalmologists for glaucoma diagnosis, with a kappa of 0.61 (95% CI [0.50, 0.72]) (Balakrishnan et al. 2024). Similarly, a teleglaucoma programme found a moderate interobserver agreement between two ophthalmologists for glaucoma diagnosis, with a kappa of 0.37 and Prevalence-Adjusted Bias-Adjusted Kappa (PABAK) of 0.58 (Anton et al. 2021). While Balakrishnan et al. (2024) used OCT, a fundus camera, and a Humphrey Visual Analyser, Anton et al. (2021) used OCT and a fundus camera. Our study's lower Kappa coefficient compared to these studies may be attributed to the absence of OCT imaging in our study.

The cases identified by the teleglaucoma screening programme were probable glaucoma, whereas the opportunistic case finding identified cases of glaucoma and probable glaucoma. This difference may be due to opportunistic case finding, which identified patients with symptoms or comorbidities that may increase their glaucoma risk. Many of these individuals in opportunistic case finding may already have advanced glaucomatous optic nerve damage due to a lack of ophthalmic care, which leads to a higher rate of confirmed glaucoma diagnoses. This finding aligns with a study in Iran,

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which reported that 55.3% patients remained undiagnosed of primary open-angle glaucoma even though they had at least one eye examination in the past year (Doozandeh et al. 2022). Many of these cases had moderate to severe visual field loss, indicating advanced glaucomatous damage by the time of diagnosis (Doozandeh et al. 2022). In contrast, our teleglaucoma programme targets high-risk populations regardless of symptoms. Therefore, teleglaucoma can identify probable glaucoma cases earlier, before the disease progresses to an advanced state. A previous study demonstrated that teleglaucoma was highly sensitive (98.7%) for detecting glaucoma but had a lower specificity (76.5%) (Wong et al. 2022). This suggests that teleglaucoma is highly effective at detecting glaucoma, making it a valuable screening tool. Thus, these findings demonstrate that a teleglaucoma screening programme can facilitate the early detection of glaucoma, thereby helping prevent blindness from the disease.

Although this teleglaucoma programme was developed to detect glaucoma, we also identified other ocular diseases, such as cataract and age-related macular degeneration, among patients referred for glaucoma or probable glaucoma. This finding was similar to other teleglaucoma programmes, which also reported the detection of other eye diseases such as cataract, age-related macular degeneration diabetic retinopathy (Giorgis et al. 2019; Maa et al. 2020; Marco et al. 2021; Newman-Casey et al. 2023; Owsley et al. 2024). The most frequent diagnosis of other eye disease was cataract, which was similarly found in other studies (Giorgis et al. 2019; Maa et al. 2020; Marco et al. 2021; Newman-Casey et al. 2023; Owsley et al. 2024).

During the study, patient compliance with in-person eye examinations at the hospital was a significant challenge. These study findings aligned with a study in Brazil, which found the highest no-show rate of 54.1% among patients referred for suspected glaucoma after a mobile unit screening (Rezende et al. 2021). The patient-reported reasons for non-attendance included a limited understanding of glaucoma, a lack of perceived urgency due to the disease's asymptomatic nature, a failure to appreciate the seriousness of their condition, and unclear communication about appointments (Rezende et al. 2021). These findings underscore the necessity of a glaucoma awareness programme to better educate the public.

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Scaling this teleglaucoma system from HCTM to a national network of primary clinics in Malaysia requires a phased roadmap that integrates seamlessly into existing infrastructure. The system works by turning primary clinics into imaging sites and major hospitals into remote reading centers. The first phase of the roadmap begins with a regional pilot to ensure that the Electronic Medical Record Standard Template (EMRST) integrates smoothly with other health systems outside HCTM. Next, the implementation of a central, cloud-based platform that handles high-volume images from different camera brands and supports offline storage for rural clinics with weak internet connectivity. The next phase is to collaborate with the Ministry of Health to integrate the glaucoma screening module into the continuing professional development (CPD) curriculum for primary eye care providers. Finally, the final phase will be the integration of AI algorithm into the system to automatically diagnose glaucoma cases for specialist review, thereby saving time without requiring additional doctors for initial screening and management.

The strength of this study was that it was the first teleglaucoma programme in Malaysia. A significant factor contributing to its successful implementation was the ability to utilise existing resources, including the EMRST CHEtS HCTM electronic medical record, a dedicated team of experienced personnel, and equipment such as a non-mydriatic fundus camera and two skilled glaucoma specialists. Furthermore, specialists do not need to be at screening sites, thereby enhancing the efficiency of glaucoma care delivery.

The limitation of our study was that the tele-glaucoma and conventional pathways were comprised of two different patient populations and were not evaluated under the same study conditions. While statistical analysis confirmed that the two groups were comparable in age and gender, they differed significantly in ethnic composition. This demographic imbalance serves as a confounding variable because specific ethnic groups within the Malaysian population may present with varying baseline risks or types of glaucoma. Consequently, differences in detection rates cannot be attributed solely to the screening modalities themselves, highlighting the need for future studies to eliminate this bias. We also did not assess the sensitivity and specificity of the teleglaucoma programme compared to an in-person examination in our study.

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Another limitation of our study was that some data on medical comorbidities were missing for the conventional pathway.

Future studies employing comparable populations and employing standardized diagnostic protocols are required to determine whether teleglaucoma improves glaucoma detection rates relative to conventional screening approaches. The accuracy of ophthalmologists' diagnoses in teleglaucoma compared with in-person examination should be conducted in future studies to demonstrate that teleglaucoma is a safe model for glaucoma care services. Moreover, future research should also consider integrating artificial intelligence (AI) into the teleglaucoma programme.

7.7 CONCLUSION

In conclusion, teleglaucoma aids in detecting glaucoma and probable glaucoma. The findings will provide valuable evidence to support the design and implementation of a nationwide teleglaucoma screening programme. This will ultimately contribute to earlier detection of glaucoma, preventing blindness and supporting a more efficient healthcare system.

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CHAPTER VIII

CONCLUSION

8.1 SUMMARY OF FINDINGS

In Phase I, the essential components of a teleglaucoma screening programme were identified. The components of a teleglaucoma screening programme include screening high-risk patients, relevant clinical examinations such as history taking, visual acuity testing, tonometry, fundus photography, and perimetry, accessible screening locations, a robust teleglaucoma system, trained personnel, and clear referral guideline.

The findings from Phase II indicated that a training programme for glaucoma screeners should be conducted by ophthalmologists for primary eye care providers. Furthermore, it should feature both theoretical and practical sessions, with a duration aligned closely with the content. The effectiveness of the training should be evaluated through theory and practical examinations. Credentialing and privileging should be implemented to ensure sustained proficiency of glaucoma screeners.

In Phase III, the new training module was developed in Malay and English with good content and face validity. The newly developed training programme improved the knowledge, skills, and self-confidence of glaucoma screeners in performing glaucoma screening. Phase IV evaluation showed that the newly adapted EMRST C-HeTS teleglaucoma system was perceived as easy to use and functional. Finally, the clinical evaluation in Phase V showed that the detection rate of glaucoma or probable glaucoma in the teleglaucoma screening programme was significantly higher (6%) than the opportunistic case finding (1.4%).

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8.2 STUDY STRENGTH

To the best of the investigator's knowledge, this was the first study conducted on the development and implementation of the teleglaucoma screening programme in Malaysia. This study utilised a newly developed training programme and teleglaucoma system for eye care providers. Therefore, this approach can be effectively used to implement a national glaucoma screening programme in Malaysia.

8.3 IMPLICATIONS OF THE STUDY

In our study, the teleglaucoma programme can effectively detect both glaucoma and probable glaucoma with the involvement of specially trained eye care providers. This technology empowers patients who previously lacked access to regular eye examinations to benefit from early detection and timely intervention, thereby reducing the risk of preventable blindness. Teleglaucoma can also reduce the workload burden on ophthalmologists, as they do not need to be on-site. This evolution not only preserves the vision of high-risk individuals but also ensures the long-term sustainability of glaucoma services. Ultimately, it will pave the way for the integration of artificial intelligence in glaucoma care enabling the transition from manual to automated grading.

8.4 STUDY LIMITATIONS

This study had some limitations. The systematic reviews were restricted to English articles and had some missing data. Different interview formats in the qualitative studies such as online and face-to-face, as well as poor internet connectivity, may affect participants' responses. Additionally, the exclusion of patient perspectives focusing solely on professionals may have narrowed the findings of the qualitative interviews. Most of the data in our study were collected in the Klang Valley, potentially failing to represent the broader Malaysian population. Another limitation was the absence of a pre-training assessment for the online fundus grading and practical tests. Reliance on simulated tasks rather than "real-world" clinical environments may have affected the assessment of the teleglaucoma system's usability and functionality. Furthermore, there was some missing comorbidity data in the conventional pathway and a lack of

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comparisons between teleglaucoma screening programme and subsequent in-person examinations.

8.5 RECOMMENDATION FOR FUTURE RESEARCH

Building upon the Phase II and III findings, future research should evaluate the long-term retention of knowledge, skills, and self-confidence among trained primary eye care providers over a 12- to 24-month period so that policymakers can develop a clear regulatory framework to establish a standardized training programme and credentialing for glaucoma screeners.

While Phase IV demonstrated that the EMRST C-HeTS teleglaucoma system is functional and easy to use, future research should focus on optimizing its technical capabilities for large-scale clinical deployment. Based on initial user feedback, future studies should investigate integrating advanced software enhancements, such as standardized history templates, sequential side-by-side image viewers to monitor progression, and 'edit' functions for submitted clinical sheets. Furthermore, future implementation should also focus on integrating Artificial Intelligence (AI) algorithms and deep learning algorithms to enhance screening accuracy by providing preliminary diagnostic decision for glaucoma screeners. Finally, future technical evaluations must assess the system's data privacy and confidentiality

Although Phase V successfully demonstrated a significantly higher glaucoma detection rate (6%) than opportunistic case-finding (1.4%), future studies should investigate the long-term clinical outcomes of these identified patients. Longitudinal research is needed to track patient adherence to follow-up visits. Future research should also focus on the diagnostic accuracy of the teleglaucoma screening programme compared with in-person examinations. It is also essential to assess the cost-effectiveness of the teleglaucoma programme compared with opportunistic case-finding to provide policy-makers with the economic justification required for nationwide implementation. Finally, further research is required to facilitate a nationwide implementation of the teleglaucoma programme across rural primary care settings to optimize the system's integration with existing national health networks.

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8.6 CONCLUSION

Our results indicated that teleglaucoma can detect glaucoma and probable glaucoma better than opportunistic case finding. Therefore, teleglaucoma can prevent future blindness in Malaysia. The results of this study are crucial for developing and implementing effective teleglaucoma screening programmes in Malaysia. Future research should include a larger sample size with more locations of the teleglaucoma programme to determine whether our results can be achieved in other clinics and populations.

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APPENDIX A

ETHICS APPROVAL LETTER FROM UNIVERSITI KEBANGSAAN MALAYSIA

UNIVERSITI KEBANGSAAN MALAYSIA
The National University of Malaysia

PUSAT PENGURUSAN PENYELIDIKAN DAN INSTRUMENTASI • *CENTRE FOR RESEARCH AND INSTRUMENTATION MANAGEMENT*

Rujukan: UKM PPI/111/8/JEP-2020-127
Tarikh: 28 Februari 2020

Profesor Madya Dr Jemaima Che Hamzah
Jabatan Oftalmologi
Hospital Canselor Tuanku Muhriz
Pusat Perubatan UKM

Y.Bhg. Profesor/Datuk/Dato'/Datin/Tuan/Puan,

KELULUSAN ETIKA MENJALANKAN PENYELIDIKAN DI UKM

Tajuk Penyelidikan : *Teleglaucoma Program For Prevention Of Future Blindness In Malaysia*

Perkara yang tersebut di atas adalah dirujuk.

2. Sukacita dimaklumkan, Jawatankuasa Etika Penyelidikan UKM meluluskan permohonan penyelidikan Y. Bhg. Profesor/Datuk/Dato'/Datin/Tuan/Puan bagi tajuk diatas. Tempoh kelulusan penyelidikan adalah daripada **27 Februari 2020 – 26 Disember 2022.** Sila kemukakan sebarang Laporan **Kesan Sampingan, Laporan Kemajuan Setiap 6 Bulan** dan **Laporan Akhir** sebaik sahaja penyelidikan tamat kepada Jawatankuasa Etika Penyelidikan UKM.

3. Sukacita diingatkan projek penyelidikan ini hanya boleh dijalankan setelah mendapat **surat kelulusan menjalankan penyelidikan** dari Timbalan Dekan Penyelidikan Fakulti atau Pengarah Pusat/Institut.

Sekian, terima kasih.

Yang benar,

PROFESOR DATO' DR. FUAD ISMAIL
Pengerusi
Jawatankuasa Etika Penyelidikan
Universiti Kebangsaan Malaysia

s.k. - **Pengarah**
Pusat Pengurusan Penyelidikan dan Instrumentasi (CRIM)
Universiti Kebangsaan Malaysia

- **Pengarah**
Hospital Canselor Tuanku Muhriz
Pusat Perubatan UKM

Sekretariat Etika Penyelidikan Universiti Kebangsaan Malaysia
Tingkat 1, Blok Klinikal, Hospital Canselor Tuanku Muhriz,Pusat Perubatan UKM, Jalan Yaacob Latif, Bandar Tun Razak, 56000 Cheras Kuala Lumpur.
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UNIVERSITI KEBANGSAAN MALAYSIA
The National University of Malaysia

FAKULTI PERUBATAN • *FACULTY OF MEDICINE*

Rujukan: UKM FPR.SPI 800-2/28/181
Tarikh : 11 November 2022

Profesor Madya Dr. Jemaima Che Hamzah
Jabatan Oftalmologi
Fakulti Perubatan UKM

YBhg. Profesor/Datuk/Dato'/Datin/Tuan/Puan,

PERMOHONAN TAMBAHAN MASA PROJEK PENYELIDIKAN

Tajuk Penyelidikan : *Teleglaucoma Program for Prevention of Future Blindness in Malaysia*

Kod Projek : FF-2020-098

Dengan hormatnya merujuk kepada perkara di atas dan borang YBhg. Profesor/Datuk/Dato'/Datin/Tuan/Puan bertarikh 16 Oktober 2022 adalah berkaitan.

Adalah dimaklumkan bahawa, Jawatankuasa Penyelidikan Perubatan, Fakulti Perubatan UKM bersetuju dan meluluskan permohonan tambahan masa bagi projek penyelidikan di atas. Butiran kelulusan adalah seperti berikut :

Tempoh kelulusan (Asal)	:	***27 Februari 2020-26 Disember 2022***
Kelulusan Tambahan Masa	:	***27 Disember 2022-26 Disember 2023***

Sekian, terima kasih.

Yang benar,

PROFESOR DR. TAN GEOK CHIN
Timbalan Dekan (Penyelidikan & Inovasi)
Merangkap Pengerusi Jawatankuasa Penyelidikan Perubatan
Fakulti Perubatan UKM

s.k. - **Pengerusi Jawatankuasa Etika Penyelidikan UKM**
Sekretariat Etika Penyelidikan
Universiti Kebangsaan Malaysia

UNIVERSITI KEBANGSAAN MALAYSIA

APPENDIX B

ETHICS APPROVAL FROM THE MINISTRY OF HEALTH MALAYSIA

JAWATANKUASA ETIKA & PENYELIDIKAN PERUBATAN
(MEDICAL RESEARCH & ETHICS COMMITTEE)
KEMENTERIAN KESIHATAN MALAYSIA
MINISTRY OF HEALTH MALAYSIA
Kompleks Institut Kesihatan Negara (NIH)
No.1, Jalan Setia Murni U13/52,
Seksyen U13 Bandar Setia Alam,
40170 Shah Alam, Selangor.
Tel.: +(6)03-33628888/ 33628205

Ref. : KKM/NIHSEC/P20-2319(12)
Date : **28-December-2020**

ASSOCIATE PROFESSOR JEMAIMA CHE HAMZAH
UNIVERSITI KEBANGSAAN MALAYSIA (UKM)

Dear Dato'/ Dr/ Sir/ Madam,

LETTER OF ETHICAL APPROVAL:

NMRR-20-2418-56993 (IIR)
TELEGLAUCOMA PROGRAM FOR PREVENTION OF FUTURE BLINDNESS IN MALAYSIA

This letter is made in reference to the matter above.

2. The Medical Research and Ethics Committee (MREC), Ministry of Health Malaysia (MOH) has provided ethical approval for this study. Please take note that all records and data are to be kept strictly **CONFIDENTIAL** and can only be used for the purpose of this study. All precautions are be taken to maintain data confidentiality. Permission from the District Health Officer / Hospital Administrator/ Hospital Director and all relevant heads of departments /units where the study will be carried out must be obtained prior to the study. You are required to follow and comply with their decision and all other relevant regulations including the Access to the Biological and Benefit Sharing Act 2017.

3. The investigators and sites involved in this study are:

Klinik Kesihatan Sentul
Associate Professor Jemaima Che Hamzah (Principal / Coordinating Investigator)
Dr. Mohd Harimi Abd Rahman
Dr. Mohd Izzuddin Bin Hairol
Dr. Rohayah Bte Ismail
Dr. Rona Asnida Binti Nasaruddin
Dr. Sharanjeet Kaur
Wee Xiao Hui

4. The following study documents have been received and reviewed with reference to the above study:

Documents received and reviewed with reference to the above study:

1. Cover letter to MREC (Version 2, dated 23-12-2020)
2. Declaration of Conflict of Interest (COI) (Version 1, dated 30-11-2020)
3. Protocol (Version 2.2, dated 23-12-2020)
4. English: Patient Information Sheet/ Informed Consent Form (Version 2, dated 23-12-2020)
5. Malay: Patient Information Sheet/ Informed Consent Form (Version 2, dated 23-12-2020)
6. Data Collection Form (Version 1.1, dated 30-11-2020)
7. Follow-up Review Report (Version 1, dated 23-12-2020)
8. IA-HOD-IA, CV and GCP Certification of:
   - Associate Professor Jemaima Che Hamzah

.../2-

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APPENDIX C

KEYWORDS FOR SEARCH STRATEGY IN PHASE I

Glaucoma* OR eye pressure OR intraocular pressure OR intra-ocular pressure OR intraocular hypertension OR intra-ocular hypertension OR intra-ocular tension OR intraocular tension OR ocular hypertension) AND (Teleglaucoma OR Tele-glaucoma OR Teleophthalm* OR Tele-ophthalm* OR Telemedicine OR Tele-medicine OR Telehealth OR Tele-health OR Telescreen* OR Tele-screen* OR Tele-screen* OR remote consult* OR Telediagnos* OR Tele-diagnos* OR remote consult* OR mobile*)) AND (diagnos* OR screen* OR evaluation* OR assessment* OR test* OR exam* OR detect* OR referral* OR pathway* OR platform* OR system*

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APPENDIX D

MMAT VERSION 2018

Category of study designs	Methodological quality criteria	Responses			
		Yes	No	Can't tell	Comments
Screening questions (for all types)	S1. Are there clear research questions?				
	S2. Do the collected data allow to address the research questions?				
	Further appraisal may not be feasible or appropriate when the answer is 'No' or 'Can't tell' to one or both screening questions.				
1. Qualitative	1.1. Is the qualitative approach appropriate to answer the research question?				
	1.2. Are the qualitative data collection methods adequate to address the research question?				
	1.3. Are the findings adequately derived from the data?				
	1.4. Is the interpretation of results sufficiently substantiated by data?				
	1.5. Is there coherence between qualitative data sources, collection, analysis and interpretation?				
2. Quantitative randomized controlled trials	2.1. Is randomization appropriately performed?				
	2.2. Are the groups comparable at baseline?				
	2.3. Are there complete outcome data?				
	2.4. Are outcome assessors blinded to the intervention provided?				
	2.5 Did the participants adhere to the assigned intervention?				
3. Quantitative non-randomized	3.1. Are the participants representative of the target population?				
	3.2. Are measurements appropriate regarding both the outcome and intervention (or exposure)?				
	3.3. Are there complete outcome data?				
	3.4. Are the confounders accounted for in the design and analysis?				
	3.5. During the study period, is the intervention administered (or exposure occurred) as intended?				
4. Quantitative descriptive	4.1. Is the sampling strategy relevant to address the research question?				
	4.2. Is the sample representative of the target population?				
	4.3. Are the measurements appropriate?				
	4.4. Is the risk of nonresponse bias low?				
	4.5. Is the statistical analysis appropriate to answer the research question?				
5. Mixed methods	5.1. Is there an adequate rationale for using a mixed methods design to address the research question?				
	5.2. Are the different components of the study effectively integrated to answer the research question?				
	5.3. Are the outputs of the integration of qualitative and quantitative components adequately interpreted?				
	5.4. Are divergences and inconsistencies between quantitative and qualitative results adequately addressed?				
	5.5. Do the different components of the study adhere to the quality criteria of each tradition of the methods involved?				

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APPENDIX E

QUADAS-2

Phase 3: Risk of bias and applicability judgments

QUADAS-2 is structured so that 4 key domains are each rated in terms of the risk of bias and the concern regarding applicability to the research question (as defined above). Each key domain has a set of signalling questions to help reach the judgments regarding bias and applicability.

DOMAIN 1: PATIENT SELECTION

A. Risk of Bias

Describe methods of patient selection:

- ❖ Was a consecutive or random sample of patients enrolled? Yes/No/Unclear
- ❖ Was a case-control design avoided? Yes/No/Unclear
- ❖ Did the study avoid inappropriate exclusions? Yes/No/Unclear

Could the selection of patients have introduced bias? **RISK: LOW/HIGH/UNCLEAR**

B. Concerns regarding applicability

Describe included patients (prior testing, presentation, intended use of index test and setting):

Is there concern that the included patients do not match the review question? **CONCERN: LOW/HIGH/UNCLEAR**

DOMAIN 2: INDEX TEST(S)

If more than one index test was used, please complete for each test.

A. Risk of Bias

Describe the index test and how it was conducted and interpreted:

- ❖ Were the index test results interpreted without knowledge of the results of the reference standard? Yes/No/Unclear
- ❖ If a threshold was used, was it pre-specified? Yes/No/Unclear

Could the conduct or interpretation of the index test have introduced bias? **RISK: LOW /HIGH/UNCLEAR**

B. Concerns regarding applicability

Is there concern that the index test, its conduct, or interpretation differ from the review question? **CONCERN: LOW /HIGH/UNCLEAR**

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DOMAIN 3: REFERENCE STANDARD

A. Risk of Bias

Describe the reference standard and how it was conducted and interpreted:

- ❖ Is the reference standard likely to correctly classify the target condition? Yes/No/Unclear
- ❖ Were the reference standard results interpreted without knowledge of the results of the index test? Yes/No/Unclear

Could the reference standard, its conduct, or its interpretation have introduced bias? **RISK: LOW /HIGH/UNCLEAR**

B. Concerns regarding applicability

Is there concern that the target condition as defined by the reference standard does not match the review question? **CONCERN: LOW /HIGH/UNCLEAR**

DOMAIN 4: FLOW AND TIMING

A. Risk of Bias

Describe any patients who did not receive the index test(s) and/or reference standard or who were excluded from the 2x2 table (refer to flow diagram):

Describe the time interval and any interventions between index test(s) and reference standard:

- ❖ Was there an appropriate interval between index test(s) and reference standard? Yes/No/Unclear
- ❖ Did all patients receive a reference standard? Yes/No/Unclear
- ❖ Did patients receive the same reference standard? Yes/No/Unclear
- ❖ Were all patients included in the analysis? Yes/No/Unclear

Could the patient flow have introduced bias? **RISK: LOW /HIGH/UNCLEAR**

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APPENDIX F

PARTICIPANT'S INFORMATION SHEET IN PHASE I

Research Title: Teleglaucoma programme for prevention of future blindness in Malaysia

Introduction:

You are invited to participate in a research study. Before participating in this study, it is important that you take time to read and understand the information in this Information Sheet.

Purpose of Study:

Glaucoma is the second leading cause of global blindness after cataract according to World Health Organization (WHO). However, glaucoma presents an even greater public health challenge than cataracts: because the blindness it causes is irreversible. Glaucoma is a chronic bilateral eye disease with progressive optic neuropathy leading to optic nerve damage. If untreated, it will result in permanent visual impairment and blindness. The aim of this study is to explore opinions on glaucoma screening and identify its components.

What will the study involve?

You are about to undergo a 20-50 minutes interview. You will be asked a few questions related to glaucoma screening. This entire interview session will be audio-recorded and transcribed. Participants will be reassured before the interview starts that they can ask for the audio recorder to be switched off at any time.

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Risks and Benefits:

There is unlikely to be a direct benefit for you in participating in this study. There is no risk involved in this study. Our approach does not involve any direct contact with you or any treatment.

Do you have to take part?

Participation in this study is voluntary. If you agree to take part, then you will be asked to sign the "Informed Consent Form". You will be given a copy of the form and this Information Sheet.

Should you decide to participate, you can still withdraw from the study without penalty. Your data will not be used and will be discarded. The researcher may also remove you from the study for various reasons. In this event, you will not be penalised or lose your rights as a participant.

Data & Confidentiality:

Each participant will be assigned an anonymous code (e.g. P01, P02, …). Audio recordings and transcripts will be labelled with the participant's anonymous code and date. Transcription will be undertaken and kept in a safe place.

The data from this study will be made into a report, which may be published. Access to the data is only by the research team. The data will be reported in a collective manner with no reference to an individual. Hence, your identity will be kept confidential.

Payment and compensation:

You do not have to pay, nor will you be paid, to participate in this study.

Who can I ask about the study?

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If you have any questions, you can direct them to the research team. You can also contact the REC UKM for clarifications.

Name: Assoc. Prof. Dr Jemaima Che Hamzah

Department of Ophthalmology UKMMC

Name: Wee Xiao Hui

Department of Ophthalmology UKMMC

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APPENDIX G

INFORMED CONSENT FORM

Research Title: Teleglaucoma Programme For Future Prevention of Blindness in Malaysia

Researcher's Name: Wee Xiao Hui

I, ……, IC No : …….....

have read the information in the Patient Information Sheet including information regarding the risk in this study

have been given time to think about it and all of my questions have been answered to my satisfaction.

understand that I may freely choose to withdraw from this study at anytime without reason and without repercussion

understand that my anonymity will be ensured in the write-up.

I voluntarily agree to be part of this research study, to follow the study procedures, and to provide necessary information to the doctor, nurses, or other staff members, as requested.

…… …….

(Signature) (Date)

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…….	…….
Witness (if any)	Researcher
…….	…….
(Signature)	(Signature)
…….	…….
(IC Number)	(IC Number)
……..…	…….
(Date)	(Date)

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APPENDIX H

TOPIC GUIDE IN ENGLISH FOR SEMI-STRUCTURED INTERVIEW IN PHASE I

Introduction: Glaucoma is the leading cause of irreversible blindness. The global prevalence of primary open-angle glaucoma is 3.05% and primary angle closure glaucoma is 0.50%. %. Overall, the prevalence of glaucoma in Asia is 3.54%. However, there is not much glaucoma screening. The purpose of today's interview is to gather your information and opinions on glaucoma screening in Malaysia.

Question 1 . What do you think of glaucoma screening in Malaysia?

Probes: Why do you think glaucoma screening is important?

Can you tell us how it is done.

Tell us about the types of glaucoma screening in Malaysia.

Question 2 . Who are the professionals that you think should be involved in this screening process?

Probe: Do you think any other non-medical professionals can be involved in glaucoma screening?

Question 3. What instrument is necessary for glaucoma screening in Malaysia?

Probes: Why did you say that the instrument is necessary for glaucoma screening?

Is a VA test or another test needed for screening?

Question 4. Who do you think should be screened for glaucoma?

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Probe: Can you tell me more about this?

Why do you think they are suitable?

Question 5. Where do you think that screening should be conducted?

Probe: Can you tell me more about this location?

Why do you think the location is suitable for glaucoma screening?

Question 6. Can you tell us the referral criteria for suspected glaucoma patients to be referred to the hospital?

Probe: Is there any other referral criteria?

Question 7. Normally, we refer to glaucoma to an eye specialist. If we have a new glaucoma screening programme, what is the suitable referral pathway? (Briefly explain to participants examples of glaucoma refinement pathways such as Manchester, Nottingham, and Huntingdon pathways)

Probe- Why do you think that the pathway is suitable?

Question 8. There is a risk of high false positives, which could place a burden on the eye clinic if a new glaucoma screening is implemented. In your opinion, what are the ways to reduce unnecessary referrals to the eye clinic?

Question 9. What do you think of teleglaucoma in Malaysia?

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APPENDIX I

TOPIC GUIDE IN MALAY FOR SEMI-STRUCTURED INTERVIEW IN PHASE I

Pengenalan: Glaukoma adalah punca utama kebutaan yang tidak dapat dipulihkan. Prevalens global glaukoma sudut terbuka primer ialah 3.05% dan glaukoma sudut tertutup primer ialah 0.50%. %. Prevalens glaukoma di Asia ialah 3.54%. Walau bagaimanapun tidak banyak saringan glaukoma dilakukan. Tujuan temu bual hari ini adalah untuk mengumpulkan maklumat dan pendapat anda tentang saringan glaukoma di Malaysia.

Soalan 1. Apakah pendapat anda tentang saringan glaukoma di Malaysia?

Soalan penyelidik: Mengapakah anda berpendapat bahawa saringan glaukoma adalah penting?

Bolehkah anda memberitahu saya bagaimana ia dilakukan.

Bolehkah anda menjelaskan tentang jenis saringan glaukoma di Malaysia?

Soalan 2 . Siapakah profesional yang anda berpendapat harus terlibat dalam proses saringan?

Soalan penyelidik: Adakah mana-mana profesional bukan perubatan lain yang boleh terlibat dalam saringan glaukoma?

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Soalan 3: Apakah peralatan yang diperlukan untuk saringan glaukoma di Malaysia?

Soalan penyelidik: Mengapa anda mengatakan bahawa peralatan itu perlu untuk saringan glaukoma ?

Adakah ujian VA atau ujian lain diperlukan untuk saringan?

Soalan 4: Pada pendapat anda, siapakah yang patut disaring untuk glaukoma?

Soalan penyelidik: Bolehkah anda memberitahu saya lebih lanjut mengenai perkara ini?

Mengapa anda berpendapat dia sesuai disaring untuk glaukoma?

Soalan 5. Pada pendapat anda, di manakah saringan perlu dijalankan?

Soalan penyelidik: Bolehkah anda memberitahu saya lebih lanjut mengenai lokasi ini?.

Mengapa anda berpendapat lokasi tersebut sesuai untuk saringan glaukoma?

Soalan 6. Bolehkah anda memberitahu saya kriteria bagi individu disyaki glaukoma untuk dirujuk ke hospital?

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Soalan penyelidik: Adakah terdapat kriteria rujukan yang lain?

Soalan 7. Kebiasaannya, kami merujuk kepada glaukoma kepada pakar mata. Jika kita mempunyai program saringan glaukoma yang baru, apakah laluan rujukan yang sesuai? (Terangkan secara ringkas kepada peserta contoh laluan glaukoma seperti laluan Manchester, Nottingham, dan Huntingdon)

Soalan penyelidik: Mengapa anda berpendapat laluan rujukan tersebut sesuai?

Soalan 8. Terdapat risiko positif palsu yang tinggi yang boleh membebankan klinik mata jika program saringan glaukoma yang baru dilaksanakan. Pada pendapat anda, apakah cara untuk mengurangkan rujukan yang tidak perlu ke klinik mata?

Soalan 9. Apakah pendapat anda mengenai teleglaukoma di Malaysia?

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APPENDIX J

KEYWORDS FOR SEARCH STRATEGY IN PHASE II

(health personnel* OR technician* OR eye healthcare professional* OR eye health professional* * OR eye healthcare provider* OR optometrist* OR nurse* OR doctor* OR physician* OR medical doctor* OR medical practitioner* OR clinician) AND (Glaucoma screen* OR glaucoma assess* OR glaucoma detect* OR glaucoma diagnos* or glaucoma evaluat*)) AND (train* OR module* OR manual* OR curriculum* OR learn* OR instruct* OR education*)

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APPENDIX K

PARTICIPANT'S INFORMATION SHEET IN PHASE II

Research Title: Teleglaucoma programme for prevention of future blindness in Malaysia

Introduction:

You are invited to participate in a research study. Before participating in this study, it is important that you take time to read and understand the information in this Information Sheet.

Purpose of Study:

Glaucoma is the second leading cause of global blindness after cataract according to World Health Organization (WHO). However, glaucoma presents an even greater public health challenge than cataracts: because the blindness it causes is irreversible. Glaucoma is a chronic bilateral eye disease with progressive optic neuropathy leading to optic nerve damage. If untreated, it will result in permanent visual impairment and blindness. The aim of this study is to explore your opinions of training glaucoma screeners and identify the contents of a glaucoma training programme .

What will the study involve?

You are about to undergo a 20-50 minutes interview. You will be asked a few questions related to glaucoma screening. This entire interview session will be audio-recorded and transcribed. Participants will be reassured before the interview starts that they can ask for the audio recorder to be switched off at any time.

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Risks and Benefits:

There is unlikely to be a direct benefit for you in participating in this study. There is no risk involved in this study. Our approach does not involve any direct contact with you or any treatment.

Do you have to take part?

Participation in this study is voluntary. If you agree to take part, then you will be asked to sign the "Informed Consent Form". You will be given a copy of the form and this Information Sheet.

Should you decide to participate, you can still withdraw from the study without penalty. Your data will not be used and will be discarded. The researcher may also remove you from the study for various reasons. In this event, you will not be penalised or lose your rights as a participant.

Data & Confidentiality:

Each participant will be assigned an anonymous code (e.g. P01, P02, …). Audio recordings and transcripts will be labelled with the participant's anonymous code and date. Transcription will be undertaken and kept in a safe place.

The data from this study will be made into a report, which may be published. Access to the data is only by the research team. The data will be reported in a collective manner with no reference to an individual. Hence, your identity will be kept confidential.

Payment and compensation:

You do not have to pay, nor will you be paid, to participate in this study.

Who can I ask about the study?

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If you have any questions, you can direct them to the research team. You can also contact the REC UKM for clarifications.

Name: Assoc. Prof. Dr Jemaima Che Hamzah

Department of Ophthalmology UKMMC

Name: Wee Xiao Hui

Department of Ophthalmology UKMMC

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APPENDIX L

TOPIC GUIDE IN ENGLISH FOR SEMI-STRUCTURED INTERVIEW IN PHASE II

Introduction: Glaucoma is the leading cause of irreversible blindness. The global prevalence of primary open-angle glaucoma is 3.05% and primary angle closure glaucoma is 0.50%. Overall, the prevalence of glaucoma in Asia is 3.54%. However, there is not much glaucoma screening. The purpose of today's interview is to gather your information and opinions on training glaucoma screeners in Malaysia and identify the contents of a glaucoma training programme.

Question 1: Do you think we need specially trained professionals for glaucoma screening to help reduce unnecessary hospital referrals?

Probe: Who are the professionals that need to be trained?

Why do you think they need to be trained in glaucoma screening?

Question 2: What training content do you think should be included in the training?

Probing: What theoretical knowledge should be included in the training?

What practical skills should be included in the training?

Question 3: What are the teaching methods that should be used in the training programme?

Probing: Can you explain why these methods are recommended?

Question 4: What assessments should be used to determine whether glaucoma

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screeners are competent during the training programme?

Probing: How should theoretical knowledge of glaucoma be assessed?

How should practical skills in glaucoma screening be assessed?

Question 5: How many hours are needed to train the glaucoma screeners?

Probing: How many hours are needed for lectures?

How many hours are needed for practical sessions?

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APPENDIX M

TOPIC GUIDE IN MALAY FOR SEMI-STRUCTURED INTERVIEW IN PHASE II

Soalan 1: Apakah pendapat kamu mengenai profesional terlatih khas untuk saringan glaukoma untuk membantu mengurangkan rujukan hospital yang tidak perlu?

Soalan penyelidik: Siapakah profesional yang perlu dilatih?

Mengapa anda berpendapat mereka perlu dilatih dalam saringan glaukoma?

Soalan 2: Apakah kandungan latihan yang perlu disertakan dalam program latihan?

Soalan penyelidik: Apakah pengetahuan teori yang perlu disertakan dalam latihan?

Apakah kemahiran praktikal yang perlu disertakan dalam latihan?

Soalan 3: Apakah kaedah pengajaran yang perlu digunakan dalam program latihan?

Soalan penyelidik: Bolehkah anda jelaskan mengapa kaedah disyorkan?

Soalan 4: Apakah penilaian untuk menilai sama ada penyaring glaukoma adalah

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mahir semasa latihan?

Soalan penyelidik: Bagaimanakah pengetahuan teori tentang glaukoma harus dinilai?

Bagaimanakah kemahiran praktikal dalam saringan glaukoma harus dinilai?

Soalan 5: Berapa jam yang diperlukan untuk melatih penyaring glaukoma?

Soalan penyelidik: Berapa jam diperlukan untuk kuliah?

Berapa jam diperlukan untuk sesi praktikal?

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APPENDIX N

PARTICIPANT'S INFORMATION SHEET IN PHASE III

Research Title: Teleglaucoma program for prevention of future blindness in Malaysia

Introduction:

You are invited to participate in a research study. Before participating in this study, it is important that you take time to read and understand the information in this Information Sheet.

Purpose of Study:

Glaucoma is the second leading cause of global blindness after cataract according to World Health Organization (WHO). However, glaucoma presents an even greater public health challenge than cataracts: because the blindness it causes is irreversible. Glaucoma is a chronic bilateral eye disease with progressive optic neuropathy leading to optic nerve damage. If untreated, it will result in permanent visual impairment and blindness. Therefore, glaucoma screening is important to detect glaucoma. Teleglaucoma is application of telemedicine in glaucoma screening. One of the objectives of this study is to determine the validity of the training modules in glaucoma screening so that it can be used with the teleglaucoma screening program.

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What will the study involve?

You will be given a form to evaluate each training module. You are required to answer the questions in the form according to your own opinion.

Risks and Benefits:

It is unlikely that participating in this study will be a direct benefit for you. There is no risk in participating in this study. Information obtained from this study will help develop the training module for implementation in Malaysia.

Do you have to take part?

Participation in this study is voluntary. If you agree to take part, then you will be asked to sign the "Informed Consent Form". You will be given a copy of the form and this Information Sheet. Should you decide to participate, you can still withdraw from the study without penalty. Your data will not be used and will be discarded. The researcher may also remove you from the study for a variety of reason. In this event, you will not be penalized or lose your rights as a participant.

Data & Confidentiality:

The data from this study will be made into a report which may be published. Access to the data is only by the research team. The data will be reported in a collective manner with no reference to an individual. Hence, your identity will be kept confidential.

Payment:

You do not have to pay to participate in this study.

Who can I ask about the study?

If you have any questions, you can direct them to the research team.

Name: Assoc. Prof. Dr Jemaima Che Hamzah

Department of Ophthalmology, UKMMC

Name: Wee Xiao Hui

Department of Ophthalmology, UKMMC

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APPENDIX O

CONTENT VALIDITY INSTRUMENT FOR EACH MODULE

Section A: Demography Data

1. Age:	
2. Gender:	
3. Race:	
4. Occupation	
5. How many years' experience do you have in your field?	

Section B: Sub Module Validity Questionnaire

Instructions for expert panel:

Please mark (√) one answer from the categories of relevance, clarity, simplicity and no ambiguity respectively**.** You can provide your comments or any additional information to be added to each category.

Below is the explanation of the scale:

1. Relevance Is this content/item relevant in training eye healthcare professionals in glaucoma screening?	**Scale:** 1. Not relevant 2. Item need some major revision 3. Item is relevant and need some minor revision 4. Very relevant
2. Clarity Is the item clear?	**Scale:** 1. Not clear

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	2. Item need some major revision 3. Item is clear but need some minor revision 4. Very clear
3) Simplicity Is the content/item easy to be understood?	**Scale:** 1. Not easy to understand 2. Item need some major revision) 3. Easy to understand but need minor revision 4. Very easy to understand
4. Ambiguity Does the content/item have ambiguity or has more than one meaning?	**Skala/*Scale*:** 1.There is ambiguity 2. Item need some major revision 3. No ambiguity but need some minor revision 4. No ambiguity

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Submodule	Relevance	Clarity	Simplicity	Not ambiguous
Module 1: Glaucoma: An Overview	☐ 1. Not relevant ☐ 2 Item need some major revision ☐ 3 . Item is relevant and need some minor revision ☐ 4. Very relevant	☐ 1. Not clear ☐ 2 Item need some major revision ☐ 3. Item is clear but need some minor revision ☐ 4. Very clear	☐ 1. Not easy to understand ☐ 2.Item need some major revision ☐ 3. Easy to understand but need minor revision ☐ 4. Very easy to understand	☐ 1. There is ambiguity ☐ 2. Item need some major revision ☐ 3. No ambiguity but need some minor revision ☐ 4. No ambiguity
Comment				
Module 2: Anatomy & Physiology of the Eye	☐ 1. Not relevant ☐ 2 Item need some major revision ☐ 3 . Item is relevant and need some minor revision	☐ 1. Not clear ☐ 2. Item need some major revision ☐ 3 Item is clear but need some minor revision	☐ 1. Not easy to understand ☐ 2. Item need some major revision ☐ 3. Easy to understand but need minor revision	☐ 1. There is ambiguity ☐ 2. Item need some major revision ☐ 3. No ambiguity but need some minor revision

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	☐ 4. Very relevant	☐ 4 Very clear	☐ 4. Very easy to understand	☐ 4. No ambiguity
Comment				
Module 3: Signs & symptoms of Glaucoma	☐ 1. Not relevant ☐ 2. Item need some major revision ☐ 3 . Item is relevant and need some minor revision ☐ 4. Very relevant	☐ 1. Not clear ☐ 2. Item need some major revision ☐ 3 Item is clear but need some minor revision ☐ 4. Very clear	☐ 1. Not easy to understand ☐ 2 Item need some major revision ☐ 3. Easy to understand but need minor revision ☐ 4. Very easy to understand	☐ 1. There is ambiguity ☐ 2. Item need some major revision ☐ 3. No ambiguity but need some minor revision ☐ 4. No ambiguity
Comment				

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Module 4: Basic Clinical Examinations Techniques for Glaucoma	☐ 1. Not relevant ☐ 2. Item need some major revision ☐ 3 . Item is relevant and need some minor revision ☐ 4. Very relevant	☐ 1. Not clear ☐ 2 .Item need some major revision ☐ 3. Item is clear but need some minor revision ☐ 4. Very clear	☐ 1.Not easy to understand ☐ 2. Item need some major revision ☐ 3. Easy to understand but need minor revision) ☐ 4. . Very easy to understand	☐ 1.There is ambiguity ☐ 2. Item need some major revision ☐ 3. No ambiguity but need some minor revision ☐ 4. No ambiguity
Comment				
Module 5: Measuring Intraocular Pressure	☐ 1. Not relevant ☐ 2. Item need some major revision ☐ 3 . Item is relevant and need some minor revision ☐ 4. Very relevant	☐ 1.Not clear ☐ 2 .Item need some major revision ☐ 3. Item is clear but need some minor revision ☐ 4. Very clear	☐ 1.Not easy to understand ☐ 2. Item need some major revision ☐ 3. Easy to understand but need minor revision ☐ 4. Very easy to understand	☐ 1. There is ambiguity ☐ 2. Item need some major revision ☐ 3. No ambiguity but need some minor revision ☐ 4. No ambiguity

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Comment				
Module 6: Examination of the Fundus	☐ 1. Not relevant ☐ 2 Item need some major revision ☐ 3 . Item is relevant and need some minor revision ☐ 4. Very relevant	☐ 1. Not clear ☐ 2. Item need some major revision ☐ 3.Item is clear but need some minor revision ☐ 4. Very clear	☐ 1. Not easy to understand ☐ 2 Item need some major revision ☐ 3 . Easy to understand but need minor revision ☐ 4. Very easy to understand	☐ 1. There is ambiguity ☐ 2. Item need some major revision ☑ 3 . No ambiguity but need some minor revision ☐ 4. No ambiguity
Comment				
Module 7: Managing Glaucoma	☐ 1. Not relevant ☐ 2. Item need some major revision	☐ 1. Not clear ☐ 2. Item need some major revision	☐ 1. Not easy to understand ☐ 2. Item need some major revision	☐ 1. There is ambiguity ☐ 2 . Item need some major revision

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	☐ 3 . Item is relevant and need some minor revision ☐ 4. Very relevant	☐ 3. Item is clear but need some minor revision ☐ 4.Very clear	☐ 3. Easy to understand but need minor revision ☐ 4. Very easy to understand	☐ 3. No ambiguity but need some minor revision ☐ 4. No ambiguity
Comment				

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APPENDIX P

OVERALL MODULE CONTENT VALIDITY INSTRUMENT

Overall Module Content Validity

Instructions for expert panel:

Please mark (√) one answer from the categories of relevance. You can give your comments or any additional information that can be added to each category.

Relevance Is this statement relevant?	1. Not relevant\ 2. Item need some major revision) 3. Item is relevant and need some minor revision 4. Very relevant

Statement	**Relevance**	**Comment**
1. The contents are in agreement with the current knowledge.	☐ 1. Not relevant ☐ 2. Item need some major revision ☐ 3 . Item is relevant and need some minor revision ☐ 4 Relevan	
2. Recommendation are necessary and are correctly approached.	☐ 1. Not relevant ☐ 2. Item need some major revision ☐ 3 . Item is relevant and need some minor revision ☐ 4. Very relevant	
3. Objectives are evident	☐ 1. Not relevant ☐ 2 .Item need some major revision	

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	☐ 3 . Item is relevant and need some minor revision ☐ 4. Very relevant	
4. Recommendations about the desired behaviour (glaucoma screening) are satisfactory.	☐ 1. Not relevant ☐ 2. Item need some major revision ☐ 3. Item is relevant and need some minor revision ☐ 4. Very relevant	
5. There is no unnecessary information.	☐ 1. Not relevant ☐ 2. Item need some major revision ☐ 3. Item is relevant and need some minor revision ☐ 4 Very relevant	
6. Information points are reviewed.	☐ 1. Not relevant ☐ 2 . Item need some major revision ☐ 3. Item is relevant and need some minor revision ☐ 4. Very relevant	

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APPENDIX Q

FACE VALIDITY INSTRUMENT

Instructions: Please answer the questions in this section based on your opinion regarding this module (Glaucoma Screening: Basic Training Module. *Please mark √ at either 'Yes' or 'No'.*

Statement	Response
Literary Presentation of the Module	
The content is concisely expressed	Yes ☐ No ☐
Planning and sequence of information is consistent	Yes ☐ No ☐
Material is reader-friendly	Yes ☐ No ☐
Language is explanatory	Yes ☐ No ☐
The vocabulary is composed of simple words	Yes ☐ No ☐
The language is suitable	Yes ☐ No ☐
Identification of headings and subheadings help in the learning process	Yes ☐ No ☐
Illustrations of the Module	
The illustrations are simple, appropriate and present an easily understandable outline	Yes ☐ No ☐
Lists, tables and graphs are self-explanatory	Yes ☐ No ☐
The illustration has suitable headings	Yes ☐ No ☐
The illustrations are related to the text (express the desired purpose)	Yes ☐ No ☐
The illustrations are integrated with the text (easily located)	Yes ☐ No ☐
Legibility of the Module	
Size of the letters is adequate	Yes ☐ No ☐

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Style of letters is adequate	Yes ☐ No ☐
Spacing between letters is adequate	Yes ☐ No ☐
Spacing between lines is adequate	Yes ☐ No ☐
Spacing between paragraphs is adequate	Yes ☐ No ☐
Use of bold characters and bullet points draw attention to specific points or key content	Yes ☐ No ☐
Adequate use of blank spaces reduces overcrowded appearance	Yes ☐ No ☐
Subheadings or the inner margins make reading and memorization easier	Yes ☐ No ☐
Format of the material is adequate	Yes ☐ No ☐
Module is specific and understandable	
Headings and subheadings are clear and informative	Yes ☐ No ☐
Technical terminology is adequately defined	Yes ☐ No ☐
Instructions are clear	Yes ☐ No ☐
Use of words or expressions with double meanings does not occur in the text	Yes ☐ No ☐
Quality of Information	
Information is updated	Yes ☐ No ☐
Material helps target users to undertake the desired actions (glaucoma screening)	Yes ☐ No ☐
Comments	

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APPENDIX R

PARTICIPANT'S INFORMATION SHEET IN PHASE III SECTION III

Research Title: Teleglaucoma Program for Prevention of Future Blindness in Malaysia

Introduction:

You are invited to participate in a research study. Before participating in this study, it is important that you take time to read and understand the information in this Information Sheet.

Purpose of Study:

Glaucoma is the second leading cause of global blindness after cataract according to World Health Organization (WHO). However, glaucoma presents an even greater public health challenge than cataracts: because the blindness it causes is irreversible. Glaucoma is a chronic bilateral eye disease with progressive optic neuropathy leading to optic nerve damage. If untreated, it will result in permanent visual impairment and blindness. Therefore, glaucoma screening is important to detect glaucoma. Teleglaucoma is the application of telemedicine in glaucoma screening. The objective of this study is to determine the effectiveness of the training modules for glaucoma screening.

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What will the study involve?

You will undergo training comprising theory and practical sessions. You will also be given tests covering the topics in the training module before and after the training to determine its effectiveness. You will also undergo the OSCE and fundus grading test and complete the self-assessment, the training module evaluation, and the programme questionnaires.

Risks and Benefits:

It is unlikely that participating in this study will be a direct benefit for you. There is no risk in participating in this study. Information obtained from this study will help develop the training module for implementation in Malaysia.

Do you have to take part?

Participation in this study is voluntary. If you agree to take part, then you will be asked to sign the "Informed Consent Form". You will be given a copy of the form and this Information Sheet. Should you decide to participate, you can still withdraw from the study without penalty. Your data will not be used and will be discarded. The researcher may also remove you from the study for various reasons. In this event, you will not be penalized or lose your rights as a participant.

Data & Confidentiality:

The data from this study will be made into a report which may be published. Access to the data is only by the research team. The data will be reported collectively, with no reference to individuals. Hence, your identity will be kept confidential.

Payment:

You do not have to pay to participate in this study.

Who can I ask about the study?

If you have any questions, you can direct them to the research team.

Name: Assoc. Prof. Dr Jemaima Che Hamzah

Department of Ophthalmology, UKMMC

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Name: Wee Xiao Hui

Department of Ophthalmology, UKMMC

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APPENDIX S

MULTIPLE CHOICE QUESTIONS IN MALAY AND ENGLISH FOR PRE-AND POST-TEST

1. Which of the following statement is **TRUE** about glaucoma? /

   Yang manakah merupakan pernyataan yang **BENAR** mengenai glaukoma?

   A. It is an important cause of reversible blindness worldwide / Ia merupakan punca kebutaan yang boleh dirawat di seluruh dunia.
   B. It is the fourth leading cause of blindness in Malaysia./ Ia merupakan punca kebutaan yang keempat di Malaysia.
   C. It is associated with a high quality of life for patients./ Ia berkaitan dengan kualiti hidup yang tinggi bagi pesakit.
   D. It is unrelated to depression among the caretakers./ Ia tidak berkaitan dengan kemurungan di kalangan penjaga.

2. Which of the following statement is TRUE about glaucoma?/Yang manakah merupakan pernyataan yang **BENAR** mengenai glaukoma?
   A. It is an acute optic neuropathy./Ia merupakan optik neuropati akut.
   B. High intraocular pressure is one of the risk factors./ Tekanan intraokular yang tinggi merupakan salah satu faktor risiko.
   C. Primary open-angle glaucoma is rare compared to close-angle glaucoma/ Glaukoma sudut terbuka primer lebih jarang berlaku berbanding glaukoma sudut tertutup.
   D. Eye screening is recommended for all patients above 45 years old./ Saringan mata disarankan bagi pesakit berumur 45 tahun ke atas.

3. Refer to the figure below to answer this question. **Number 6** refers to /Rujuk gambar rajah di bawah untuk menjawab soalan ini. **Nombor 6** merujuk kepada

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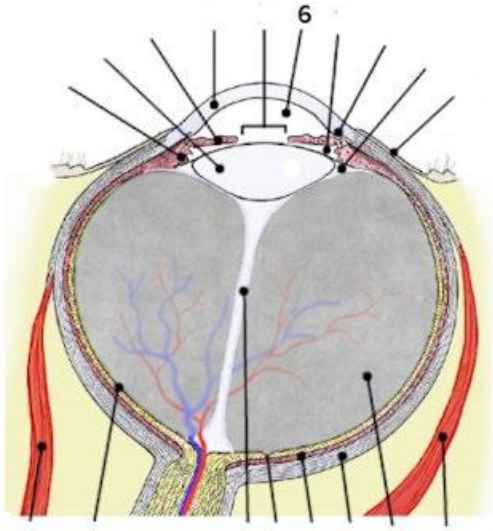

A. anterior chamber/ruang anterior

B. posterior chamber/ruang posterior

C. zonular space/ ruang zonular

D. vitreous chamber/ruang vitreous.

4. Aqueous humour is produced by / Cecair akueus dihasilkan oleh

A. iris.

B. ciliary body/ badan siliari.

C. crystalline lens/kanta kristalin.

D. cornea/kornea.

5. The Schlemm canal /Saluran *Schlemm*

A. is a sieve-like structure for drainage of aqueous humour./
ialah struktur seperti jaring untuk aliran keluar cecair akueus.

B. collects aqueous humour from the anterior chamber and delivers it into the episcleral veins./
mengumpulkan cecair akueus dari ruang anterior dan mengalirkan ke saluran darah episklera.

C. is the termination of Descemet's membrane./
ialah penamatan membrane Descemet.

D. is a ring of collagen fibres parallel to the limbus./
ialah cincin serat kolagen selari dengan limbus

6. Axons extending from the nasal part of the retina project to which side of the brain?/

Akson dari bahagian nasal retina mengunjur ke bahagian mana otak?

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A. Opposite/Bertentangan
B. Medial
C. Same /Sama
D. Lateral

7. The following statement is **TRUE** about open-angle glaucoma/

Pernyataan berikut adalah **BENAR** mengenai glaukoma primer terbuka.

A. Increased intraocular pressure (IOP) causes damage to the retinal ganglion cells axons./Peningkatan tekanan intraokular (IOP) menyebabkan kerosakan kepada akson sel ganglion retina.
B. Patients always change their distance glasses. /Pesakit selalu menukar kaca mata jauh.
C. Patients find it easy to adjust vision in dim light. /Pesakit mendapati senang untuk menyesuaikan penglihatan dalam cahaya yang malap.
A. The difference in cup-to-disc ratio between the two eyes is less than 0.2./ Perbezaan nisbah cawan ke diska optik di antara kedua-dua mata kurang daripada 0.2.

8. The following statement is **TRUE** about angle-closure glaucoma. / Pernyataan

berikut adalah **BENAR** mengenai glaukoma sudut tertutup

A. Patient complaint of severe eye pain in chronic attack./ Pesakit mengadu sakit mata yang teruk semasa serangan kronik.
B. The cornea is clear when the intraocular pressure increases rapidly./ Kornea adalah lutsinar apabila tekanan intraokular meningkat dengan cepat.
C. The pupil is small in an acute attack./ Pupil adalah kecil semasa serangan akut.
D. Glaukomflecken are indicators of previous attacks of acute angle-closure. /*Glaukomflecken* merupakan indikasi serangan sudut tertutup akut sebelumnya.

9. The following are risk factors for primary open-angle glaucoma **EXCEPT /** Berikut

merupakan faktor risiko bagi glaukoma sudut terbuka primer **KECUALI**

A. Thick central cornea/ Kornea sentral yang tebal
B. Disc haemorrhage/ Pendarahan diska
C. Myopia/ Miopia
D. Lower ocular perfusion pressure/ Tekanan perfusi okular yang rendah

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10. The following are risk factors for primary angle-closure glaucoma **EXCEPT/**

Berikut merupakan faktor risiko glaukoma sudut tertutup primer **KECUALI**

A. Age 60 years and above/ Usia 60 tahun dan ke atas
B. Male/ Lelaki
C. Family history of glaucoma/Sejarah keluarga mempunyai glaukoma
D. Shorter axial length/ Panjang aksial yang pendek

11. The following systemic diseases are correctly associated with its glaucoma type **EXCEPT/** Berikut merupakan penyakit sistemik yang berkaitan dengan jenis glaukoma **KECUALI**

A. Diabetes mellitus – open-angle glaucoma/ Diabetes melitus-glaukoma sudut terbuka
B. Obstructive sleep apnoea – open-angle glaucoma/ *Obstructive sleep apnoea*-glaukoma sudut terbuka
C. Raynaud's phenomenon – angle-closure glaucoma/ Fenomena *Raynaud*-Glaukoma sudut tertutup
D. Migraine – normal tension glaucoma/ Migrain-glaukoma tekanan normal

12. A patient is only able to read the 6/12 line on the Snellen chart with her right eye. What should you do next? / Pesakit hanya boleh membaca baris 6/12 pada Carta Snellen dengan mata kanan. Apa yang kamu perlu buat selepas itu?

A. Pinhole test / Ujian lubang pin
B. +1.00D test/ Ujian +1.00
C. Measure VA for the left eye/ Mengukur VA bagi mata kiri
D. Measure near VA/ Mengukur VA dekat

13. A patient cannot read the largest letter (6/60) on the Snellen chart. What should you do next? / Pesakit tidak boleh membaca huruf terbesar (6/60) pada Carta Snellen. Apa yang kamu perlu buat selepas itu?

A. Instruct the patient to move closer towards the chart by 1m and ask him to read the chart again./ Arahkan pesakit untuk bergerak 1m mendekati carta dan meminta dia membaca carta semula.
B. Do a pinhole test and ask the patient to read the chart again. /Buat ujian lubang pin dan suruh pesakit membaca carta semula

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C. Ask the patient to remove glasses and read the chart again./Suruh pesakit untuk menanggalkan kaca mata dan membaca carta semula

D. Record VA as 'worse than 6/60' and continue to measure near VA./ Rekodkan VA sebagai 'teruk dari 6/60' dan teruskan mengukur VA dekat.

14. A patient is not able to read the largest letter on the Snellen Chart from 1mdistance. What is the following best next step in recording vision?/ Pesakit tidak boleh membaca huruf terbesar pada Carta Snellen dari jarak 1m. Apakah langkah seterusnya yang terbaik untuk merekod penglihatan?

A. Counting finger/Pengiraan jari
B. Hand movement/Pergerakan tangan
C. Light perception/Persepsi cahaya
D. Record as 'blind'/ Rekod sebagai 'buta'

15. You are checking a patient's pupil reaction to light. The pupillary light reflex is tested by shining a light on the right eye. Which of the findings is normal?/ Anda sedang memeriksa reaksi pupil pesakit terhadap cahaya. Refleks cahaya pupilari diuji dengan menyuluh cahaya ke mata kanan. Yang mana keputusan berikut adalah normal?

A. Constriction of the right and left pupil/ Pupil kanan dan kiri mengecil.
B. Constriction of the right pupil and dilatation of the left pupil/ Pupil kanan mengecil dan pupil kiri membesar
C. Dilatation of the right pupil and constriction of the left pupil/ Pupil kanan membesar dan pupil kiri mengecil
D. Dilatation of the right and left pupil/ Pupil kanan dan kiri membesar

16. What is usually the smallest line in a reading chart?/ Apakah baris huruf terkecil pada carta membaca?

A. N10
B. N8
C. N5
D. N4

17. The following statement on near VA procedure is **FALSE** /
Pernyataan berikut mengenai prosedur VA adalah **TIDAK BENAR**

A. Near vision chart is held at a 40 cm distance from the patient./ Carta penglihatan dekat dipegang pada jarak 40 cm dari pesakit.

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B. Both eyes are tested at the same time./Kedua-dua mata diuji pada masa yang sama.
C. Patients wear their reading glasses./Pesakit memakai kaca mata membaca.
D. The room lights are turned on./Lampu bilik dinyalakan.

18. The following statement is **FALSE** when preparing a patient for the pupillary light reflex test./ Pernyataan berikut adalah **TIDAK BENAR** semasa persiapan pesakit untuk ujian refleks pupilari Cahaya.

A. The examiner sits to the right side of the patient/ Pemeriksa duduk di sebelah kanan pesakit
B. The patient wears their existing glass./ Pesakit memakai kaca mata yang sedia ada.
C. The patient looks at a distant target./ Pesakit melihat sasaran jau
D. The room lights are turned off./ Cahaya bilik dipadamkan.

19. If a patient has relative afferent pupillary defect (RAPD) on the left eye,
Jika pesakit mempunyai RAPD di mata kiri,
A. both pupils constrict in dim room./ kedua-dua pupil mengecil di dalam bilik gelap.
B. both pupils constrict when light is shone on the left eye./ kedua-dua pupil mengecil apabila cahaya disuluhkan ke mata kiri.
C. both pupils dilate when light is shone on the left eye./ kedua-dua pupil membesar apabila cahaya disuluhkan ke mata kiri.
D. both pupils dilate when light is shone on the right eye. / kedua-dua pupil membesar apabila cahaya disuluhkan ke mata kanan.

20. An oblique flashlight test is performed on a patient. Which findings indicate the shallowest anterior chamber depth? / Ujian ***oblique flashlight*** dijalankan pada seorang pesakit. Keputusan yang mana menunjukkan kedalaman ruang anterior yang cetek?

A.

B.

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C.

D.

21. What is anisocoria? Apakah anisokoria?

A. More than 1mm difference in size of the right and left pupils / Perbezaan saiz lebih daripada 1mm di antara pupil kanan dan kiri
B. An irregular shape of the pupil/ Pupil yang berbentuk tidak normal
C. Pupil position that is not at the centre/ Kedudukan pupil yang tidak berada di tengah-tengah
D. An eye that has more than one pupil./Mata yang mempunyai lebih daripada satu pupil

22. What is polycoria? Apakah polikoria?

A. More than 1mm difference in size of the right and left pupils./Perbezaan saiz lebih daripada 1mm di antara pupil kanan dan kiri
B. An irregular shape of the pupil/ Pupil yang berbentuk tidak normal
C. Pupil position that is not at the centre/ Kedudukan pupil yang tidak berada di tengah-tengah
D. An eye that has more than one pupil/ Mata yang mempunyai lebih daripada satu pupil

23. What is the most convenient tool to measure the intraocular pressure in an eye screening program?/ Apakah peralatan yang paling sesuai digunakan untuk mengukur tekanan intraokular dalam program saringan mata?

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A. Applanation tonometer / Tonometer aplanasi

B. Shiotz tonometer/ Tonometer Shiotz

C. Goldmann tonometer/ Tonometer Goldmann

D. Airpuff Tonometer /Tonometer *airpuff*

24. The normal intraocular pressure is / Tekanan intraokular normal adalah
    A. 20-40 mmHg
    B. 10-21 mmHg
    C. 5-15 mmHg
    D. 40-60 mmHg

25. The following statement about iCare tonometer is **TRUE./** Pernyataan berikut mengenai tonometer iCare adalah **BENAR**
    A. It has an indisposable probe./ Ia mempunyai prob tidak pakai buang.
    B. The probe will create an induction current which will be converted into intraocular pressure**./** Prob akan menghasilkan arus induksi yang akan ditukarkan kepada tekanan intraokular.
    C. Anaesthetic eye drop is used during the examination./ Ubat titis bius digunakan semasa pemeriksaan.
    D. It cannot be used in children./ Ia tidak boleh digunakan pada kanak-kanak.

26. The following statement is **FALSE** about the optic nerve examination in FORGE (Focusing Ophthalmology on Reframing Glaucoma Evaluation)./
    Pernyataan berikut adalah **TIDAK BENAR** mengenai pemeriksaan saraf optik dalam FORGE **(**Focusing Ophthalmology on Reframing Glaucoma Evaluation)

    A. Observe the size of the neuroretina/Perhatikan saiz rim neuroretina
    B. Examine the retinal nerve fiber layer/Periksa lapisan serat saraf retina
    C. Examine the region of the peripapillary atrophy/ Perhatikan kawasan atrofi peripapillary
    D. Perhatikan nisbah cawan ke diska optic/Observe the cup to disc ratio

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27. The following statement is **TRUE** regarding troubleshooting for fundus photography./ Pernyataan berikut adalah **BENAR** mengenai penyelesaian masalah bagi fotografi fundus.

    A. Hazy media image- Refer to ophthalmologist /
       Imej fundus media yang kabur- Rujuk ke pakar mata
    B. Dark fundus image-Dilate the patient's pupil/
       Imej fundus yang gelap- Kembangkan anak mata pesakit
    C. Crescent artefact image- Pull the patient's upper eyelid/
       Imej fundus artifak berbentuk bulan sabit- Tarik kelopak mata atas pesakit
    D. Lashes artefact image- Ask patient to open his eyes wider/
       Imej artifak bulu mata- Minta pesakit membuka matanya besar

28. The best possible diagnosis for the fundus photo below is / Diagnosis yang paling sesuai untuk foto fundus di bawah ialah

    A. Glaucoma suspect/ Pesakit disyaki glaukoma
    B. Normal
    C. Glaucoma/Glaukoma
    D. Morning glory syndrome/Sindrom *morning glory*

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29. Frequency of eye examination for individuals aged 55 -64 years old with risk factors of glaucoma is / Kekerapan pemeriksaan mata bagi individu berumur 55-64 tahun dengan faktor risiko glaukoma adalah
    A. every 1-2 years /setiap 1-2 tahun
    B. every 6-12 months/ setiap 6-12 bulan
    C. every 1-3 years/ setiap 1-3 tahun
    D. every 5-10 years/ setiap 5-10 tahun

30. Which of the following is the suitable management for the patient with the fundus image below?/ Yang mana merupakan pengurusan yang sesuai bagi pesakit dengan imej fundus di bawah?

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    A. Discaj/ Discharge
    B. Rujuk ke klinik mata/ Refer to eye clinic
    C. Beri temujanji lawatan susulan/ Give a follow up appoinment
    D. Cadangkan pesakit membuat kaca mata/ Suggest patient to do new spectacle

31. The following eye conditions need immediate referral to eye clinic in the same day **EXCEPT/** Keadaan mata yang berikut memerlukan rujukan ke klinik mata pada hari yang sama **KECUALI**
    A. Acute angle-closure glaucoma/ Glaukoma sudut tertutup akut
    B. Glaucoma suspect/ Pesakit disyaki glaukoma

C. Retinal detachment/ Lekangan retina

D. Sudden loss of vision/ Kehilangan penglihatan tiba-tiba

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APPENDIX T

SELF-ASSESSMENT OF PARTICIPANT'S SKILLS IN GLAUCOMA SCREENING INSTRUMENT

Sila nilai tahap kemahiran kamu bagi kemahiran di bawah mengikut skala yang berikut:
Please rate your level of ability for each skills below using the following scale:

1= Tidak mahir/ *Not competent*

2= Sedikit mahir/ *Low competent*

3= Sederhana/ *Average*

4 = Sangat mahir/*Highly competent*

7. Pengambilan sejarah/Conducting a *History taking* *

Mark only one oval.

	1	2	3	4	
Tidak mahir/Not competent	◯	◯	◯	◯	Sangat mahir/Highly competent

8. Pengukuran ujian akuiti/ *Assessing visual acuity*

Mark only one oval.

	1	2	3	4	
Tidak mahir/Not Competent	◯	◯	◯	◯	Sangat mahir/Highly competent

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9. *

Menjalankan ujian pemeriksaan pupil dan ujian *oblique flashlight/ Conducting pupil examination and oblique flashlight test*

Mark only one oval.

	1	2	3	4	
Tidak mahir/Not competemt	◯	◯	◯	◯	Sangat mahir/Highly competent

10. Pengukuran tekanan intraokular dengan menggunakan tonometer airpuff atau iCare/*Measuring intraocular pressure using air puff tonometer or iCare* *

Mark only one oval.

	1	2	3	4	
Tidak mahir/Not competent	◯	◯	◯	◯	Sangat mahir/Highly competent

11. Menggunakan kamera fundus/ *Using fundus camera* *

Mark only one oval.

	1	2	3	4	
Tidak mahir/Not competent	◯	◯	◯	◯	Sangat mahir/Highly competent

12. Mengenalpasti tanda-tanda dan gejala glaukoma/ Recognising signs and symptoms of glaucoma *

Mark only one oval.

	1	2	3	4	
Tidak mahir/Not competent	◯	◯	◯	◯	Sangat mahir/Highly competent

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13. Mengenalpasti pesakit dengan faktor risiko glaukoma/*Identify patient with risk factors of glaucoma* *

Mark only one oval.

	1	2	3	4	
Tidak mahir/Not competent	◯	◯	◯	◯	Sangat mahir/Highly competent

14. Boleh merujuk pesakit glaukoma dengan sesuai/Knowing when to refer a glaucoma patient appropriately *

Mark only one oval.

	1	2	3	4	
Tidak mahir/Not competent	◯	◯	◯	◯	Sangat mahir/Highly competent

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Google Forms

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APPENDIX U

RUBRIC FOR OSCE

Visual acuity test (Both eye)

Name: _____

Examiner: _____

For the following items in the following tests, did the candidate:

NO	ITEMS	YES/NO	MARKS
1.	Room illuminations is turned on?	Y/N	/1
2.	Explain the purpose of the test?	Y/N	/1
3.	Proper position of the examiner-examiner does not block the patient's view?	Y/N	/1
4.	Setup proper testing distance (distance & near)?	Y/N	/2
5.	Give proper instruction?	Y/N	/1
5.	Perform correct steps for distance VA measurement? -patient occlude the eye properly and read the chart from the top to the smallest line that they can read	Y/N	/5
6.	Perform correct use of pinhole?	Y/N	/1
7.	Perform correct steps for near VA measurement? (patient occlude the eye properly and read the smallest line that they can read) *	Y/N	/4

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8.	Testing monocular VA for distance & near VA	Y/N	/2
9.	Record the findings accurately (distance & near VA)?	Y/N	/2
	TOTAL		/20

The items marked in * need to be performed correctly to pass the test.

PASS/FAIL

Comments:

Name: _____

Examiner: _____

Icare Tonometer (both eyes-5min)

For the following items in the following tests, did the candidate:

NO	ITEMS	YES/NO	MARKS
1.	Explain the purpose of the test?	Y/N	/1
2.	Give proper instruction?	Y/N	/1
3.	Setup correctly the position of the patient?	Y/N	/1
4.	Perform correct steps for non-contact tonometer/iCare?	Y/N	/2

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5.	Get reliable IOP measurement? *	Y/N	/2
	TOTAL		/7

The items marked in * need to be performed correctly to pass the test.

PASS/FAIL

Comments:

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The items marked in * need to be performed correctly to pass the test.

Fundus Camera- 1eye (10 min)

Name: _____

Examiner: _____

For the following items in the following tests, did the candidate:

NO	ITEMS	YES/NO	MARKS
1.	Explain the purpose of the test?	Y/N	/1
2.	Give proper instruction?	Y/N	/1
3.	Setup correctly the position of the patient?	Y/N	/1
4.	Perform correct steps for fundus camera?	Y/N	/2
5.	Get proper fundus image?*	Y/N	/3

	TOTAL		/8

The items marked in * need to be performed correctly to pass the test.

PASS/FAIL

Comments:

Name: _____

Examiner: _____

HISTORY TAKING TEST (20 min)

For the following items in the following tests, did the candidate:

NO	ITEMS	YES/NO	MARKS
1.	Probed on chief complaint?	Y/N	/4
2.	Probed on present illness history (onset, frequency, severity, etc)?	Y/N	/5
3.	Performed symptom check if patient had no specific complaint?	Y/N	/1
4.	Probed on past ocular history	Y/N	/2
5.	Probed on past medical history?	Y/N	/2
6.	Probed on medication intake?	Y/N	/1
7.	Probed on presence of any allergy?	Y/N	/1

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8.	Probed on family history (medical and ocular)?	Y/N	/2
9.	Probed on social history (occupation, hobby?)	Y/N	/1
10.	Recorded the history findings appropriately?	Y/N	/1
	TOTAL		/20

PASS/FAIL

Comments:

Name: _____

Examiner: _____

Pupil examination (10min)

For the following items in the following tests, did the candidate:

NO	ITEMS	YES/NO	MARKS
1.	Explain the purpose of the test?	Y/N	/1
2.	Setup proper lighting:off?	Y/N	/1
3.	Proper position of the examiner?	Y/N	/1
4.	Use proper target?	Y/N	/1
5.	Give proper instruction?	Y/N	/1
6.	Inspect		

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	- pupil size in dim and bright illumination? - pupil shape? -pupil symmetry (include position as well as size)?	Y/N Y/N Y/N	/1 /1 /1
7.	Perform correct steps for direct and consensual reflex?*	Y/N	/2
8.	Perform correct steps for swinging flash light test*	Y/N	/2
9.	Recorded the findings accurately?	Y/N	/3
	TOTAL		/15

The items marked in * need to be performed correctly to pass the test

PASS/FAIL

Comments:

Name: _____

Examiner: _____

Oblique flashlight test (5min)

For the following items in the following tests, did the candidate:

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NO	ITEMS	YES/NO	MARKS
1.	Explain the purpose of the test?	Y/N	/1
2.	Setup proper lighting:off the light	Y/N	/1
3.	Proper position of the examiner?	Y/N	/1
4.	Use proper target?	Y/N	/1
5.	Give proper instruction?	Y/N	/1
6.	Perform correct steps for oblique flashlight test*	Y/N	/2
9.	Recorded the findings accurately?	Y/N	/3
	TOTAL		/10

The items marked in * need to be performed correctly to pass the test

PASS/FAIL

Comments:

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APPENDIX V

EVALUATION OF TRAINING MODULE INSTRUMENT

Evaluation of Training Module Questionnaire

Please rate the glaucoma screenning module according to the scale

1 = not at all
2= slightly
3 = average
4= highly
5= very

	Not at all	Slightly	Average	Highly	Very
How useful did you find the module content?					
How relevant was the content to your work/performance					
How likely do you think you are to utilize this module in the future?					
How accessible was the module?					
How well did the module maintain your interest and attention?					
How clearly was the information in the module presented?					
How likely would you be to recommend this module to other eye healthcare providers?					

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APPENDIX W

EVALUATION OF TRAINING PROGRAMME QUESTIONNAIRE

Borang Maklum Balas Peserta Mengenai Program Latihan Saringan Glaukoma/ Evaluation of Glaucoma Screening Training Programme

* Indicates required question

1. Email *

2. Umur /*Age* *

3. Pekerjaan/*Occupation* *

4. Berapa lama bekerja dalam bidang ini/*How many years working in this field?* *

5. Tahap Pendidikan tertinggi /*the highest Education level* *

Mark only one oval.

- Ijazah Sarjana Muda/Degree
- Ijazah Sarjana/Master
- Ijazah Doktor Falsafah/PhD
- Lain-lain/ Other:

6. Jantina/Gender *

Mark only one oval.

- Lelaki/Male
- Perempuan/Female

Sila nilai program latihan mengikut skala berikut. /Please rate the training programme according to the scale

1. Sangat tidak baik/Very poor
2. Tidak baik/Poor
3. Sederhana/ Average
4. Baik/ Good
5. Sangat baik/ Very good

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Mark only one oval per row.

	Sangat tidak baik/ Very poor	Tidak Baik/ Poor	Sederhana/ Average	Baik/ Good	Sangat baik/ Very good
Quality of Content/ Qualiti Kandungan					
Trainers/Pelatih					
Teaching methodology (Video lectures with the Google Classroom platform)/ Kaedah Pengajaran (Video Kuliah dengan platform Google Classroom)					
Training workshop/ Bengkel latihan					
Relevance for the training for own job/Kaitan latihan dengan pekerjaan sendiri					

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7. Sila nyatakan kebaikan program ini/ Please state the advantages of this programme.

8. Sila nyatakan kelemahan program ini/ Please state the weakness of this programme.

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APPENDIX X

PARTICIPANT'S INFORMATION SHEET IN PHASE IV

Research Title: Teleglaucoma Programme for Prevention of Future Blindness in Malaysia

Introduction:

You are invited to participate in a research study. Before participating in this study, it is important that you take time to read and understand the information in this Information Sheet.

Purpose of Study:

Glaucoma is the second leading cause of global blindness after cataract according to World Health Organization (WHO). However, glaucoma presents an even greater public health challenge than cataracts: because the blindness it causes is irreversible. Glaucoma is a chronic bilateral eye disease with progressive optic neuropathy leading to optic nerve damage. If untreated, it will result in permanent visual impairment and blindness. Teleglaucoma is the application of telemedicine in glaucoma screening. The components required for an efficient teleglaucoma system were the ability to register the patient's data and history, upload clinical examination results, enable specialists to view the results, support their diagnosis and management, and refer patients for follow-up. A functional and usability study is an essential component of the system's evaluation before it is used in the teleglaucoma programme. Therefore, the aim of this study is to test the functionality and usability of the teleglaucoma system.

What will the study involve?

You will receive an instruction manual that explains how to use the teleglaucoma system. You will be assigned specific tasks within the teleglaucoma system based on your occupation. You are required to complete all tasks within 20 minutes and fill out two online Google Forms containing two questionnaires.

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Risks and Benefits:

It is unlikely that participating in this study will be a direct benefit for you. There is no risk involved in this study. Our approach does not involve any direct contact with you or any treatment.

Do you have to take part?

Participation in this study is voluntary. If you agree to take part, then you will be asked to sign the "Informed Consent Form". You will be given a copy of the form and this Information Sheet. Should you decide to participate, you can still withdraw from the study without penalty. Your data will not be used and will be discarded. The researcher may also remove you from the study for various reasons. In this event, you will not be penalised or lose your rights as a participant.

Data & Confidentiality:

Each participant will be assigned an anonymous code (e.g. P01, P02, …). Audio recordings and transcripts will be labelled with the participant's anonymous code and date. Transcription will be undertaken and kept in a safe place.

The data from this study will be made into a report, which may be published. Access to the data is only by the research team. The data will be reported in a collective manner with no reference to an individual. Hence, your identity will be kept confidential.

Payment and compensation:

You do not have to pay, nor will you be paid, to participate in this study.

Who can I ask about the study?

If you have any questions, you can direct them to the research team. You can also contact the REC UKM for clarification.

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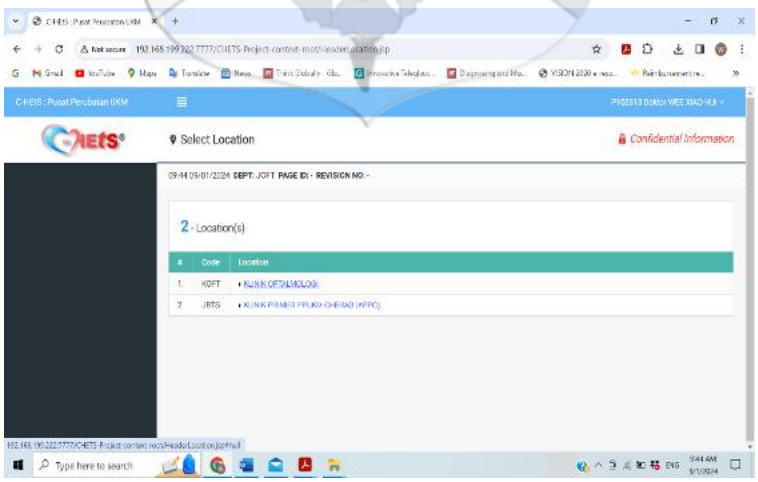
APPENDIX Y

INSTRUCTION MANUAL FOR PRIMARY EYE CARE PROVIDERS

Instructions

1. Go to Google Chrome and key in http://newhis.hukm.ukm.my:7777/CHETS-Project-context-root/inclogin.jsp.
2. Enter your existing **username** dan **password** used in UKM EMRST.
3. Click **Login** to access the system.

4. Click location on the list. For teleglaucoma project, click **KLINIK PRIMER PPUKM CHERAS (KKPC).**



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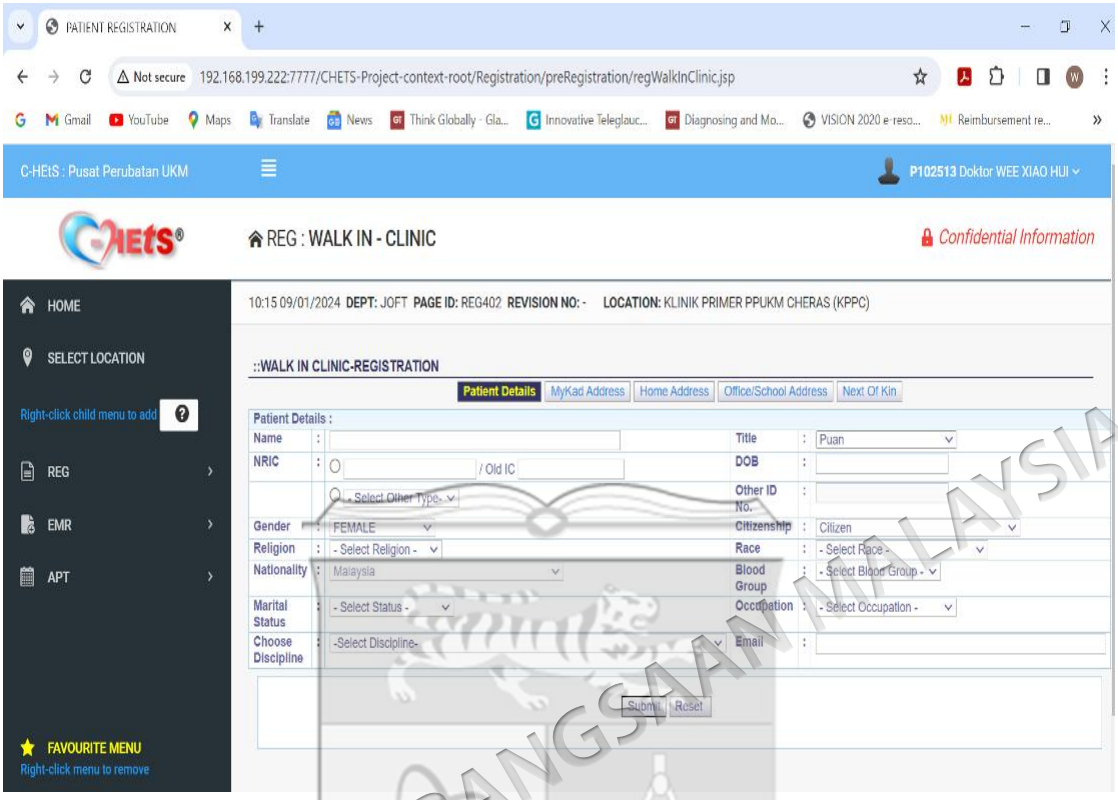
5. For new patient, click **REG** > **WALK IN** > **Walk in Clinic**



i) Enter the patient information at column 'Patient Details'.

ii) Click **Discipline**. For teleglaucoma,click **Pusat Perubatan Primer-MDT Session.**

iii) Click **Submit** after finish entering the information.

iv) Enter the patient information for each of the column "MyKad Address", "Home Address", "Office/School Address" and "Next of Kin". Click **Submit** after finish entering the information to complete the registration.

6. If patient is already registered with Klinik Primer, click **REG** > **WALK IN** > **FOLLOW UP**

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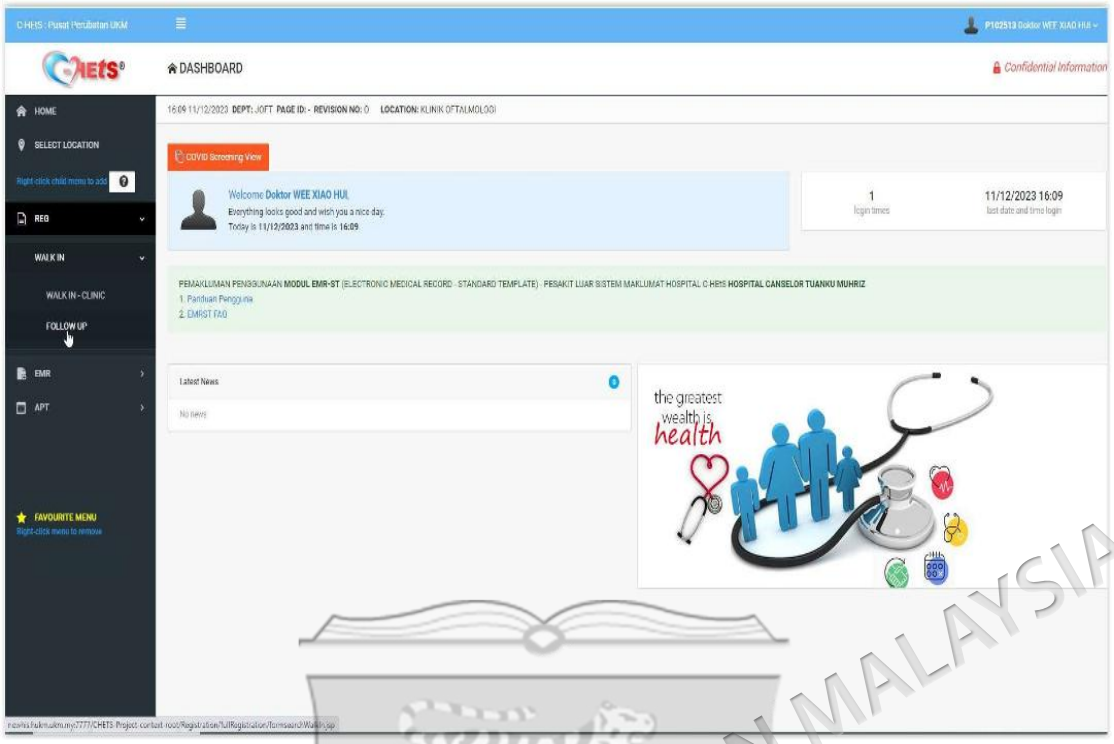
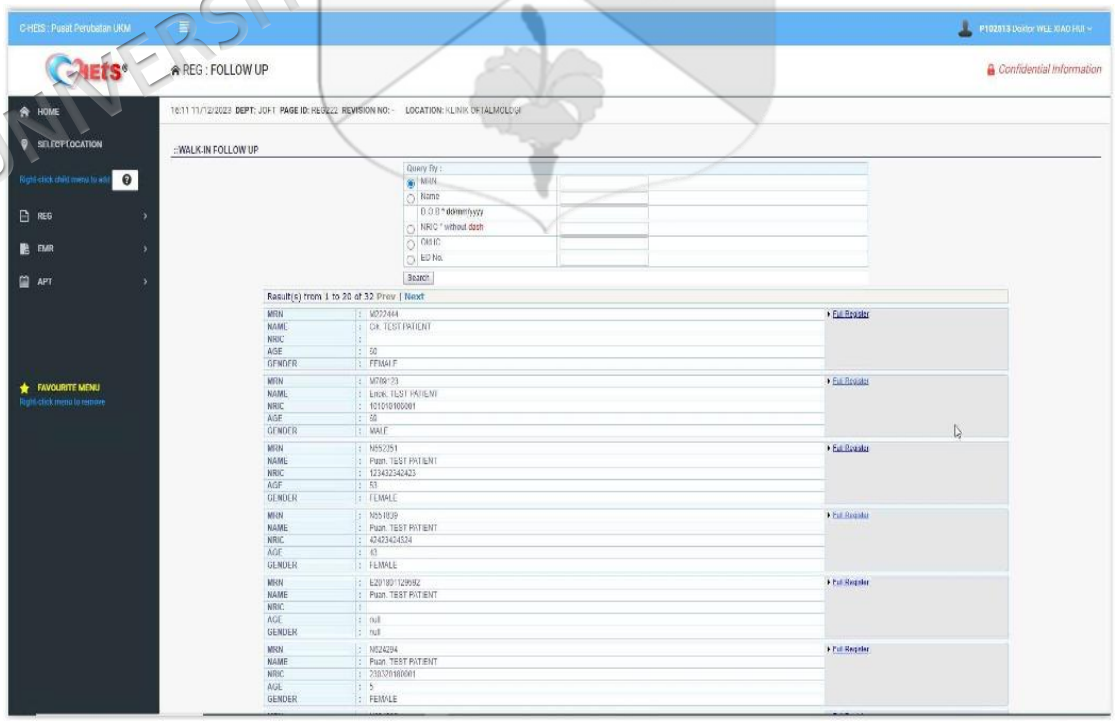


i) Find the patient's information by using **MRN**, Name and other parameters.

ii) Click **Search** to find the patient's information.

iii) Click **Full Register** to register the patient.



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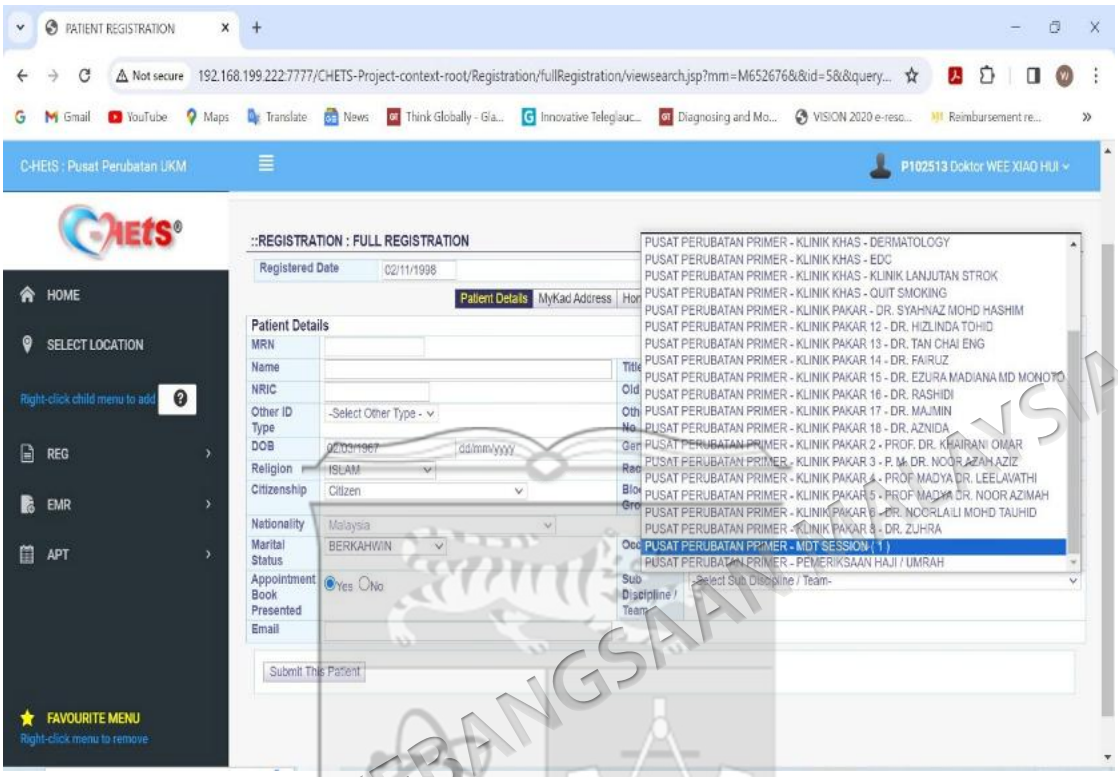
iv) Edit the patient's information if needed. Click *Sub Discipline/Team*. For teleglaucoma,click **Pusat Perubatan Primer-MDT Session**

v) Click **Submit This Patient.**



vi) Check the information that have been entered. Click **Confirm Patient** to register the patient

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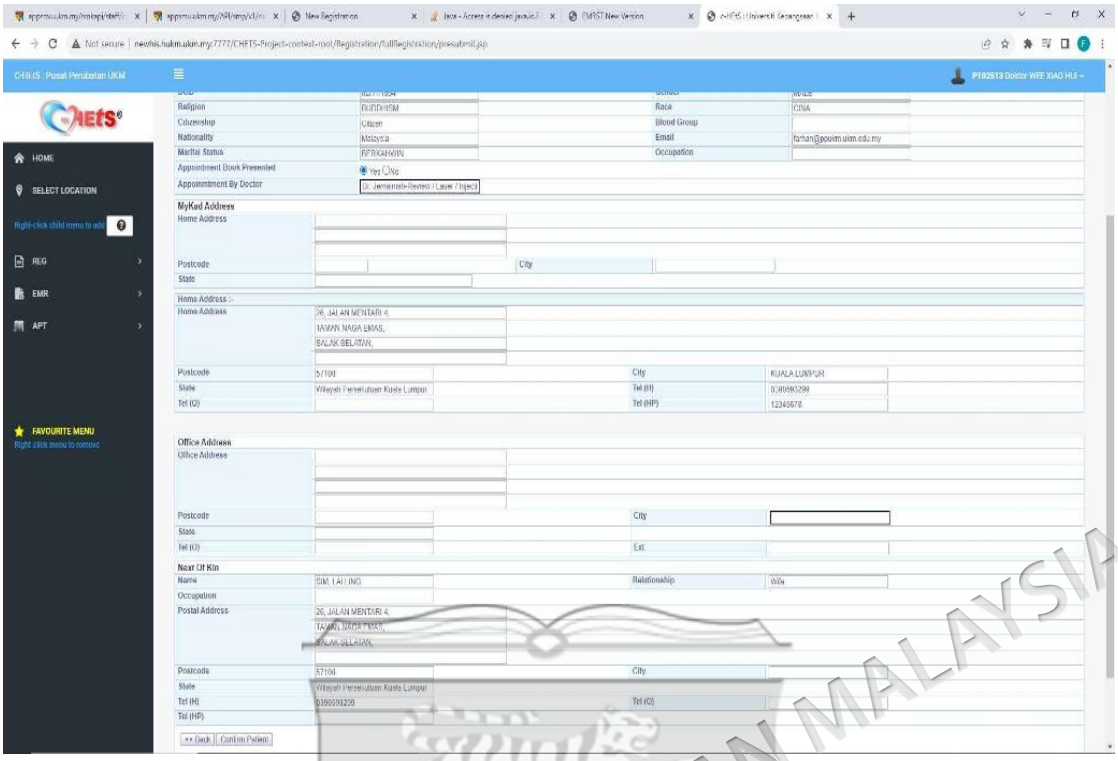
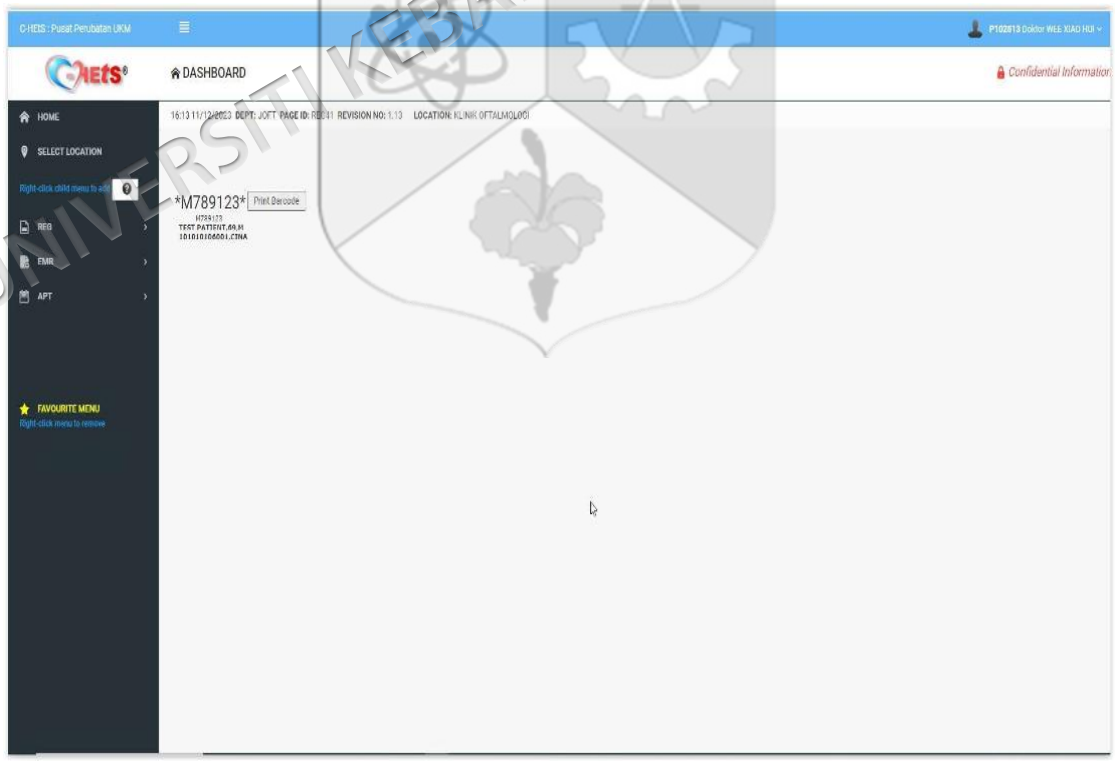


7. The dashboard will showed that the patient has been registered.



8. To upload the clinical information, click **EMR** > **EMR NURSE** to enter the clinical information.

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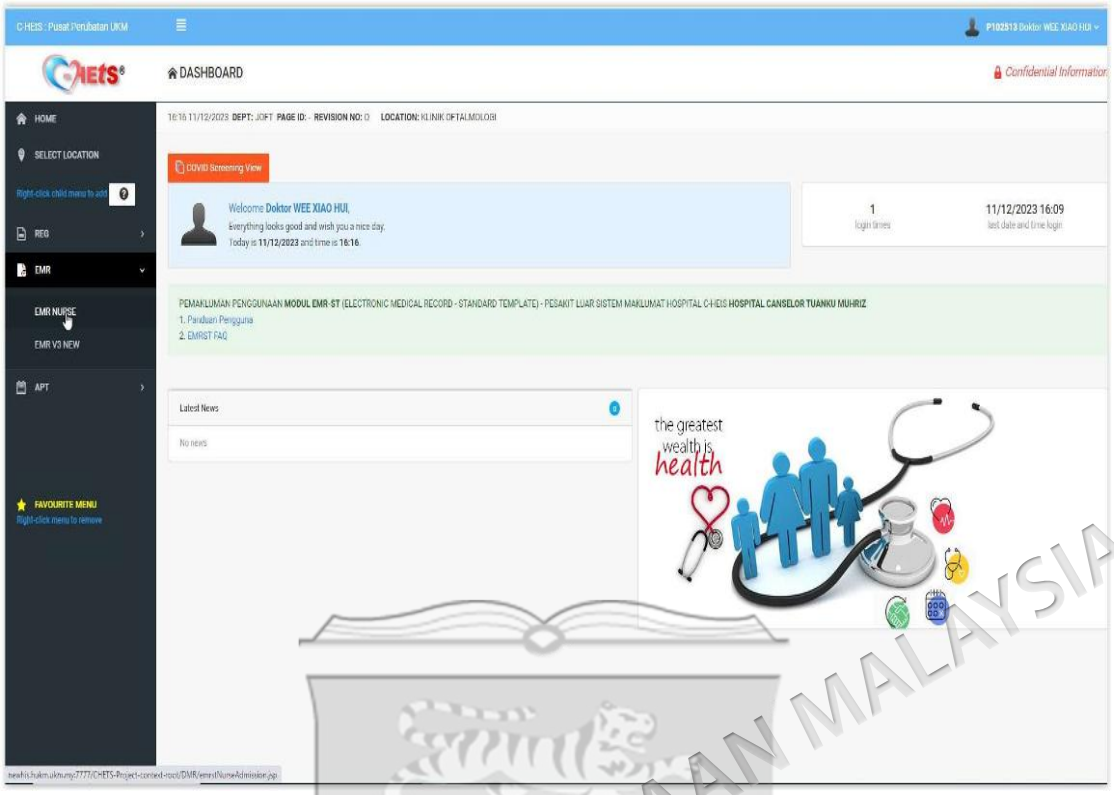
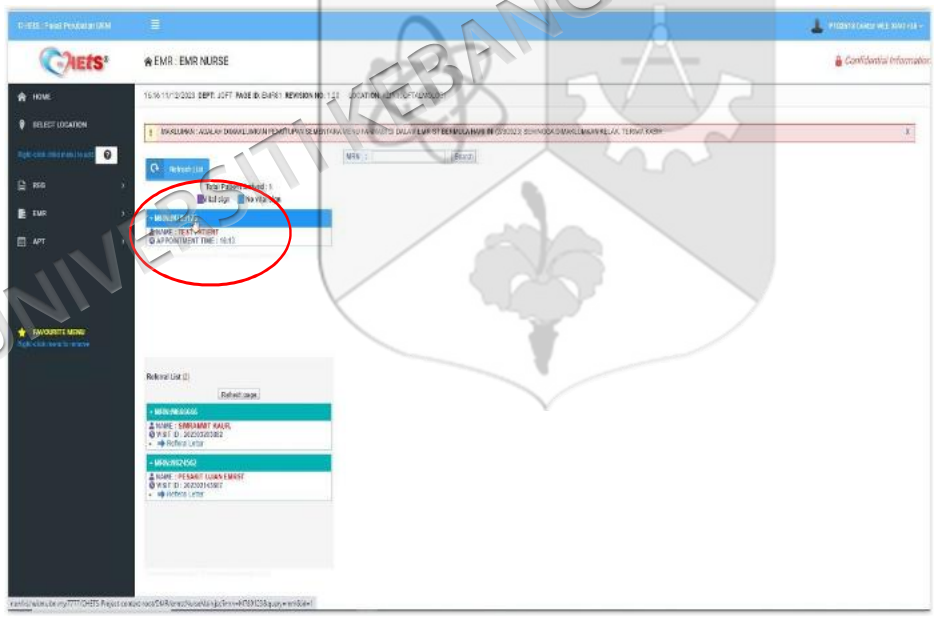


9. Click **MRN** at the list showed below.



10. Click **Vital Sign** to enter the visual acuity (VA) of the patient.

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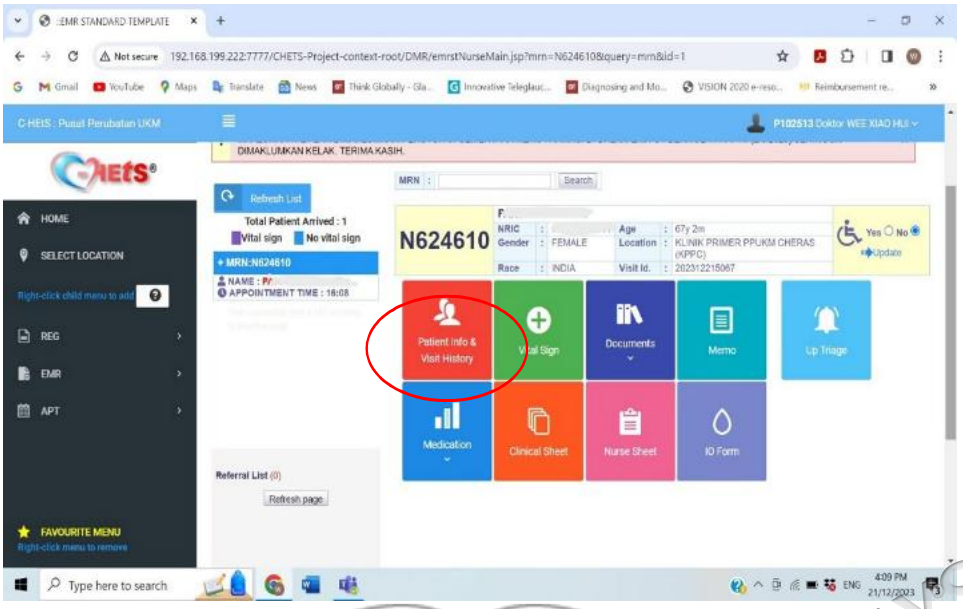
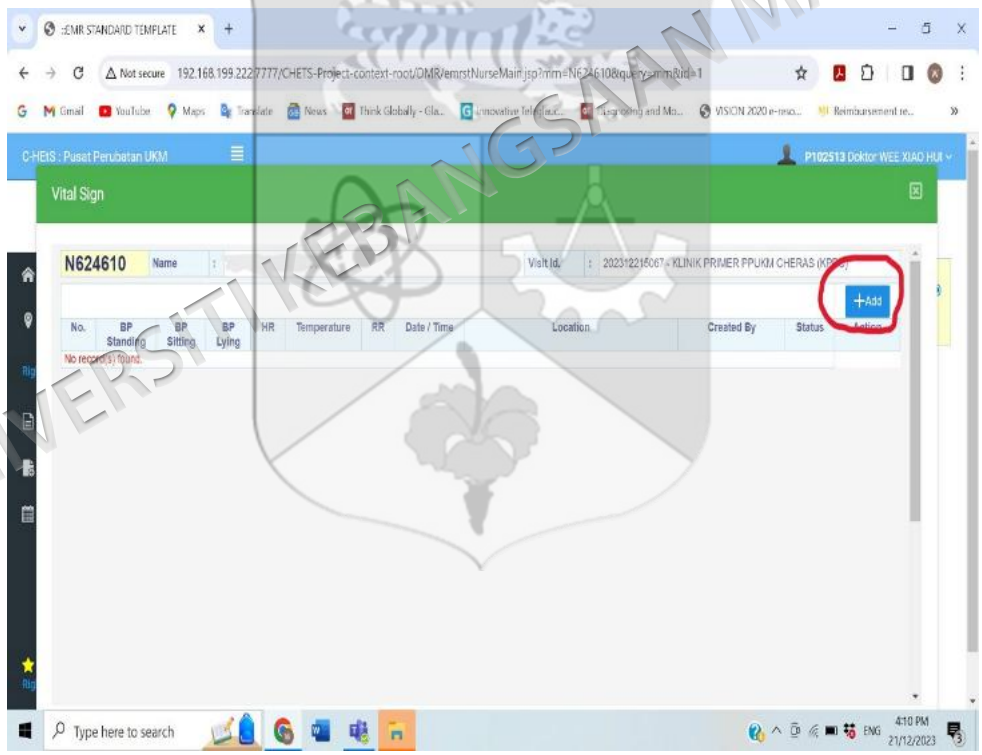


i) Click on +**Add** to enter the VA.



ii) Enter the VA for the patient in the Visual acuity column. Click **Submit** after finish entering the VA.

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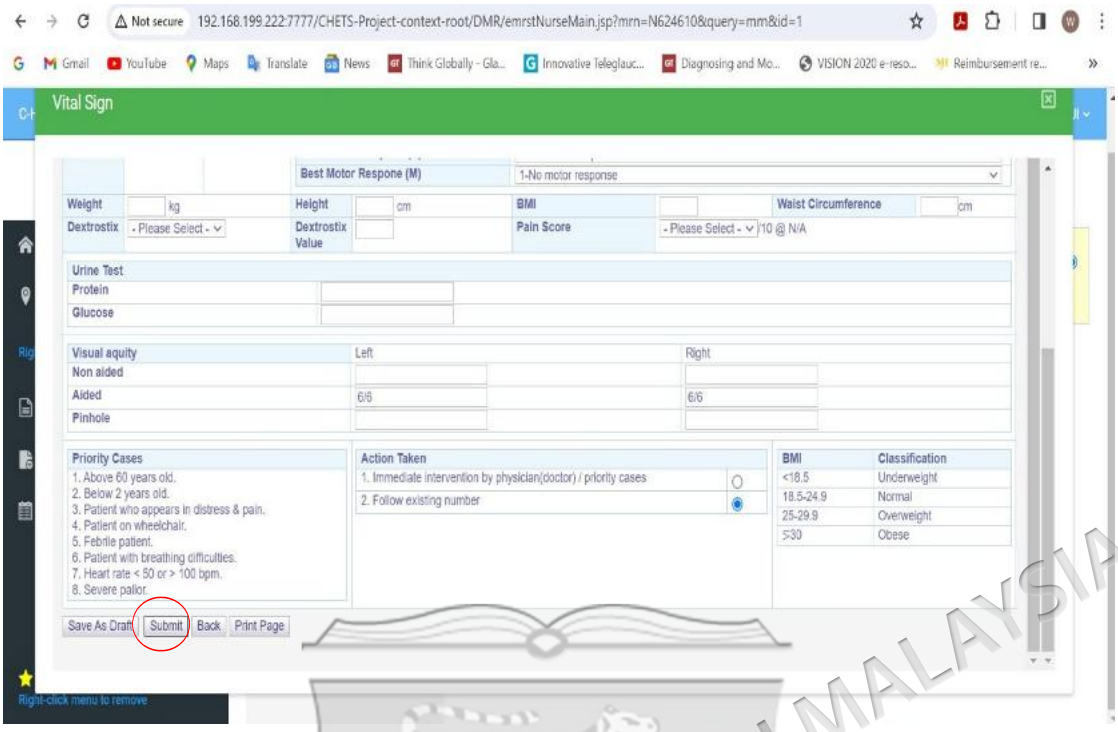
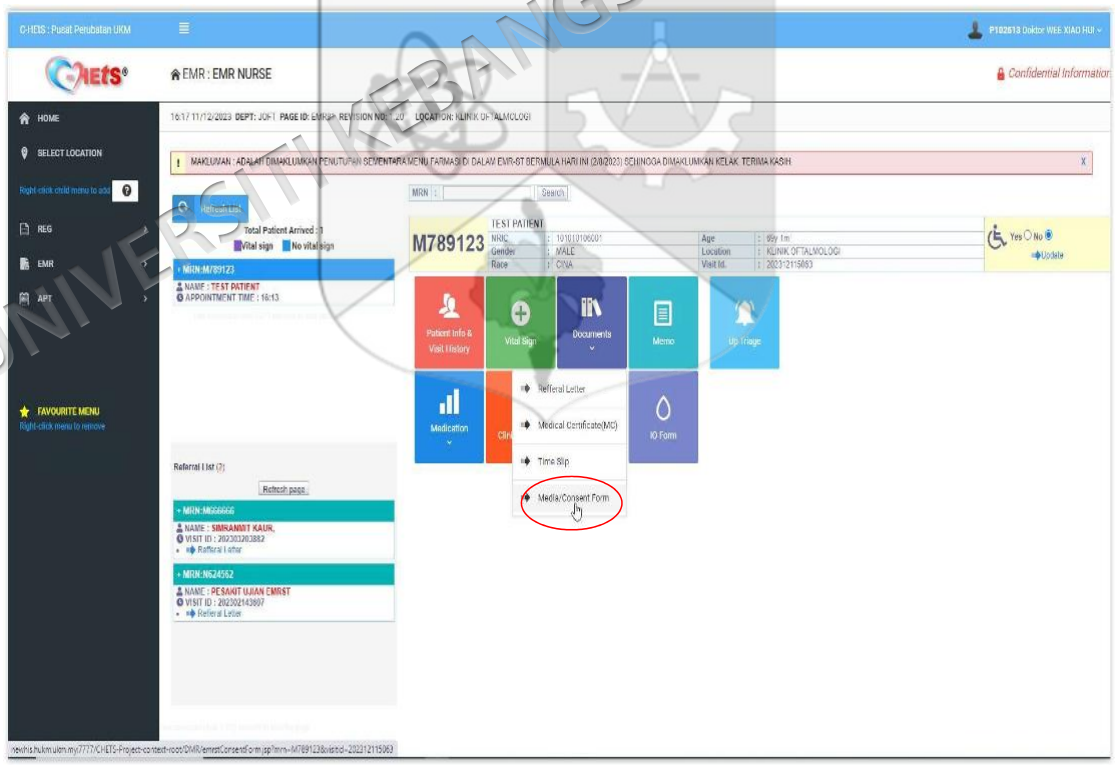


11. To upload the images in the system, click **Documents > Media/Consent Form**

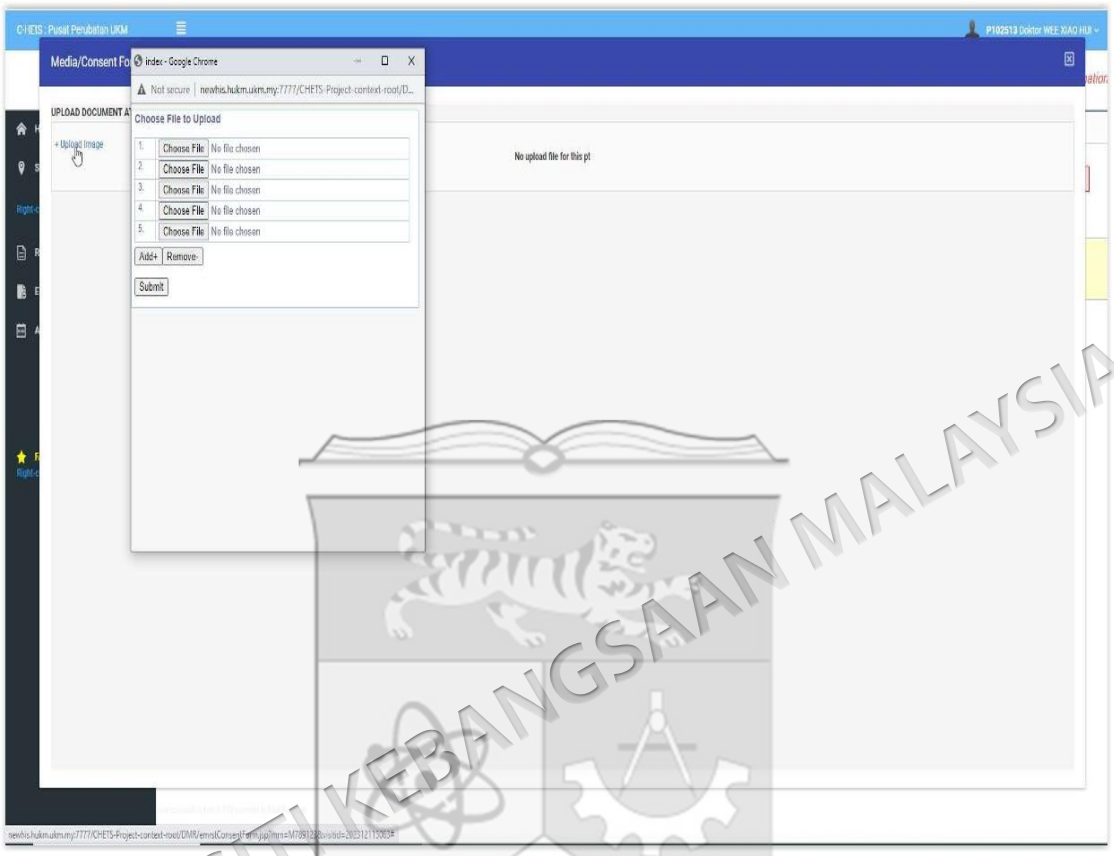


i) Click Upload Image, choose the file to be uploaded into the system by pressing button **Choose File.**

ii) Choose file and click **Open**. jpeg, png and PDF are recommended for

uploading in the system.

iii) Click **Submit** to save the file in the system.



i) Press **F5** or click **refresh** to ensure the files that have been uploaded can be seen on the screen.

ii) Click **View File Image** and the **file** to see the images that have been uploaded in the system.

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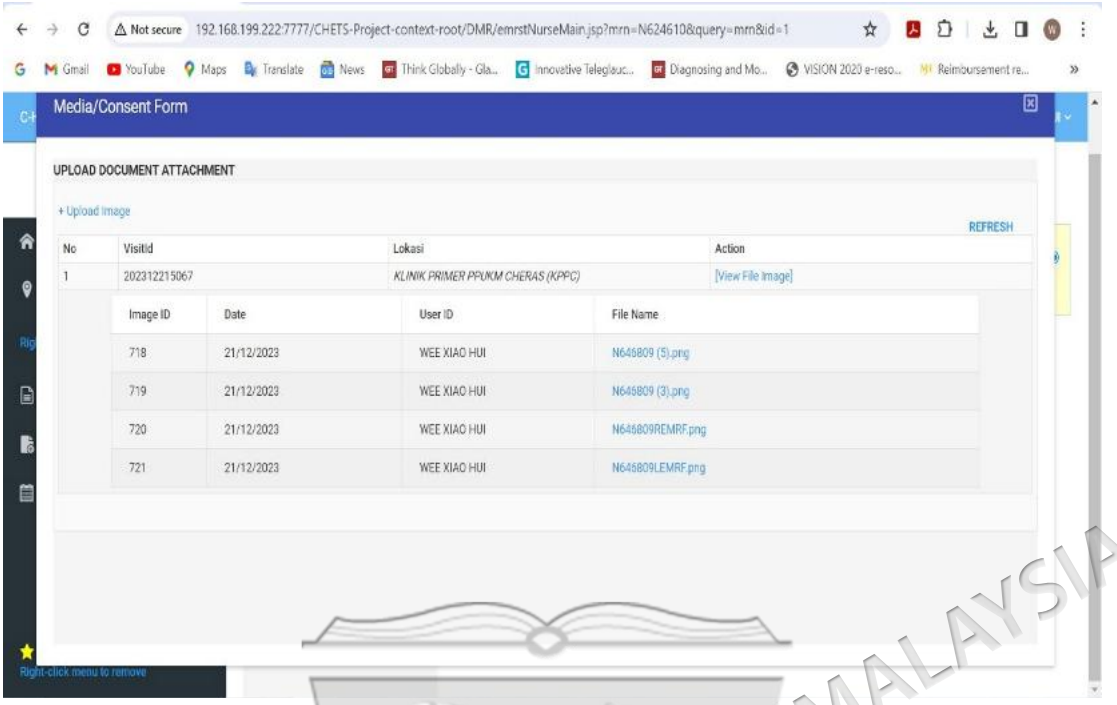
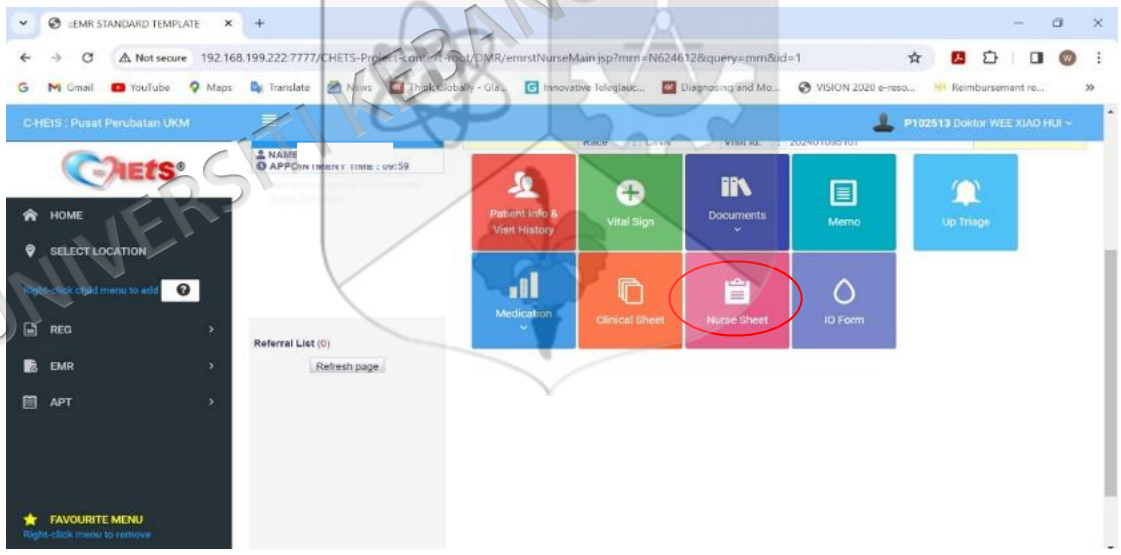


12. Click the **Nurse Sheet** to enter the glaucoma screening test results (history taking, IOP, RAPD and etc).



i) Click the **Ophthalmology** for department and **Glaucoma** for speciality.

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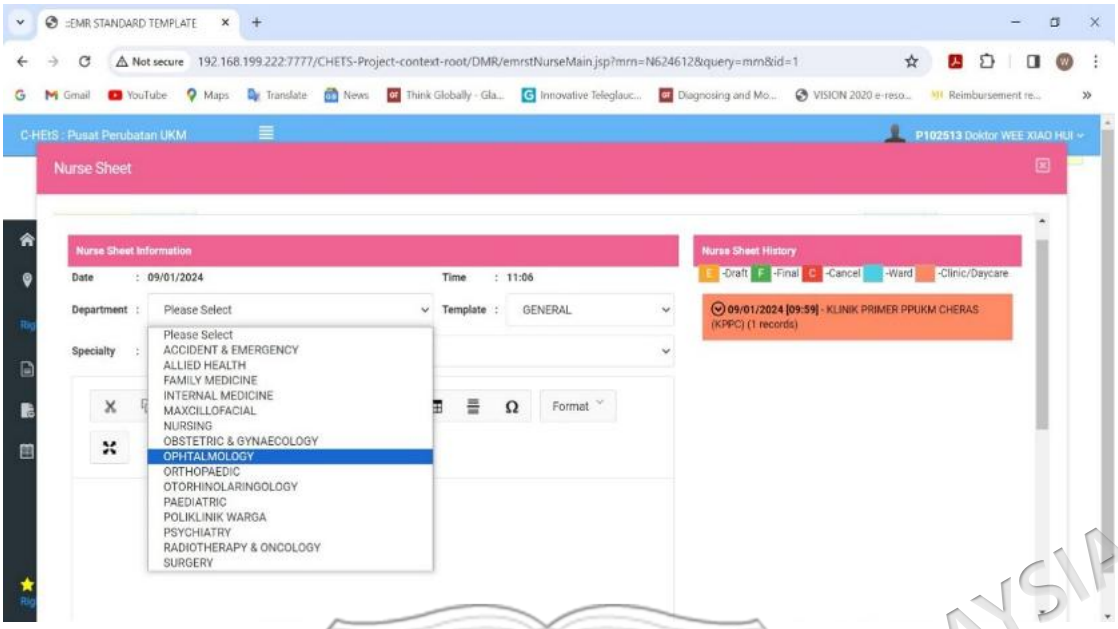

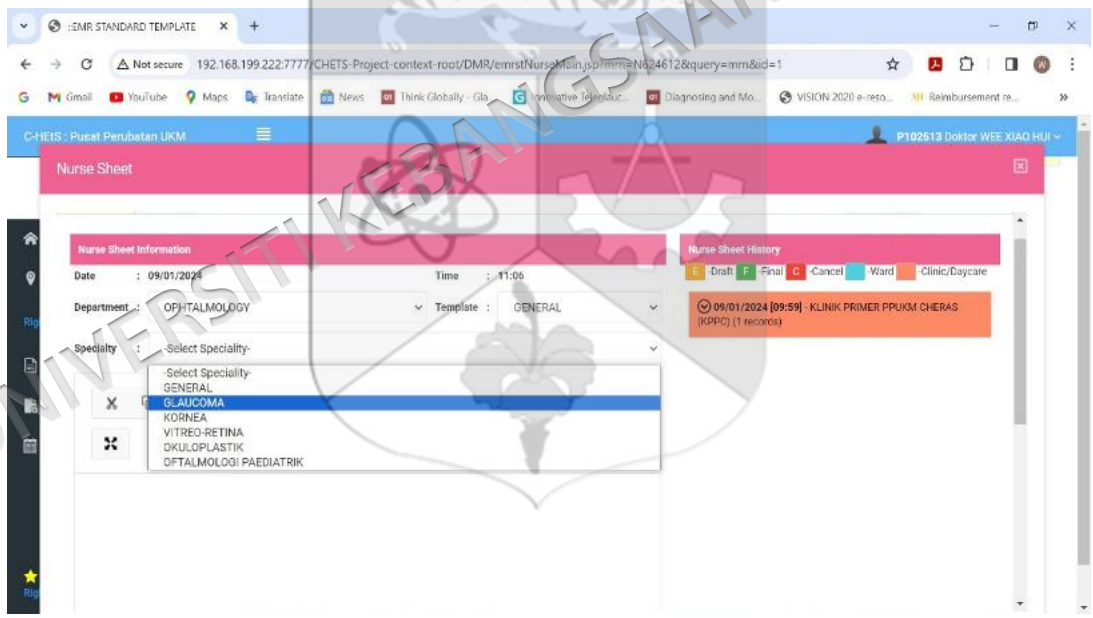

ii) Open the provided Microsoft Word document for result of the glaucoma screening. Copy the tables using **CTRL-C** key and paste it using **CTRL-V** key in the nurse sheet.

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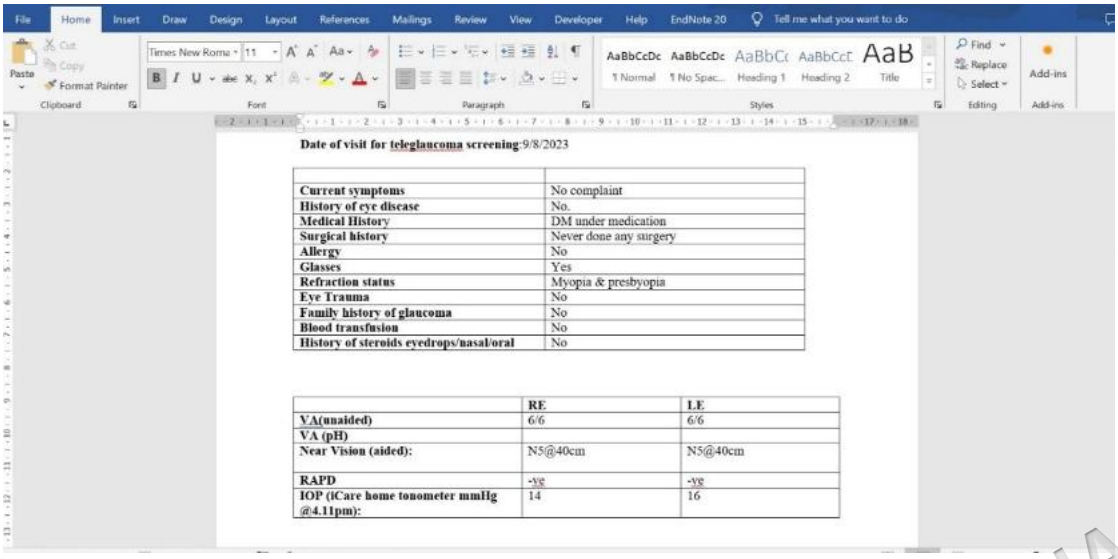
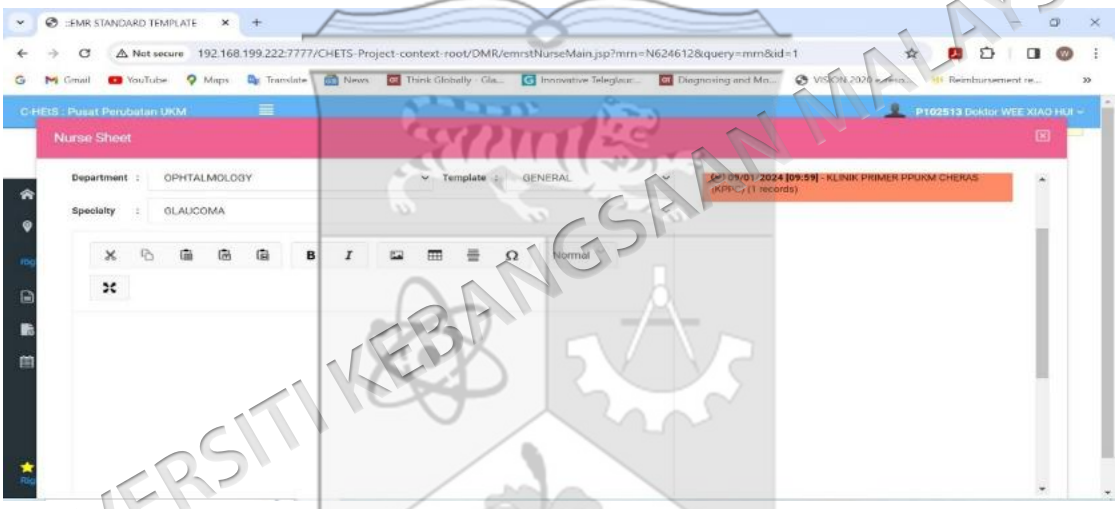


Date of visit for teleglaucoma screening:9/8/2023

Current symptoms	No complaint
History of eye disease	No.
Medical History	DM under medication
Surgical history	Never done any surgery
Allergy	No
Glasses	Yes
Refraction status	Myopia & presbyopia
Eye Trauma	No
Family history of glaucoma	No
Blood transfusion	No
History of steroids eyedrops/nasal/oral	No

	RE	**LE**
VA(unaided)	6/6	6/6
VA (pH)		
Near Vision (aided):	N5@40cm	N5@40cm
RAPD	-ve	-ve
IOP (iCare home tonometer mmHg @4.11pm):	14	16



iii) Click **Submit & Confirm** to upload the screening result.

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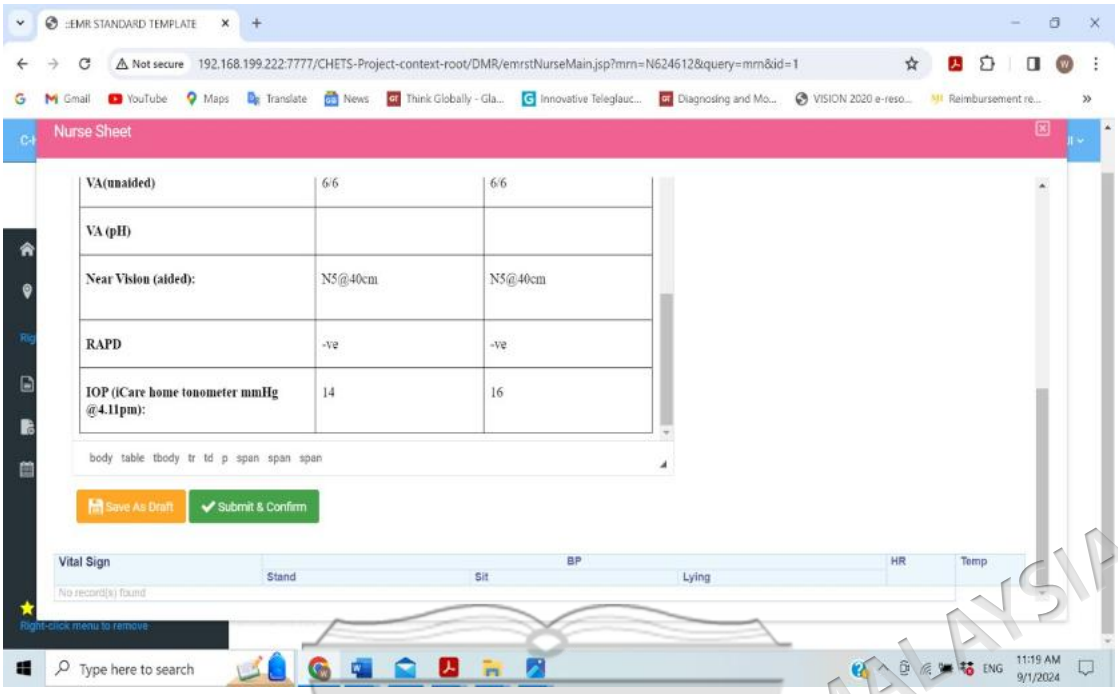

13. Ensure that you logged off after finished entering the information.

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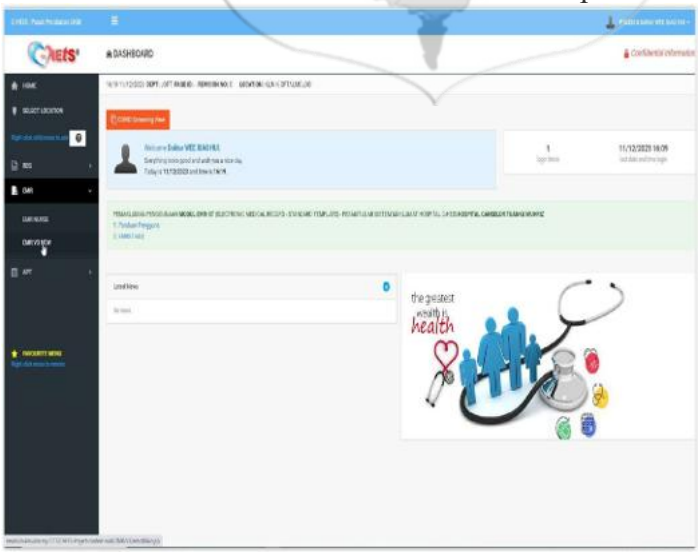
APPENDIX Z

INSTRUCTION MANUAL FOR OPHTHALMOLOGISTS

Instructions

1. Go to Google chrome and key in http://newhis.hukm.ukm.my:7777/CHETS-Project-context-root/inclogin.jsp.
2. Enter your existing **username** dan **password** used in UKM EMR.
3. Click **Login** to access the system.

4. Go to the **EMR > EMR V3 NEW** to see the patient's information.



5. Enter the patient's MRN and press **ENTER**. If the consultation is done on a different day from the date of glaucoma screening, patient need to be

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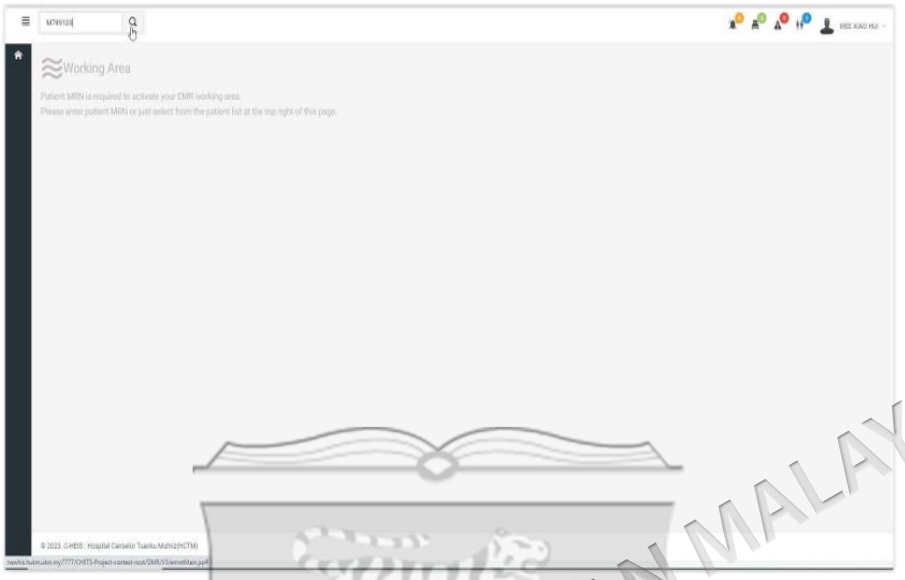
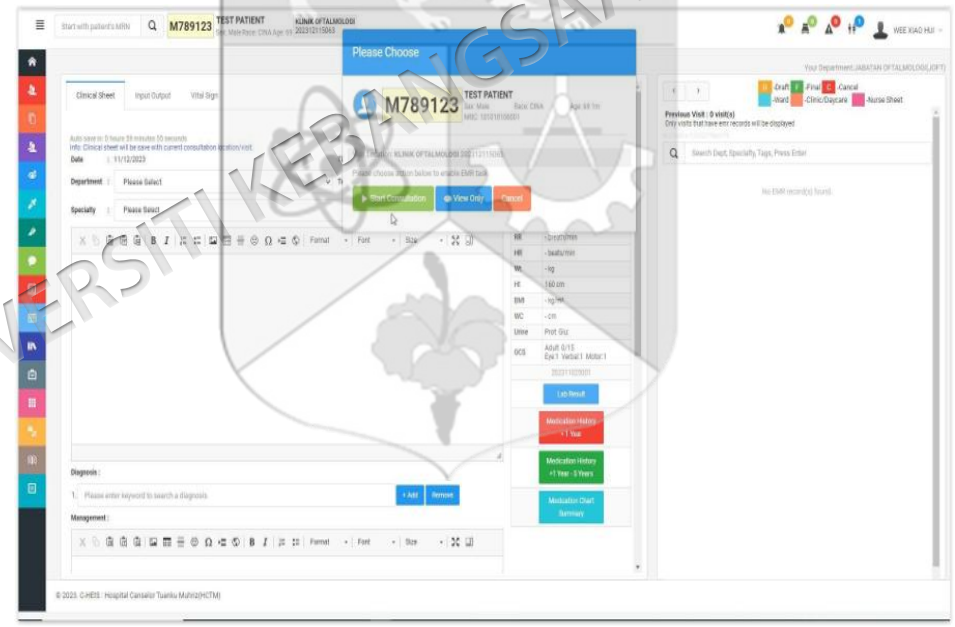
registered again by the nurses to enable consultation (Refer user manual for primary eyecare provider).



6. Click **Start Consultation.**



7. The media icon will appear below the Medication Chart button if there are any images uploaded for the patient. Click the **Media** icon at the left side of the screen to view the images.

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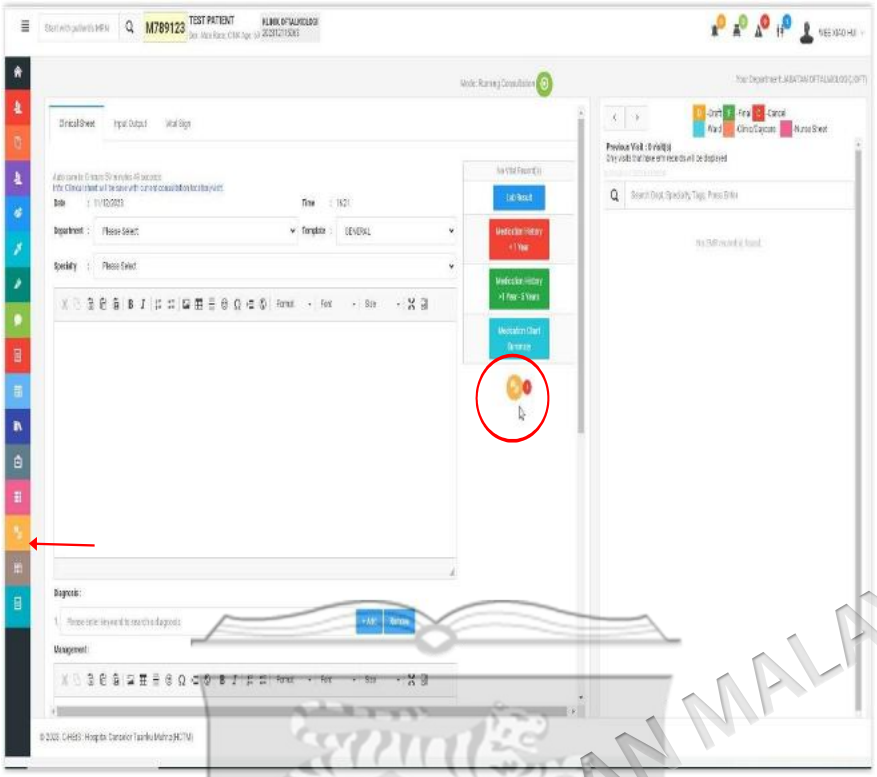
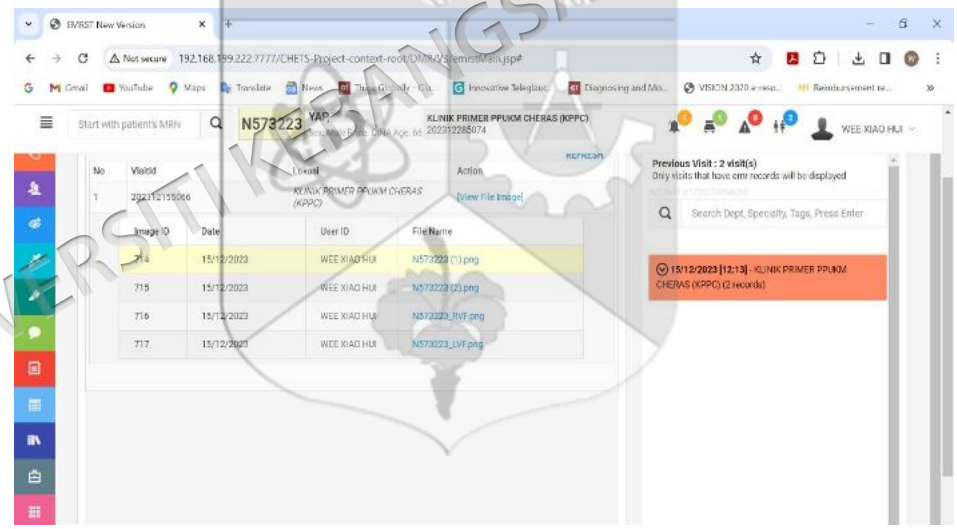


8. Click **View File Image** to view the images that have been uploaded.



9. Click on the file image that you want to review.

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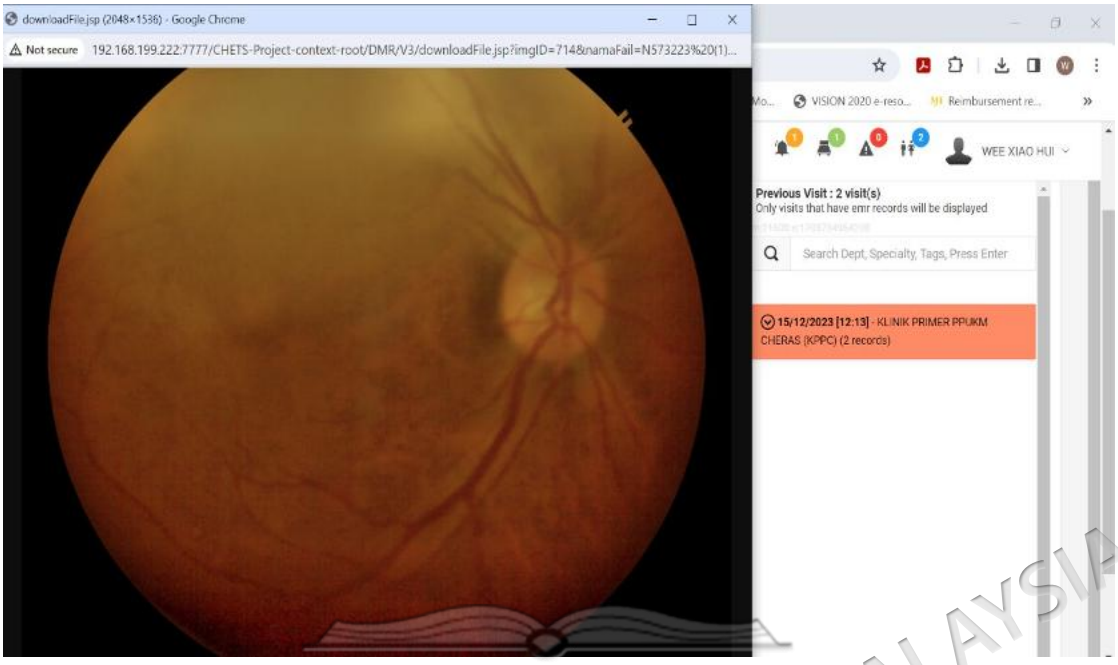
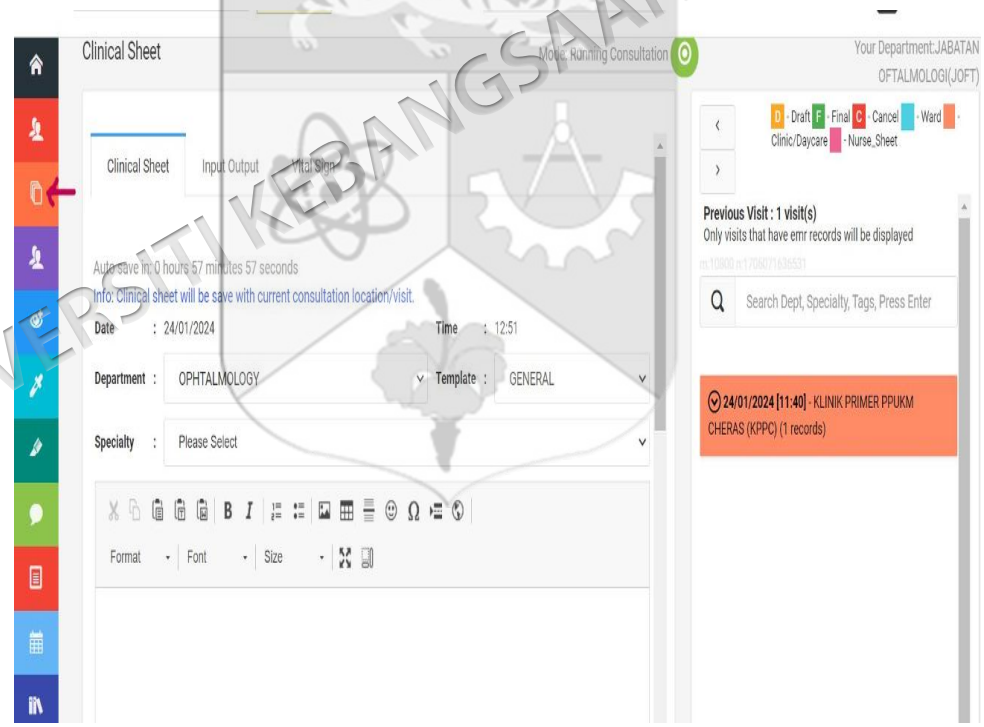


10. After viewing all images that have been uploaded, click on the clinical sheet icon at the left side of the menu.



11. Click on the nurse clinical sheet on the right side of the screen to view the results from the glaucoma screening. It will appear on the clinical sheet.

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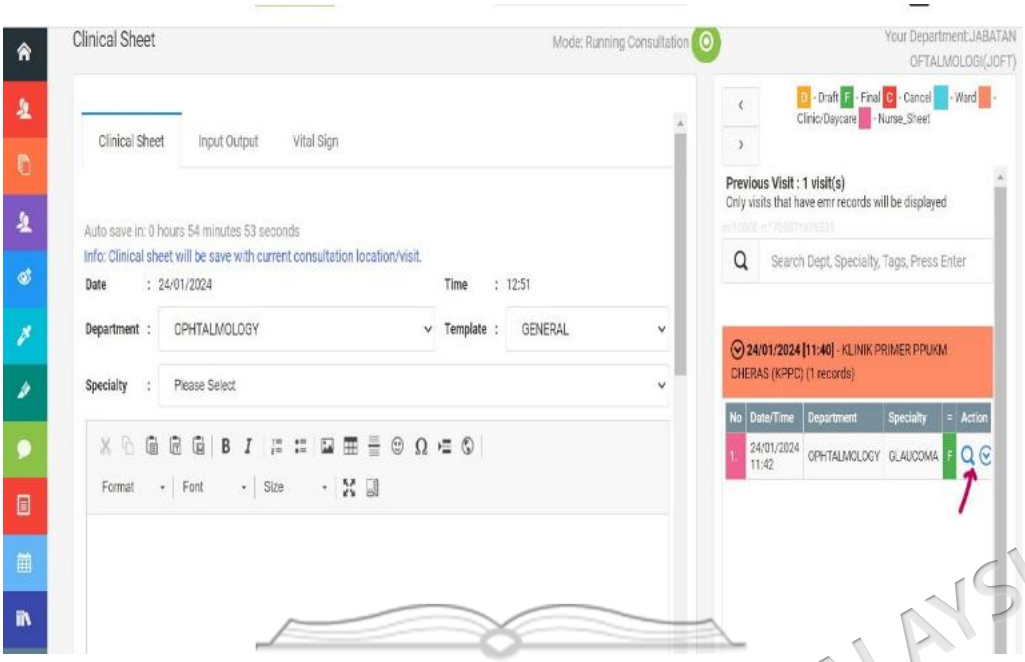
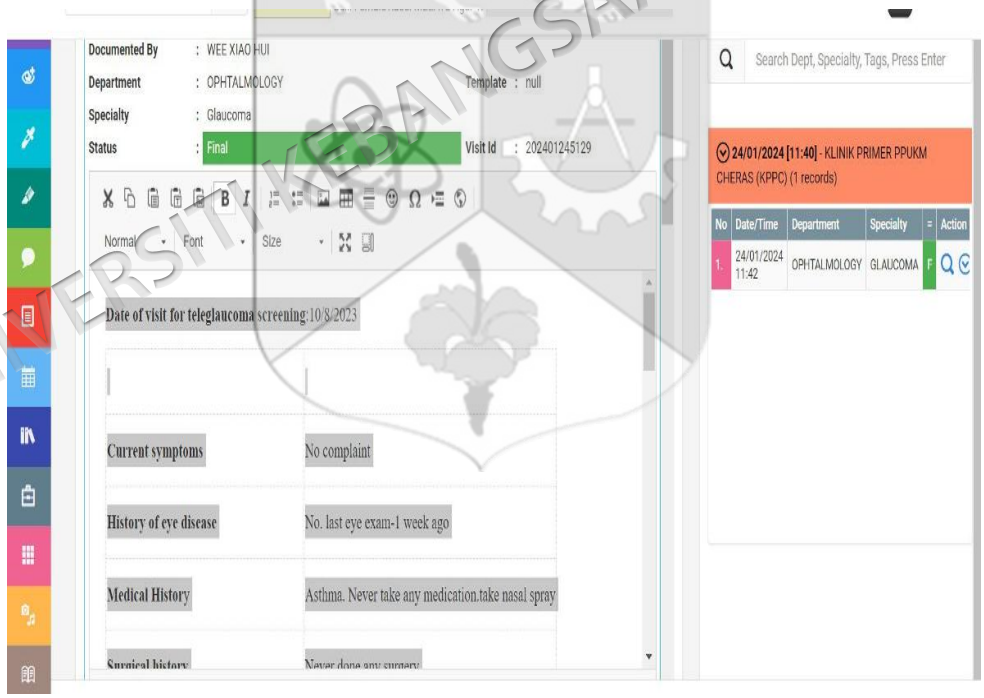


12. Copy the results of the glaucoma screening using the **CTR-C** key.



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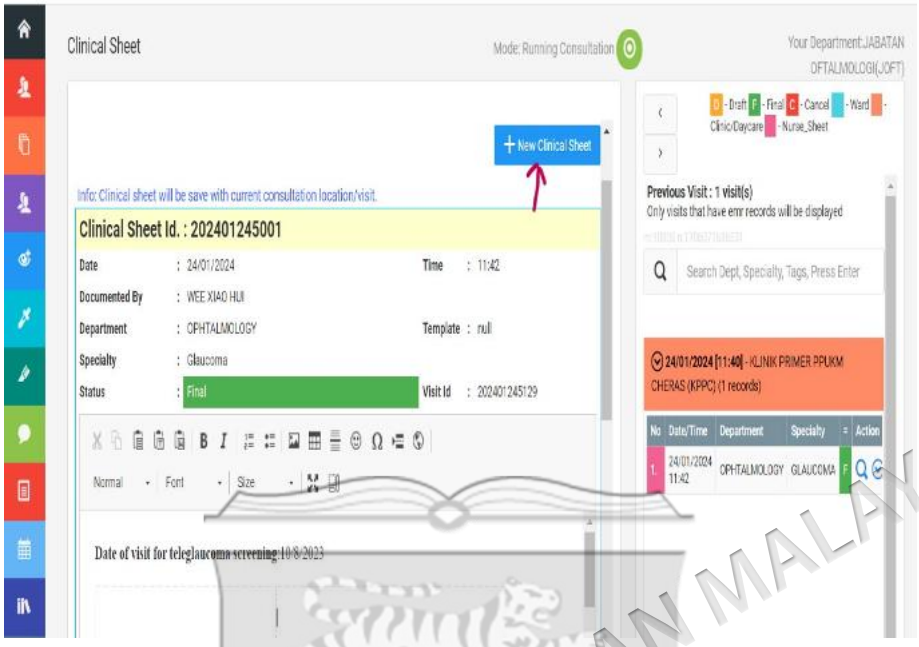
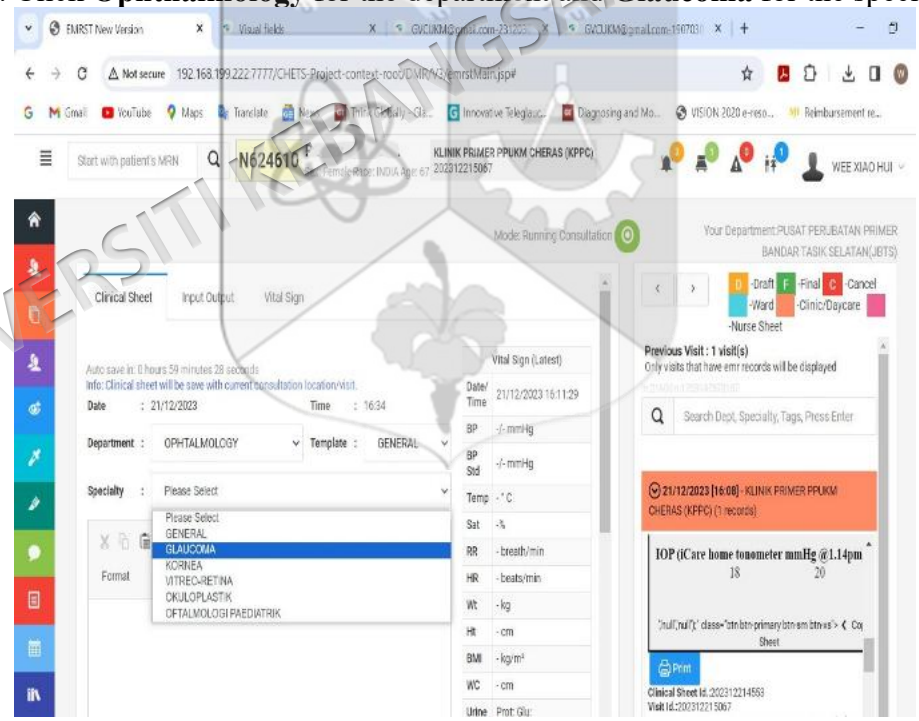
13. Click on the new clinical sheet.



14. Click **Ophthalmology** for the department and **Glaucoma** for the speciality.



15. Paste the results of the glaucoma screening on the nurse sheet that has been copied on the new clinical sheet using CTR-V key.
16. Write the findings from the reviewed images on the clinical sheet. You can right click mouse and click **Insert Row After** to write the findings for the fundus and visual field images.

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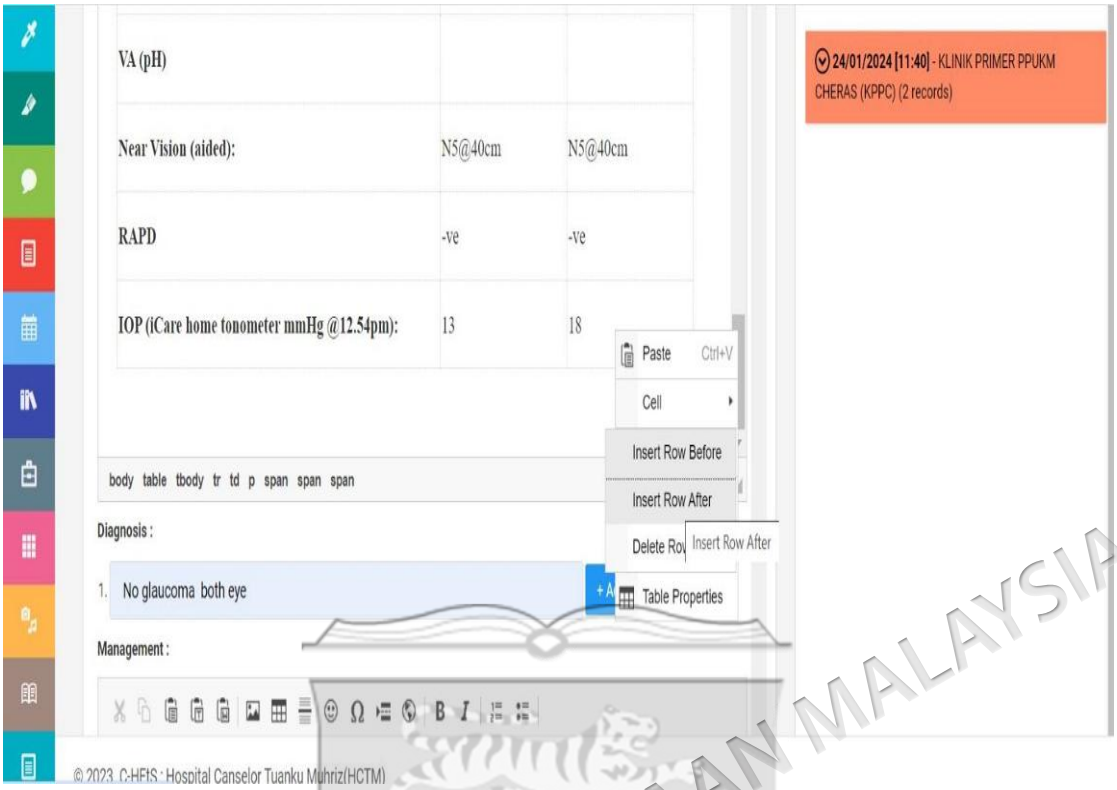

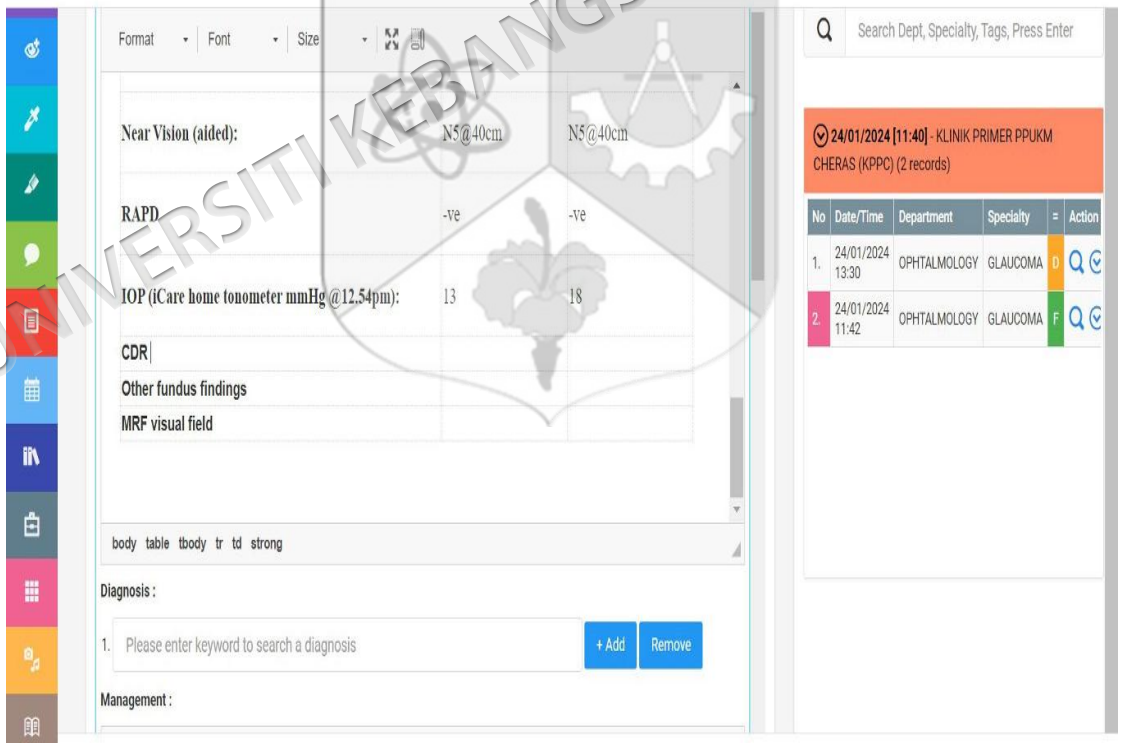

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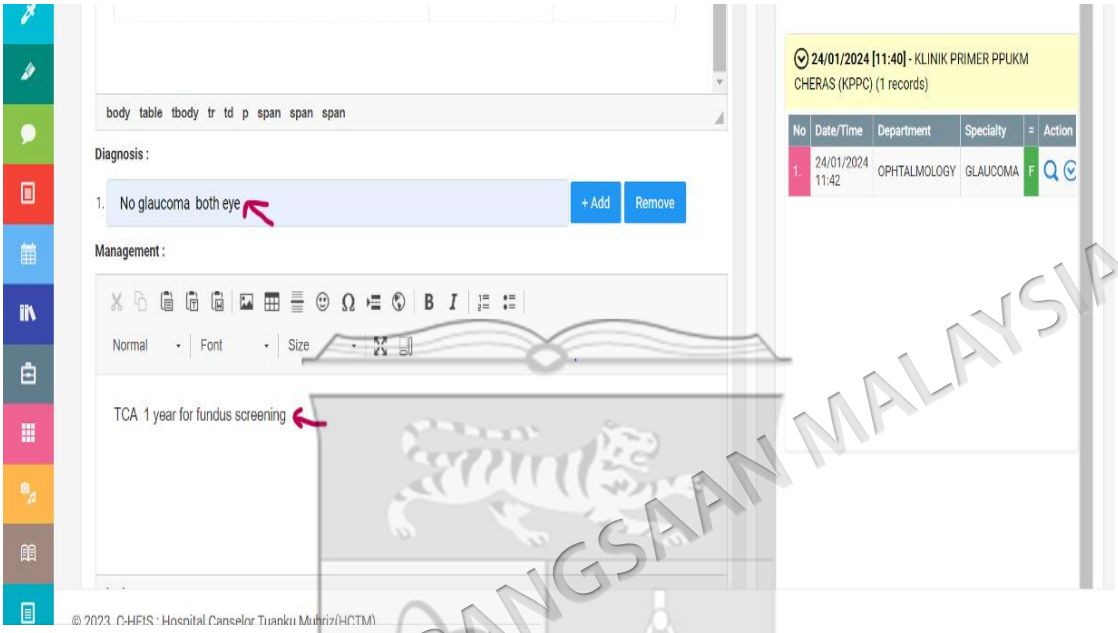
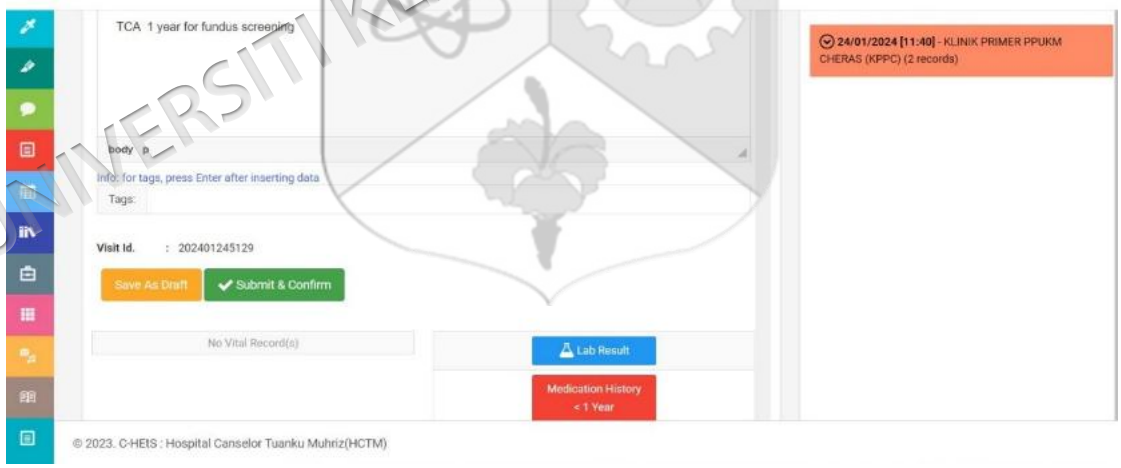
17. Fill in the diagnosis and management. Click **Submit & Confirm** if you are sure there is no error with the clinical sheet. If you are not sure that there is no error, you can click **Save as Draft** so that you can edit it before submitting the sheet.





18. Click **Others** icon on the left side menu on the screen to write a referral letter.

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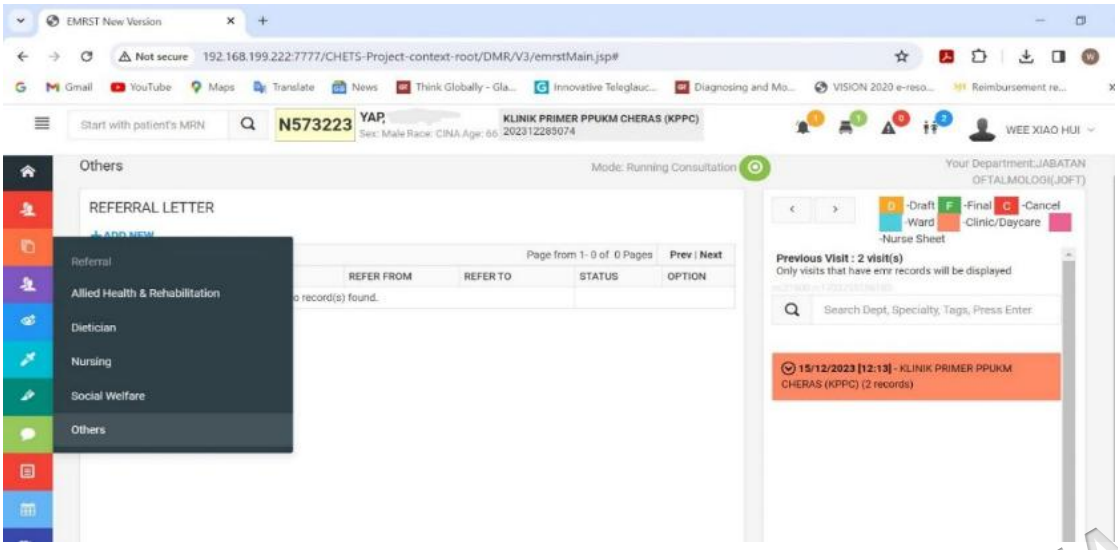
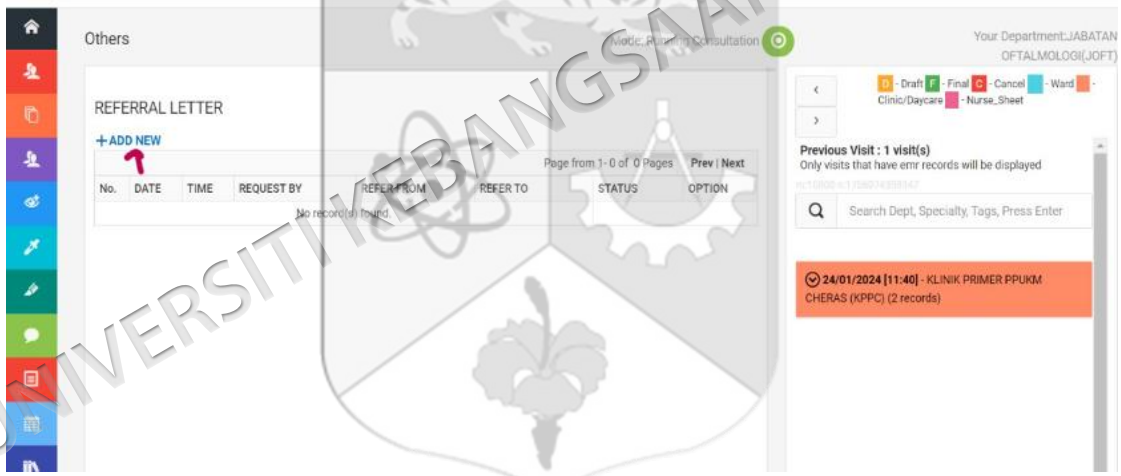


19. Click **ADD NEW** to write a referral letter.



20. Enter the details on the referral letter (Clinic, Department, Speciality, etc.).

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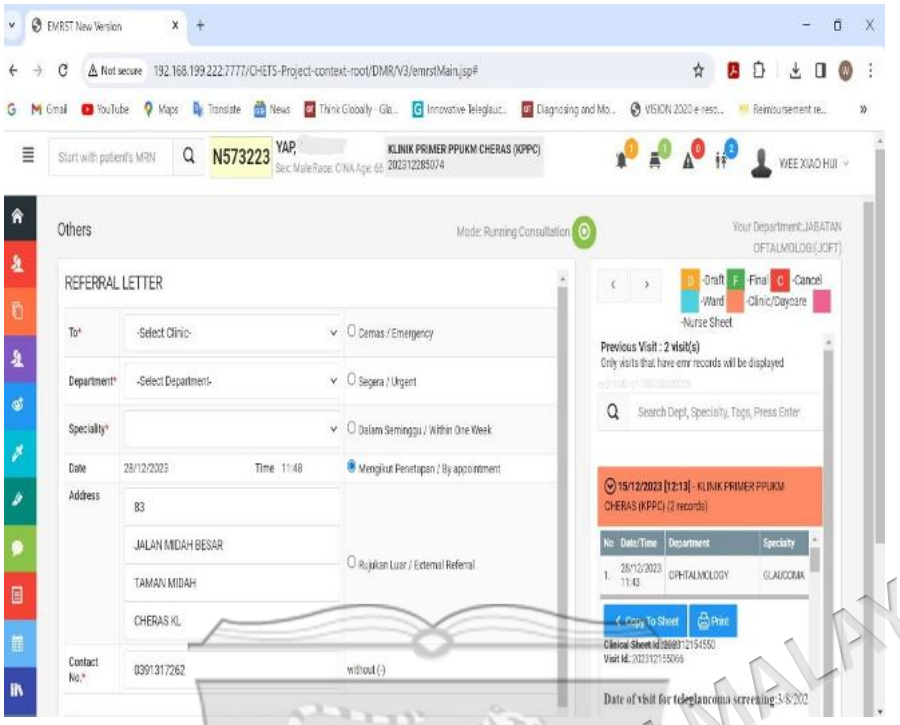
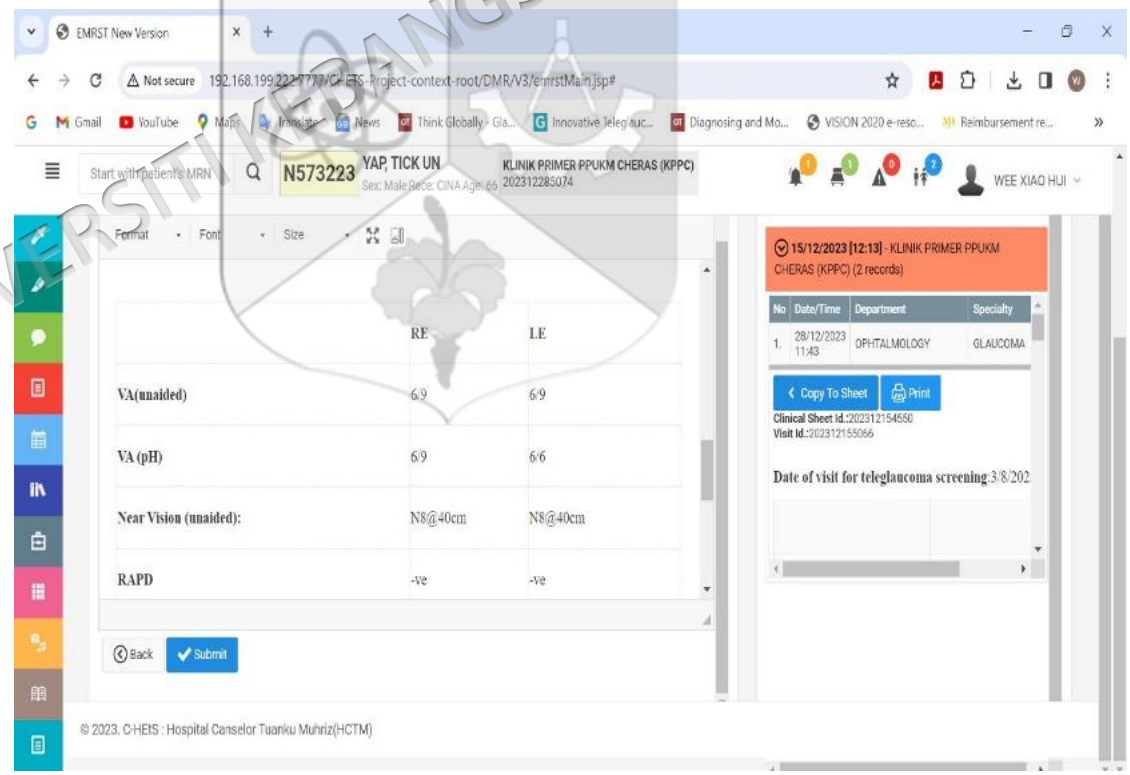


21. Click **COPY TO SHEET** from the completed clinical sheet. Click **Submit** after you have finished writing the referral letter.



22. Ensure that you log off after finishing entering the information.

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APPENDIX AA

FUNCTIONALITY OF THE SYSTEM QUESTIONNAIRE

Teleglaucoma Functionality Questionnaire

This survey is to test the functionality of a teleglaucoma system by the users.This survey will take you about 10-15 minutes only. This survey is part of a research titled "**Teleglaucoma for Future Prevention of Blindness in Malaysia**". You may contact the research team for clarifications:
Ass.Prof Dr Jemaima Che Hamzah (jemaima@ppukm.ukm.edu.my) and Wee Xiao Hui (xiaohui_98@hotmail.com).

* Indicates required question

1. Email *

2. I give my consent to be a part of this research study, to follow the study procedures and to provide necessary information as requested. *

   Mark only one oval.

   - ( ) Yes
   - ( ) No

Section I: Demographic Information

3. What is your age? *

   Mark only one oval.

   - ( ) 20-29 years old
   - ( ) 30-39 years old
   - ( ) 40-49 years old
   - ( ) 50-59 years old
   - ( ) 60-69 years old
   - ( ) >70 years old

https://docs.google.com/forms/d/1Xv-M7D8NFQqsTm7GlmW_xZtNnnvHNOPPom_WFD8M_I8/edit

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4. What is your gender? *

Mark only one oval.

- Male
- Female

5. *

What is your ethnicity?

Mark only one oval.

- Malay
- Chinese
- Indian
- Other: _____

6. What is your highest education level? *

Mark only one oval.

- Diploma
- Degree
- Master
- PhD
- Other: _____

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7. Where is your current working place? *

Mark only one oval.

- ◯ Primary health clinic
- ◯ Hospital
- ◯ Other: _____

8. How many years of working experience in your current field? *

Mark only one oval.

- ◯ Less than 3 years
- ◯ 3-5 years
- ◯ 6-8 years
- ◯ 8-10 years
- ◯ More than 10 years

9. What is your occupation? *

Mark only one oval.

- ◯ Medical assistant *Skip to question 10*
- ◯ Optometrist *Skip to question 10*
- ◯ Medical laboratory technologist *Skip to question 10*
- ◯ Ophthalmologist *Skip to question 20*
- ◯ Doctor *Skip to question 20*
- ◯ Nurse *Skip to question 10*

Section II: Teleglaucoma System Functionality For Primary Eye Care Providers

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10. I was able to register new case *

Mark only one oval.

- Yes
- No

11. I was able to view the patient list for the current day *

Mark only one oval.

- Yes
- No

12. I was able to view details of a new patient *

Mark only one oval.

- Yes
- No

13. I was able to edit details of a new patient *

Mark only one oval.

- Yes
- No

14. I was able to delete patient details if necessary *

Mark only one oval.

- Yes
- No

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15. I was able to make comments in the nurse sheet *

Mark only one oval.

- Yes
- No

16. I was able to upload file images *

Mark only one oval.

- Yes
- No

17. I was able to change/re-upload another file images *

Mark only one oval.

- Yes
- No

18. I was able to delete the uploaded images*

Mark only one oval.

- Yes
- No

19. I was able to view the uploaded file images *

Mark only one oval.

- Yes
- No

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Section II: Teleglaucoma System Functionality For Ophthalmologists

Answer the statements accordingly

20. I was able to view the patient list for the day *

Mark only one oval.

- Yes
- No

21. I was able to view the details of a new patient *

Mark only one oval.

- Yes
- No

22. I was able to view the uploaded file images *

Mark only one oval.

- Yes
- No

23. I was able to make comments,diagnoses and management in the patient's clinical sheet *

Mark only one oval.

- Yes
- No

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24. I was able to successfully submit the patient's clinical sheet

Mark only one oval.

- Yes
- No

25. I was able to issue a referral letter to a patient if necessary *

Mark only one oval.

- Yes
- No

Skip to question 26

Section III: Suggestions for improvement

26. Please give suggestions for improvement to the system *

Google Forms

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APPENDIX BB

USABILITY OF THE SYSTEM QUESTIONNAIRE

Usability of the Teleglaucoma System Questionnaire

Please rate each statement using the scale below
1- strongly disagree
2- largely disagree
3- Disagree
4-Neutral
5- Agree
6- Largely agree
7- Strongly agree

1. Overall, I am satisfied with how easy it is to use this system *

Mark only one oval.

	1	2	3	4	5	6	7	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

2. It was simple to use this system *

Mark only one oval.

	1	2	3	4	5	6	7	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

3. I could effectively complete my work using this system *

Mark only one oval.

	1	2	3	4	5	6	7	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

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4. I was able to complete my work quickly using this system *

Mark only one oval.

	1	2	3	4	5	6	7	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

5. I was able to efficiently complete my work quickly using this system *

Mark only one oval.

	1	2	3	4	5	6	7	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

6. I feel comfortable using this system *

Mark only one oval.

	1	2	3	4	5	6	7	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

7. It was easy to learn to use this system *

Mark only one oval.

	1	2	3	4	5	6	7	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

8. I believe I could become productive quickly using this system *

Mark only one oval.

	1	2	3	4	5	6	7	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

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9. The system gives error message that clearly tell me to fix the problem *

Mark only one oval.

	1	2	3	4	5	6	7	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

10. Whenever I made a mistake using the system, I could recover easily and quickly. *

Mark only one oval.

	1	2	3	4	5	6	7	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

11. The information provided in the system (user manual) provided with this system was clear *

Mark only one oval.

	1	2	3	4	5	6	7	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

12. It was easy to find information I needed in the system *

Mark only one oval.

	1	2	3	4	5	6	7	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

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13. The information provided in the system was easy to understand *

Mark only one oval.

	1	2	3	4	5	6	7	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

14. The information was effective in helping me complete the tasks and scenarios *

Mark only one oval.

	1	2	3	4	5	6	7	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

15. The organization of information on the system screens was clear *

Mark only one oval.

	1	2	3	4	5	6	7	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

16. The interface of this system was pleasant *

Mark only one oval.

	1	2	3	4	5	6	7	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

17. I liked using the interface of this system *

Mark only one oval.

	1	2	3	4	5	6	7	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

18. This system has all the functions and capabilities I expect it to have *

Mark only one oval.

	Stro	1	2	3	4	5	6	7	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	◯	Strongly agree

19. Overall, I am satisfied with this system *

Mark only one oval.

	1	2	3	4	5	6	7	
Stro	◯	◯	◯	◯	◯	◯	◯	Strongly agree

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APPENDIX CC

ETHICS APPROVAL FROM MINISTRY OF HEALTH MALAYSIA FOR PHASE V

JAWATANKUASA ETIKA & PENYELIDIKAN PERUBATAN
(*MEDICAL RESEARCH & ETHICS COMMITTEE*)
KEMENTERIAN KESIHATAN MALAYSIA
MINISTRY OF HEALTH MALAYSIA
Kompleks Institut Kesihatan Negara (NIH)
No.1, Jalan Setia Murni U13/52,
Seksyen U13 Bandar Setia Alam,
40170 Shah Alam, Selangor.
Tel.: +(6)03-33628888/ 33628205

Ruj.Kami/ *Ref* : 22-02206-RRK
Tarikh/ *Date* : **19-01-2023**

JEMAIMA CHE HAMZAH
HOSPITAL UNIVERSITI KEBANGSAAN MALAYSIA (HUKM)

Dato'/ Dr/ Tuan/ Puan,

SURAT KELULUSAN ETIKA/ *LETTER OF ETHICAL APPROVAL*:

NMRR ID-22-02206-RRK (IIR)
COMPARISON BETWEEN TELEGLAUCOMA PROGRAM AND OPPORTUNISTIC CASE FINDING FOR DETECTING GLAUCOMA AND PROBABLE GLAUCOMA

Dengan hormatnya perkara di atas adalah dirujuk.

This letter is made in reference to the matter above.

2. Bersama dengan surat ini dilampirkan surat kelulusan saintifik dan etika bagi projek ini. Segala rekod dan data subjek adalah SULIT dan hanya digunakan untuk tujuan kajian dan semua isu serta prosedur mengenai *data confidentiality* mesti dipatuhi. Kebenaran daripada Pengarah Hospital / Institusi di mana kajian akan dijalankan mesti diperolehi terlebih dahulu sebelum kajian dijalankan. Dato'/ Tuan/ Puan perlu akur dan mematuhi keputusan tersebut dan undang-undang lain yang berkaitan.

   *The Medical Research and Ethics Committee (MREC), Ministry of Health Malaysia (MOH) has provided ethical approval for this study. Please take note that all records and data are to be kept strictly **CONFIDENTIAL** and can only be used for the purpose of this study. All precautions are be taken to maintain data confidentiality. Permission from the District Health Officer / Hospital Administrator/ Hospital Director and all relevant heads of departments /units where the study will be carried out must be obtained prior to the study. You are required to follow and comply with their decision and all other relevant regulations.*

3. Penyelidik- penyelidik dan lokasi penyelidikan yang terlibat ialah:

   The investigators and sites involved in this study are:

   Hospital Universiti Kebangsaan Malaysia (HUKM)
   Jemaima Che Hamzah (Penyelidik Utama/ *Principal Investigator*)
   Rona Asnida Binti Nasaruddin

   Klinik Kesihatan Sentul
   Rohayah Bte Ismail
   Wee Xiao Hui

   Klinik Primer PPUKM Cheras
   Sharanjeet Kaur
   Mohd Izzuddin Bin Hairol
   Mohd Harimi Abd Rahman
   Aznida Firzah Abdul Aziz

.../4-

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APPENDIX DD

PARTICIPANT'S INFORMATION SHEET IN PHASE V

1**. Title of study**: Comparison between teleglaucoma program and opportunistic case finding for detecting glaucoma and probable glaucoma

2. Introduction:

It is important that you understand why the research is being done and what it will involve. Please take your time to read through and consider this information carefully before you decide if you are willing to participate. Ask the study staff if anything is unclear or if you would like more information. After you are properly satisfied that you understand this study, and that you wish to participate, you must sign this informed consent form.

Your participation in this study is voluntary. You do not have to be in this study if you do not want to. You may also refuse to answer any questions you do not want to answer. If you volunteer to be in this study, you may withdraw from it at any time. If you withdraw, any data collected from you up to your withdrawal will still be used for the study. Your refusal to participate or withdrawal will not affect any medical or health benefits to which you are otherwise entitled.

This study has been approved by the Medical Research and Ethics Committee, Ministry of Health Malaysia.

3.What is the purpose of the study?

Glaucoma is the second leading cause of global blindness after cataract according to World Health Organization (WHO). If untreated, it will result in permanent blindness. Early detection of glaucoma can prevent this disease from becoming worse. Teleglaucoma is the transfer of the examination results of the eye to an eye specialist via electronic communications to detect glaucoma. The purpose of this

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study is to compare the detection rate of cases with glaucoma and probable glaucoma in the population between teleglaucoma and opportunistic case finding.

4. **Study sites**:

Klinik Primer PPUKM (Teleglaucoma program), Klinik Kesihatan Sentul (opportunistic case finding) and Klinik Mata PPUKM (confirmation of the diagnosis of glaucoma or probable glaucoma)

5. What are my responsibilities when taking part in this study?

I) For participants in the teleglaucoma program at Klinik Primer UKM, you will undergo an eye screening which consists of:

a) History taking: The nurse/optometrist will ask you questions regarding your medical condition, family history of glaucoma, current complaint, allergy, surgery history, eye history and etc.

b) Vision test at distance and near: Before starting the vision test at distance, you will be instructed to cover the untested eye with an occluder. You will be asked to read the smallest line of the Snellen chart that you can read clearly for each eye. Similarly, for the near vision test, you will be instructed to cover the untested eye with an occlude and read the smallest line of the reading chart that you can read clearly for each eye.

c) Measurement of eye pressure: You will be instructed to look straight. The nurse/optometrist will measure eye pressure for each eye using iCare tonometer.

d) Fundus photography: You will be asked to sit in front of fundus camera and rest your chin on the chin rest. You will be instructed to focus on the target inside the fundus camera. The nurse/optometrist will capture the picture of the back part of your eye with the fundus camera.

e) Visual field screening: The nurse/optometrist will perform visual field screening for each eye with iPAD apps called Melbourne Rapid test. You will be instructed to cover the untested eye with an occluder. You will be

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instructed to look at the red dot fixation target and press the iPAD screen when you can see the grey spot appear at the peripheral screen.

This screening will take at least 45 minutes to 50 minutes. The nurse will inform you once they get the diagnosis from an ophthalmologist, who will review the clinical findings from the teleglaucoma platform. If you are suspected of having glaucoma or probable glaucoma, you will be given an appointment at the eye clinic in PPUKM for an eye examination which will take about two hours to three hours. The eye examination at PPUKM will be free of charge. The examination at PPUKM consists of below:

i. Vision test at distance and near: Before starting the vision test at distance, you will be instructed to cover the untested eye with an occluder. You will be asked to read the smallest line of the Snellen chart that you can read clearly for each eye. Similarly, for the near vision test, you will be instructed to cover the untested eye with an occlude and read the smallest line of the reading chart that you can read clearly for each eye.

ii. Measurement of eye power: The optometrist will perform an eye test to determine your eye power for each eye.

iii. History taking: The ophthalmologist will ask you questions regarding your medical condition, family history of glaucoma, current complaint, allergy, surgery history, eye history and etc.

iv. Slit lamp examination: You will be asked to sit in front of the slit lamp and rest your chin on the chin rest. The ophthalmologist will perform an examination of the front part of your eyes using the slit lamp.

v. Measurement of eye pressure: The ophthalmologist will instill one drop of anesthetic eye drop to numb your eye. He or she will also instill fluorescein into your eye. You will be asked to look straight and open both eyes wide. The ophthalmologist will hold your upper eyelid and move the Goldmann tonometer forward until it touches your eye. The ophthalmologist will take the reading for each eye.

vi. Fundus examination: The ophthalmologist will instill an eye drop to dilate both of your pupils (Tropicamide). You will be asked to sit in

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front of the slit lamp and rest your chin on the chin rest after both pupils have dilated. You will be asked to look straight. The ophthalmologist will examine the back of your eyes using a lens called 90D.

vii. Ocular coherence tomography (OCT) test: You will be asked to sit in front of Ocular coherence tomography (OCT) machine and rest your chin on the chin rest. You will be instructed to focus on the green target inside the OCT machine. The ophthalmic technician will take a picture of the OCT scan for each eye.

viii. Humphrey Visual Field test: You will be asked to sit in front of the Humphrey Visual Field Analyser and rest your chin on the chin rest. You will be instructed to cover the untested eye with an occluder. You will be instructed to focus on the fixation target inside the machine. You will be asked to press the response button when you can see small flashes of light appear in your peripheral vision.

If you are diagnosed to have glaucoma or probable glaucoma at the eye clinic PPUKM, you will be given the option to continue the treatment at PPUKM if you are willing to pay for the treatment or referred to a government hospital if you cannot afford the treatment.

2) For participants from the opportunistic case finding at Klinik Kesihatan Sentul, if you are interested in participating in this study, please provide your contact number and email address to the assistant medical officer so that he will pass your contact details to the investigator. The investigator will contact you to explain the study in detail and to obtain your consent to participate. If you agree to participate in this study, she will give you another consent form to sign. After getting the consent form, she will retrieve the following information from your medical record: The investigator will retrieve the following information from your medical record:

- Demographic data such as age, gender, race
- Date onset of symptom
- Symptom
- Associated symptom

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- Health conditions such as diabetes mellitus, high blood pressure
- Allergy
- Clinical findings during at the visit at Klinik Kesihatan Sentul
- Diagnosis at Klinik Kesihatan Sentul: glaucoma, probable glaucoma

6. What are the potential risks and side effects of being in this study?

There is a minimal risk in participation. The main reported effect is temporary stinging sensation associated with the use of Alcaine (topical anaesthetic eye drop before measuring eye pressure with Goldmann tonometer) and tropicamide 1% (an eye drop instilled to dilate the pupil to examine the fundus). Other effects that have been reported include reduced near vision and sensitivitiy towards bright light. The medication and its effect usually last 6 hours or sometimes longer. A very serious allergic reaction to this drug is RARE. However, seek immediate medical attention if you notice any symptoms of a serious allergic reaction including rash, itching, dizziness or trouble breathing. History taking will be taken before instillation of eye drop to make sure that the patient is not allergy to the eye drop. During the eye examination at PPUKM, the ophthalmologist indemnity is covered under UKM insurance. You may withdraw from this study anytime if you wish. Your participation in this study may be terminated if the investigator/sponsor decide to stop the study due to circumstances such as lack of recruitment or inability to manage the study.

7. What is the alternative procedures and their potential risk or benefits?

There is no alternative procedures.

8. **What are the benefits of being in this study?**

If you are diagnosed as glaucoma or glaucoma suspect patient, your eye sight may be saved as glaucoma patient usually come to clinic at late stage which cause blindness. Treatment can be started earlier if detected at early stage. Information

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obtained from this study will help to develop the teleglaucoma program so that it can be implemented in Malaysia.

9. **Who is funding the research?**

This study is sponsored by Universiti Kebangsaan Malaysia. You will not be paid for participating in this study.

10. Will my medical information be kept private?

All your information obtained in this study will be kept and handled in a confidential manner, in accordance with applicable laws and/or regulations. When publishing or presenting the study results, your identity will not be revealed without your expressed consent. Individuals involved in this study, qualified monitors and auditors, and governmental or regulatory authorities may inspect the study data, where appropriate and necessary.

11. **Will I be informed about the study findings?**

You will be informed about the study findings if you request to know the result .

11) Will I be informed about the new information relevant to consent becomes available?

Yes, you will be informed once the new information relevant to consent becomes available.

12) Who should I call if I have questions?

If you have any questions about the study or if you think you have a study related injury and you want information about this study, please contact the study's investigator, Ass. Prof Dr Jemaima Che Hamzah at telephone number (013-3302722). If you have any questions about your rights as a participant in this study, please contact: The Secretary, Medical Research & Ethics Committee, Ministry of Health Malaysia, at telephone number 03-3362 8407/8205/8888.

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APPENDIX EE

INFORMED CONSENT FORM FOR PHASE V

Title of Study: Comparison between teleglaucoma program and opportunistic case finding for detecting glaucoma and probable glaucoma

By signing below, I confirm the following:

- I have been given oral and written information for the above study and have read and understood the information given.
- I agree to share my personal contact details so that the investigator can contact me in order to recruit me to participate in this research.
- I have had sufficient time to consider participation in the study and have had the opportunity to ask questions and all my questions have been answered satisfactorily.
- I understand that my participation is voluntary and I can at anytime free withdraw from the study without giving a reason and this will in no way affect my future treatment. I am not taking part in any other research study at this time. I understand the risks and benefits, and I freely give my informed consent to participate under the conditions stated. I understand that I must follow the study doctor's (investigator's) instructions related to my participation in the study.
- I understand that study staff, qualified monitors and auditors, the sponsor or its affiliates, and governmental or regulatory authorities, have direct access to my medical record in order to make sure that the study is conducted correctly and the data are recorded correctly. All personal details will be treated as STRICTLY CONFIDENTIAL
- I will receive a copy of this subject information/informed consent form signed and dated to bring home.
- I agree/disagree* for my family doctor to be informed of my participation in this study. *(*delete which is not applicable)*

Subject:

Signature: I/C number:

Name: Date:

Personnel in Primer Clinic HCTM/ Sentul Health Clinic:

Signature: I/C number:

Name: Date:

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Impartial witness:

Signature: I/C number:

Name**:** Date:

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APPENDIX FF

LIST OF PUBLICATIONS AND PRESENTATIONS

List of Publications

1. Wee, X.H., Hamzah, J.C., Adam A., Kaur, S.S., Hairol, M.I., Abd Rahman, M. H., Nasaruddin, R.A., Isa, Z.M. 2026. Functional evaluation of an EMR teleglaucoma system in a Malaysian Urban Setting. *Journal of Clinical and Diagnostic Research* 20(5): NC05-NC09.

2. Wee, X.H., Kaur, S.S., Hairol, M. I., Abd Rahman, M. H., Nasaruddin, R.A., Md Isa, Z., Ismail, R., & Che Hamzah, J. 2026. Development of Components for A Glaucoma Screening Programme in Malaysia: A Qualitative Study. *IIUM Medical Journal Malaysia* 25(02). https://doi.org/10.31436/imjm.v25i02.2875

List of Presentations

1. Wee, X. H., Hamzah, J. C., Kaur, S. & Hairol, M. I. 2020. Training Eye Care Providers in Glaucoma Screening: A Qualitative Study. *Proceedings of the 4th UUM International Qualitative Research Conference (QRC 2020)*
2. Wee, X.H., Kaur, S.S., M. I., Abd Rahman, M. H., Nasaruddin, R.A., Md Isa, Z., Che Hamzah, J. 2022. The Perception of Eye Healthcare Professionals towards Glaucoma Screening in Malaysia: A Qualitative Study. *Med & Health* 17(4) (Suppl): 01-61.

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QRC2020

"Bridging Knowledge and Experience through Qualitative Research"

4th UUM INTERNATIONAL QUALITATIVE RESEARCH CONFERENCE

1-3 December 2020 . Virtual Conference

Certificate of Participation

This certificate is awarded to

Wee Xiao Hui

for the participation as

Presenter

Presentation title:

Training of Eyecare Providers in Glaucoma Screening: A Qualitative Study

ASSOC. PROF. DR. ROSE SHAMSIAH SAMSUDIN
Dean
Tunku Puteri Intan Safinaz School of Accountancy
(TISSA-UUM)
Universiti Utara Malaysia

Organised by:

Pusat Pengajian Perakaunan Tunku Puteri Intan Safinaz
Universiti Utara Malaysia

Institut Kajian Strategik dan Pembangunan Perakaunan Mampan
Universiti Utara Malaysia

FACULTY OF MEDICINE
THE NATIONAL UNIVERSITY OF MALAYSIA

CERTIFICATE OF PARTICIPATION

it is hereby confirmed that

Wee XH, Sharanjeet KMS, Mohd Izzuddin H, Mohd Harimi AR, Rona AN, Zaleha MI, Jemaima CH

has participated in

POSTER COMPETITION

24th MEDICAL & HEALTH RESEARCH WEEK

8th - 19th August 2022

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ASSOC. PROF. DR. WAN HASLINA WAN ABDUL HALIM
Chairperson
24th Medical & Health Research Week

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