NATIONAL SURVEY OF PREVALENCE AND RISK FACTORS OF GLAUCOMA IN SRI LANKA

Project Report
December 2019 to December 2022

Glaucoma Interest Group - College of Ophthalmologists of Sri Lanka
DDG-NCD Unit Ministry of Health Sri Lanka
Vision 2020 Country Programme Sri Lanka

Primary Healthcare System Strengthening Project (PSSP)

Message from Secretory Ministry of Health Services

Sri Lanka is gradually and fast becoming an aging population. With this transition it is invariable that the tendency for many age-related diseases and health conditions seem to be increasing. In addition to non-communicable diseases and risk factors such as raised blood pressure or raised blood sugar levels, the results of this first national survey on prevalence of glaucoma and risk factors indicate that unless early detection is strengthened blindness due to glaucoma in old age too can become a problem in Sri Lanka.

As a Medical professional at the administrative capacity with a long history of association with vision 20 20 and other community organizations I am confident that this will pave the way to Ministry of Health to work more closely with such organizations to strengthen early detection process at the primary medical care institution level.

I congratulate Dr. Lalitha Senerath and all others who were involved with this survey for presenting this valuable information so that Health Authorities can quickly plan for putting information into actions to reduce the chance of a possible menace of blindness.

I sincerely thank the PSSP and world bank for considering this nationally important activity for financial assistance and certainly foresee that by improving the capacity of the HLC to strengthen the delivery of primary medical care will improve the quality of eye care at population level.

Dr. P. G. Maheepala

Secretary, Ministry of Health

Message from Director General of Health Services

I am honored to write foreword for the publication of the National Survey - Prevalence of Glaucoma in Sri Lanka. This is the first national survey conducted in Sri Lanka on of prevalence of Glaucoma and the risk Factors with randomly selected from the voters list over the age of 40 years list representing from all the districts in nine provinces.

I highly appreciate this collaborative survey together with the Ministry of Health, Glaucoma Interest Group – College of Ophthalmologists of Sri Lanka and Vision 2020 Secretariat. concluded the survey successfully in 2022 December.

Glaucoma is the second commonest cause of irreversible blindness in the world. Identifying the lack of data at national level, primary responsibility of this survey is to generate evidence to improve health care delivery to have strategic plan on eye care delivery hence to serve glaucoma patient to prevent Glaucoma Blindness in Sri Lanka.

Department of Health Services is to ensure the quality of life of the nation by providing Efficient Eye Care Service. We are committed to promote such endeavors and collaborate with researchers to support their initiatives.

I express my sincere gratitude to the principal Investigator, Co Investigators and the research team who conducted this National study by physically become involved with overcoming the stumbling block due to the Covid Pandemic. The devotion shown by the team is highly appreciated.

Further, I wish to extend my gratitude for all the officials who supported the research project by giving administrative clearance, transportation, and practical help at the ground level. Good vision in elders is a wealth to country.

Dr. Asela Gunawardena,

Director General of Health Services,

Ministry of Health

Message from Deputy Director General of Directorate of Non-Communicable Disease Prevention

Vision impairment is a major public health issue and population aging will lead to an increasing burden over the next decades. Glaucoma, one of the leading causes of blindness, is a chronic optic neuropathy with irreversible but preventable visual field loss and progressive optic nerve damage. Therefore, early detection and appropriate treatment is essential, which can be facilitated by better knowledge of the prevalence and incidence of glaucoma, and the risk factors associated with primary open-angle glaucoma (POAG), which is the most common type of glaucoma.

The latest National Blindness Survey reported a prevalence of blindness of 1.7% based on the WHO definition of presenting vision among the population aged 40 years and above and Glaucoma accounted for 2.1% of the causes for blindness as identified in the National Survey. However, there is a paucity of evidence on prevalence at population level and the risk factors of glaucoma in Sri Lanka to implement and develop health care strategies at national level. Such local data are crucial for development of strategic plans for early identification and best management of glaucoma in order to optimize the quality of life of Sri Lankan population.

Therefore, Glaucoma Interest Group of the College of ophthalmologists of Sri Lanka conceptualized and initiated this "National Survey of Assessing the Prevalence and Risk factors for Glaucoma" in December 2019 with guidance and collaboration of Ministry of Health and Vision 2020 Country Program of Sri Lanka. This survey was planned with the intention of exploring the variability of the prevalence of blindness across the country to organize the service delivery according to population requirements and maximally utilize the available resources to improve access to glaucoma services.

The survey was completed facing lot of challenges brought forward by the COVID epidemic. I would like to extend my heartfelt thanks to the entire survey team of National Survey of Assessing the Prevalence and Risk factors for Glaucoma who worked tirelessly to make it a success.

Dr. S C Wickramasinghe

Deputy Director General (Non-Communicable diseases),

Ministry of Health

Message from Director of Primary Healthcare System Strengthening Project (PSSP)

"Ensuring effective quality health coverage universally through strengthening our primary health care approach" has identified as the way forward in our health system. The "Primary Healthcare System Strengthening Project" was launched with the objective of reorganizing primary health care to provide people-centered primary care services.

Eye diseases are at the top of primary care agenda as on prevention of blindness requires early detection of blinding disease and appropriate referral at primary care level for necessary treatment.

Glaucoma is the second commonest cause of irreversible visual impairment and blindness worldwide. There was a gap of evidence and national data on glaucoma prevalence in Sri Lanka. Identifying the absence of national data on Glaucoma Prevalence, Chairperson of the Glaucoma Interest Group college of Ophthalmologist of Sri Lanka, being the principal Investigator, initiated this survey in December 2019.

I highly appreciate initiative of this collaborative survey together with the Ministry of Health, Glaucoma Interest Group – College of Ophthalmologists of Sri Lanka and Vision 2020 Secretariat and we could be the stake holder for the entire survey. The survey successfully concluded in 2022 December.

I believe that, the results of this study will fill that gap and provide timely recommendations to deliver appropriate services for the eye care on Glaucoma.

The commitment of all the members in the research team is outstanding and I also acknowledge the support extended by all the health staff who supported this research project.

Dr. J M W Jayasundara Bandara

Project Director,

Primary Healthcare System Strengthening Project

National Survey of Prevalence and Risk Factors of Glaucoma in Sri Lanka

Investigators and Contributors

Principal Investigator

Dr Lalitha L. C. Senarath

Consultant Ophthalmologist, National Hospital Galle

Former Chairperson Glaucoma Interest Group – Collage of Ophthalmologists of Sri Lanka, Regional Secretary and Counsil member of Asia Pacific Academy of Ophthalmology

Co- Investigators

- Dr Amila Chandrasiri: Consultant Community Physician, RDHS office, Galle
- Dr Pradeepa K Siriwardana: Consultant Ophthalmologist - National Eye Hospital Colombo
- Dr Dilruwani Aryasinghe: Consultant Ophthalmologist, Golden Key Eye and ENT Hospital, Colombo
- Dr Prabhath Piyasena: Medical Officer and Postdoctoral Research Fellow in Global Eye Health, Queen's University Belfast, United Kingdom

- Dr MALD Malwatta: Lecturer in Physiology, Department of Physiology, Faculty of Medicine, University of Ruhuna

The Team of Data Collection

- Dr Lalitha Senarath: Principal Investigator (PI)
- Dr Asoka Senarath: Medical Officer
- Dr Ranil Sharminda: Medical Officer- Eye
- Mr Upathissa Vidanapathirana: Ophthalmic Technologist
- Mr Sandeepa Perera: Technical Assistant
- Mr Rangika Marasinghe: Technical Assistant
- Mr Indika Bulathsinghala : Technical Assistant
- Mrs. P H Ranasinghe: Nursing Officer
- Mr L G Vajira: Health Care Assistant
- Ms Roshini Kulendrika: Research Assistant
- Mr H Herath: Research Assistant
- Ms Surangani: Research Assistant

Data entry Team

- Dr. L Senarath
- Dr. MALD Malwatta

Statistical Analysis Team

- Dr. PWD Wasana: Senior Lecturer in Pharmacy, Department of Pharmacy, Faculty of Allied Health Science, University of Ruhuna

Proof Reading, Report Compiling and Editing

- Professor Sampath Gunawardena: Senior Professor of Physiology, Department of Physiology, Faculty of Medicine, University of Ruhuna
- Dr. Prabhath Piyasena

Acknowledgements

List of Abbreviations

ARMD –   Age Related Macular Degeneration
C:D   –   Cup to Disc Ratio
CCT   –   Central Corneal Thickness
CME   –   Continuous Medical Education
DDG   –   Deputy Director General
DGHS –   Director General of Health Services
GN   –   Grama Niladhari
GND   –   Grama Niladhari Division
GNI   –   Gross National Income
HLC   –   Healthy Lifestyle Centre
HS   –   Health Services
ICO   –   International Council of Ophthalmology
IOP   –   Intra Ocular Pressure
LKR   –   Lankan Rupees
MO   –   Medical Officer
MOH   –   Medical Officer of Health
MoH   –   Ministry of Health
NCD   –   Non-communicable Diseases
NPDR –   Non-Proliferative Diabetic Retinopathy
NSGP –   National Survey of Glaucoma Prevalence
PACG –   Primary Angle Closure Glaucoma
PDR   –   Proliferative Diabetic Retinopathy
PHI   –   Public Health Inspector
PHM   –   Public Health Midwife
POAG –   Primary Open Angle Glaucoma
PSSP –   Primary Health Care System Strengthening Project
RAO   –   Retinal Arterial occlusion
RDHS –   Regional Director of Health services
RVO   –   Retinal Vascular Occlusion
SPSS –   Statistical Package for the Social Science
TA   –   Technical Assistant
TLC   –   Tender Loving Care

Contents

List of Tables and Figures

INTRODUCTION

Global magnitude of glaucoma burden

Glaucoma is the second leading cause of blindness by progressive irreversible visual impairment worldwide. It is estimated that 38 million persons are blind globally. Moreover, a further 110 million have low vision and are at greater risk of becoming blind. In 2013, the number of people (aged 40-80 years) with glaucoma worldwide was estimated to be 64.3 million, with the figure projected to increase to 76.0 million by 2020. The global prevalence of glaucoma for population aged 40-80 years is 3.54% (95% CI 2.09-5.82%).[2] Bilateral blindness from glaucoma is projected to affect greater than 11 million individuals worldwide by the year 2020.[3] The prevalence of primary open angle glaucoma (POAG) is highest in Africa (4.20% 95% CI 2.08 to 7.35%), and the prevalence of primary angle closure glaucoma (PACG) is higher in East than South East Asia (1.09%, 95% CI 0.43 to 2.32).[2] Prevalence estimates at population level by different types of glaucoma are instrumental in designing of glaucoma screening and treatment programme and developing related public health strategies. As per current estimates, almost 58.5 million people were predicted to have POAG worldwide by the year 2020. Half (47%) of these people reside in Asia.[5] The mean prevalence of POAG is estimated to be 1.96%. Women are expected to comprise of over 55% of those with OAG conceivably because of their longer life span compared to men.[6]

Public health implications of glaucoma

Patients with glaucoma are reported to have poorer quality of life, reduced levels of physical, emotional, and social well-being, and utilize scarce health care resources[3]. Lack of knowledge of the prevalence of glaucoma and its consequential blindness, coupled with lack of awareness about the disease in the general population and unavailability effective tools to detect the disease early at population level are some of the key barriers with respect to tackling glaucoma as a sizeable public eye health problem.[7] In low-and middle-income countries (LMICs) managing patients with glaucoma has unique challenges. Inability to afford services, treatment rejection, poor compliance, and lack of knowledge and awareness, are main barriers to improve glaucoma care.[3]

Glaucoma is a multifactorial condition resulting from progressive optic neuropathy and visual field loss. This Optic neuropathy is often associated with elevated intraocular pressure (IOP). The mechanical theory hypothesizes how elevated IOP directly damages the lamina cribrosa and the neural axons, whereas according to the vascular theory the optic neuropathy ensues as a consequence of insufficient blood supply due to either increased IOP or other risk factors reducing ocular blood flow[8,10]. These

changes often progress slowly, leading to an asymptomatic stage, hence many glaucoma patients remain unaware about their underlying glaucomatous eye[7].

Chennai Glaucoma Study as well as Aravind comprehensive eye survey, observed that more than 90% cases of glaucoma were undiagnosed and were identified only at the time of the study. They proposed periodic screening of high-risk population for diagnosis of the disease at an early stage which is a highly applicable screening strategy for Sri Lanka.[8]

Sri Lanka country profile

The Democratic Socialist Republic of Sri Lanka has an estimated population of 21.8 million. The Gross National Income (GNI) per capita was LKR 668,748 in 2019 .[9] The country has excellent health indices compared to the peers in South Asia and South east Asia regions. Sri Lanka is situated off the southern coast of India. It lies between Northern latitudes 5'55^0 and 50'9^0 and Eastern latitudes 79'42^0 and 81'52^0.[4]

Sri Lanka's Human Development Index value is 0.782 in 2019 (Human Development Report 2020), which falls under the high human development category. Compared to neighbor countries in South Asian region Sri Lanka has significantly better human development indicators. However, Sri Lanka has one of the fastest ageing populations in the entire Southeast Asia region, which has led to a rapid transition in its disease profile from predominantly communicable diseases towards an abundance of non-communicable disease burden.[11]

Sri Lanka has nine administrative provinces which are further divided in to 25 districts, spanning a total area of 65,610 Km^2. The Western Province is the most densely populated whereas the Northern Province is the least. The 25 districts are sub-divided in to 331 Divisional Secretary (DS) areas. The crude birth rate is 14.6/1000 population while crude death rate is 6.7/1000 population.[16] Infant Mortality rate was 8.5/1000 live births in 2015. Sri Lanka has a high literacy rate (95.7%) in the adult population which is an advantage for implementing health promotional strategies. There is a significant difference in life expectancy between males (72.0 years) and females (78.6 years)[28]. Most of the population resides in rural areas (77.3%) while 18.3% reside in urban areas and 4.4% in estate areas.[15]

Sri Lanka has a universal government healthcare system which pursues health equity among all citizens. The system is state-funded, and in principle anyone can utilize outpatient and inpatient services in public hospitals for free without any restriction. The universal public healthcare system seems to contribute to good health outcomes in comparison to certain other LMIC and even high-income nations.[1]
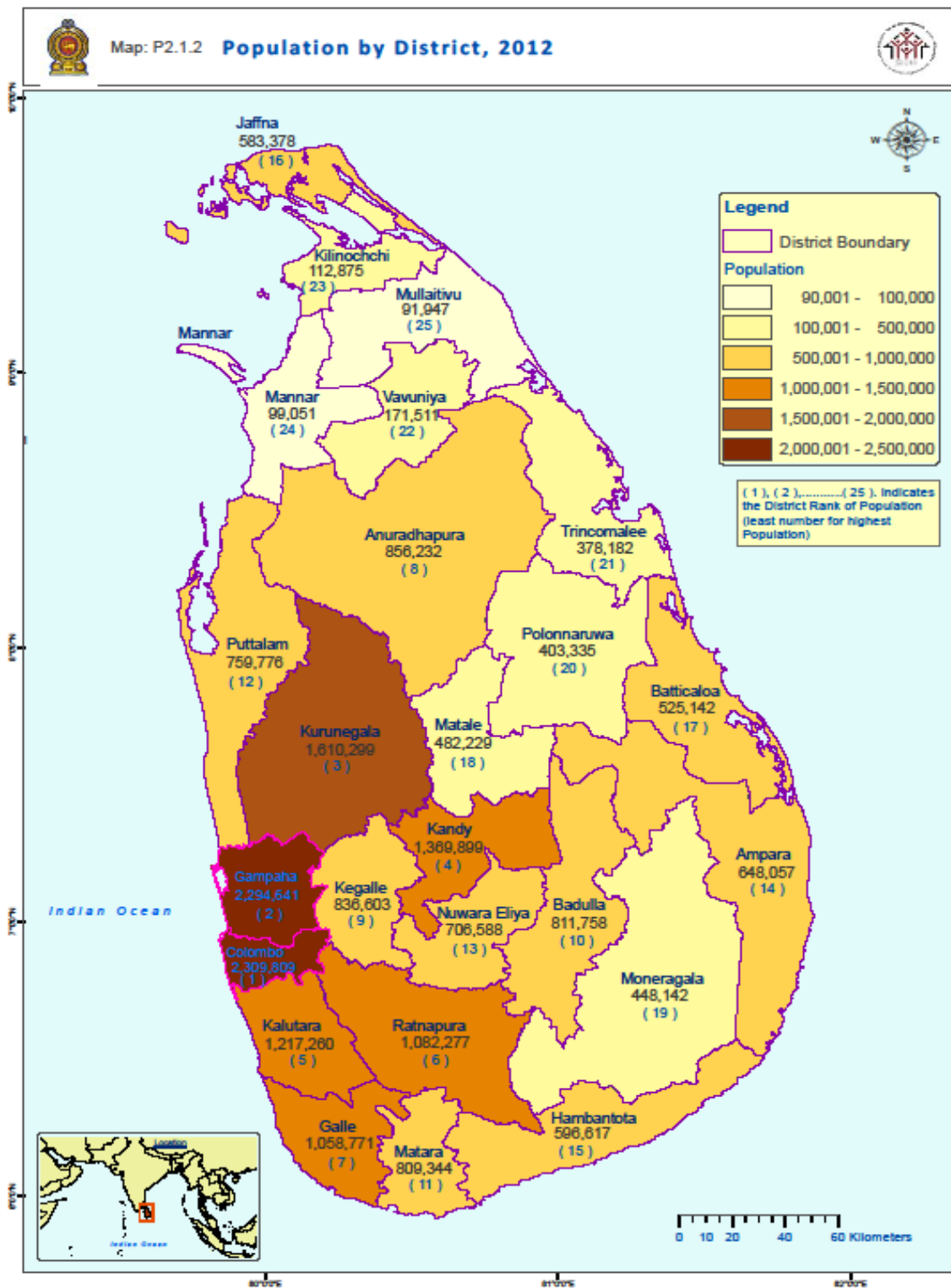
Figure 1 District map of Sri Lanka (Reference: Department of Census and Statistics Sri Lanka)
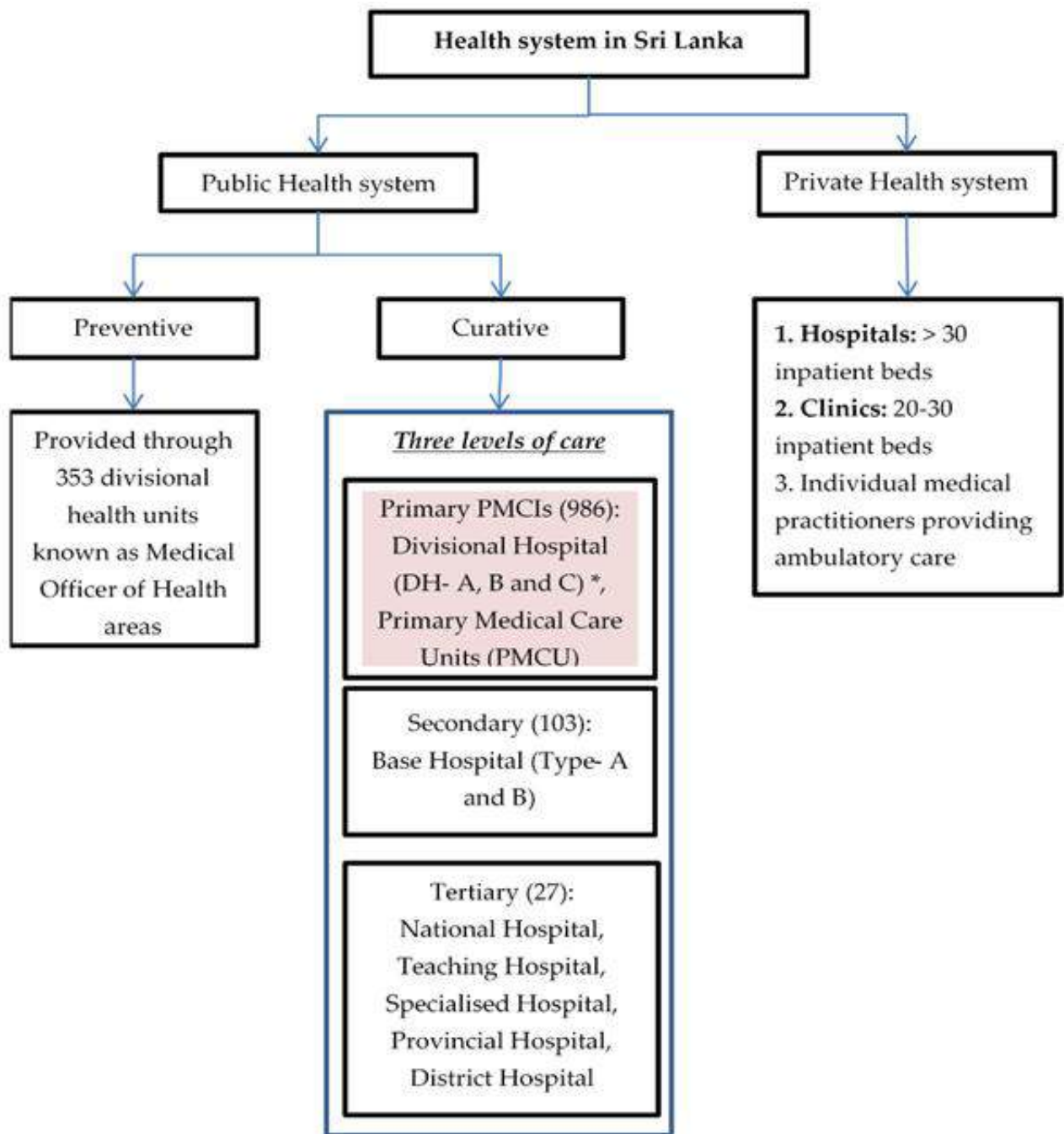
Figure 2 Health Care System in Sri Lanka

Health system and eye care service provision in Sri Lanka

Healthcare institutions are under the regulation of the Ministry of Health (MoH) centrally and Provincial Ministries regionally. Curative health services are delivered by secondary and tertiary level institutions across the island, which are strengthened by an exemplary network of primary level healthcare institutions under the Department of

Health Service.[11] There are 87 specialist ophthalmologists appointed in Government hospitals island wide. Among them, 62 General Ophthalmologists, 13 Vitreoretinal Surgeons, 5 Pediatric Ophthalmologists, 5 Cornea Specialists, 2 Orbit and Oculoplastic Surgeons, provide services in eye care in the country. There is a mal-distribution of ophthalmology specialist services according to the population density in individual provinces.

The public sector healthcare institutions provide free eye care to the nation. The "Vision 2020" Country Program launched in Sri Lanka in the year 2007 in collaboration with the College of Ophthalmologists of Sri Lanka and MoH and covers five main area of blinding eye disease categories. These comprise of cataract, glaucoma, refractive errors and childhood blindness, diabetic retinopathy, and low vision[13].

Rationale for the study

The previous surveys on assessing blindness and visual impairment due to glaucoma in Sri Lanka are, the Kandy Eye Study and the National Survey of Blindness and Visual Impairment.[25] The Kandy Eye Study reported a prevalence of blindness of 1.1% based on best corrected vision definition, the latest National Blindness Survey reported a prevalence of blindness of 1.7% based on the WHO definition of presenting vision among the population aged 40 years and above.[16] Glaucoma accounted for 2.1% of the causes for blindness as identified in the National Survey. However, there is a paucity of evidence on prevalence at population level and risk factors of glaucoma in Sri Lanka to implement and develop health care strategies at national level programme. Such local data are crucial for development of strategic plans for early identification and best management of glaucoma in order to optimize the quality of life of Sri Lankan population.

Presently global figures have been utilized to develop health care strategies as well as to format guidelines on management of glaucoma in Sri Lanka. Therefor it is utmost importance to have our own national data. Therefore, **Glaucoma Interest Group of the College of ophthalmologists of Sri Lanka** conceptualized and initiated this "**National Survey of Assessing the Prevalence and Risk factors for Glaucoma**" in December 2019 with guidance and collaboration of Ministry of Health and Vision 2020 Country Program of Sri Lanka. This survey was planned with the intention of exploring the variability of the prevalence of blindness across the country to organize the service delivery according to population requirements and maximally utilize the available resources to improve access to glaucoma services.

Purpose of the study and description of the condition

Glaucoma is a leading cause of visual impairment and blindness in the world. It may be classified by structural optic nerve damage resulting in functional visual field loss. The main identified modifiable factor is level of intraocular pressure. Glaucoma optic neuropathy is irreversible, and therefore detection at an early stage and proper management is the only way to prevent debilitating visual loss. Due to the asymptomatic nature of the disease most cases are detected late.[18] The barriers to access glaucoma services include lack of awareness about glaucoma, asymptomatic nature of the disease, difficulty in access to the eye care facilities, and lack of a single simple test to identify people with glaucoma at primary care level. Accordingly, a national level survey was inferred to be advantageous to identify the prevalence and nature of glaucoma in Sri Lanka. Additionally, it was presumed to be beneficial in developing future population-based glaucoma screening programmes in a regular manner among high-risk groups.[18] A significant proportion of undiagnosed glaucoma patients will subsequently end up with considerable visual loss which poses a major socio-economic burden due to the irreversibility of their visual disability. Thus, it is appropriate to explore the possibility of population-based glaucoma screening for early detection of glaucoma and identifying glaucoma suspects who need regular lifelong follow up.[18] We are planning to propose, developed screening strategies to be incorporated in to National NCD Screening Programs under the Ministry of Health.

As the risk of optic nerve damage from glaucoma is lessened by early detection and treatment, it is always beneficial when identify the diseases at an early age. With the rise of the aging population, there will likely be a rise in glaucoma prevalence and glaucoma blindness, which will add to the financial and social burden of the country.[20] Considering all these factors it is appropriate to start screening for glaucoma at an early age such as 40 years which coincides with the time people feel the need for visual checkup for presbyopia. This provides and avenue to identify-glaucoma suspect and treat them early to prevent sight loss.

Population-based data are important, as evidence-based eye care planning for glaucoma had never been performed as a nationwide program in Sri Lanka. The results of the National Glaucoma Survey will demonstrate what measures are needed to implement in order to control visual impairment and blindness and to improve the quality of life in the population as well as to plan effectively. The use of scarce resources (i.e. human, financial, infrastructure, and equipment).[21]

AIMS AND OBJECTIVES

Overall Aim

To determine the prevalence of Glaucoma and Glaucoma Suspects in Sri Lankan population aged 40 years and above, to provide evidence for implementation of a national screening program to identify them in early stage of the disease which is the only way to control blindness and visual impairment due to glaucoma.

Specific Objectives

1. To determine the demographic and other physical comorbidity risk factors associated with glaucoma in the Sri Lankan population aged 40 years and above.

2. To determine the prevalence of primary open angle glaucoma, angle closure glaucoma and secondary glaucoma.

3. To provide local contextual evidence for program planning and implementation, towards greater coverage of diagnosis and effective treatment, to reduce the burden of visual impairment and blindness due to glaucoma in Sri Lanka.

METHODOLOGY

Study design

A population based descriptive study was conducted in a randomized selected sample from voters list according to the population density.

Study setting

The assessment of prevalence and risk factors of glaucoma was conducted as a national survey, covering all nine administrative provinces by physical participation, of the sample and the data collecting research team.

Study period

The data collection of the survey was planned for a period of one year but extended from December 2019 to March 2022 because of the Covid-19 pandemic and health restrictions.

Study population

The study population (aged 40 years and above) were selected from 62 *Grama Niladari* (Village Head officer - GN) division out of 25 Districts.

Inclusion criteria

Any Sri Lankan citizen aged 40 years and above who registered in the Electoral Register.

Exclusion criteria

People who could not participate physically at the data collection center on the given date and time.

Sample size calculation

In the absence of adequate data on the prevalence of Glaucoma in Sri Lanka, available evidence from the South Asia region was used for the sample size calculation.

The required sample size (n) was calculated using the following formula (Lwanga and Lemeshow 1991); $[N=z^2 (1-p)/d^2]$

z - Critical value of specified confidence. z is considered as 1.96 at 95% confidence interval

d - Absolute precision required on either side of the proportion (0.025)

p - Prevalence of Glaucoma among the population ages 40 years and above. This was estimated based on a meta-analysis of population-based prevalence studies done in Asia, which estimated the prevalence of Glaucoma to be 3.5%. Therefore, p was considered 0.35.

Therefore, n = 1.96 x 0.35 (1-0.35) / 0.025^2 = 1398 (which was rounded off to 1400)

To minimize the effect due to 'clustering' in the sampling technique this sample size was multiplied by a design effect of 2 (Moser and Kalton, 1971).

n = 1400 x 2 = 2800

The final sample size was calculated allowing for a 10% non-response rate,

N = 2800 + 280 = 3080

Rounding off, a sample size of 3100 subjects was decided on. However, the collected sample was exceeded the calculated sample due to satisfactorily high participation.

Sampling technique

Multistage cluster randomized sampling was carried out to obtain a sample that was representative of the total population aged 40 years and above.

Sampling was carried out in several stages. In the first stage, primary sampling unit (PSU) were selected. In this study, a PSU was taken to be a *Grama Niladari Division* (GND), with 60 subjects to be taken from each GND totaling 3820, based on the practical feasibility of obtaining the required sample. To obtain the required sample size of a total of 62 GNDs were selected, proportionate to the population of each province (Table 1). Population figures were taken from the 2012 census data obtained from Department of Census and Statistics of Sri Lanka.[28]

Table 1 Allocation of Grama Niladari Divisions per province based on the population

Province	Population	%	Allocated PSU's (GND's)	Number recruited
Western	5,851,130	28.7	18	940
Southern	2,477,285	12.2	8	408
Eastern	1,555,510	7.6	5	282
Northern	1,061,315	5.2	3	166
North Central	1,266,663	6.2	4	260
Northwestern	2,380,861	11.7	6	378
Sabaragamuwa	1,928,655	9.5	6	301
Uva	1,266,463	6.2	4	229
Central	2,571,557	12.6	8	302
Total	**20,359,439**	**99.9**	**62**	**3266**

In each province, the required number of GND was selected based on the probability proportionate to the size (population) of each province. A list of GND divisions with cumulative populations were prepared for each province; and sampling intervals were

calculated for each province (Table 2). A random number less than the sampling interval for a particular province was generated using a random number generator, and the first GND to be selected was the GND whose cumulative population included that random number. Subsequent GNDs were identified by adding the sampling interval for that province to the random number, and so on.

Table 2 Sampling intervals used in each province, proportionate to the population

Province	Sampling interval
Western	325062
Southern	309661
Eastern	311102
Northern	353772
North Central	316666
North Western	340123
Sabaragamuwa	321443
Uva	316616
Central	321445

From each identified GND, 50 participants were selected using the Electoral Register as the sampling frame. The Electoral Register (voters' list) was last renewed in 2016 and can be considered as a satisfactorily updated list. In the voters' list households are arranged according to roads. A road was randomly selected by dropping a pin on a map of the GND. Having selected a road, the first person living on that road (based on the voters list) who was aged 40 years or above was selected. Subsequent participants were chosen by systematic sampling, where every fifth person who was aged 40 years or above was systematically chosen.

Identified subjects were stratified by gender to make sure that representative proportions from both genders were selected.

The Pilot Study

A pilot study was carried out in December 2018 in four GNDs in the Galle district, Southern province. The GND were randomly selected from the list of GND in Galle district and were excluded from the sampling frame used in the proper study.

Figure 3 Pilot study Galle district

Data collection was carried out using a study instrument consisting of four sections. The first three sections, consisting of basic socio-demographic data by a trained research assistant, past medical history, and ocular history, were collected by a Medical Officer. Clinical Examination of the eye done by well-trained medical officer assisted by principal Investigator. Fundus photographs were taken by well-trained technical officer (Research Assistant). All data were entered to the software for further analysis Section A was ascertained from the participant through an interview. Identification of the status for variables under past medical history (Section B) and ocular history (Section C) were done by reviewing medical records of the participants (Appendix 1- please find in separate attachment).

In Section D, determining the presence of Glaucoma by the characteristic pattern of damage to the optic nerve head was undertaken in accordance with the International Council of Ophthalmology (ICO) guidelines[2]. Fundus photographs were captured using a hand-held retinal camera for a detailed analysis of the optic disc and macula. Glaucomatous optic neuropathy was recorded as per optic disc changes which

include, a large **vertica**l Cup to Disc ≥ 0.7 (VC:D) and disc and significant Glaucoma optic neuropathy signs such as disc hemorrhage, and departure from the ISNT rule, focal nerve fiber layer defects, polar notching, beta zone atrophy, VC:D asymmetry more than 0.2.[8] These disc signs were analyzed by using fundus images.

In this study, all individuals were screened for visual acuity, tonometry, pachymetry, detail slit lamp examination and indirect ophthalmoscopy as per ICO guidelines[8].

Fundus photos analysis was done by the principal investigator and the data were entered by co-investigator.

According to the ICO guidelines, the **criteria used to diagnose glaucoma** in a participant were,

1. Criteria 1- Intraocular pressure > 21 mmHg
2. Criteria 2- Vertical C:D - 0.7 and or more
3. Criteria 3- Features of glaucomatous optic neuropathy signs (Figure 4). Discs were classified into small (<1.6 mm^2), average (1.6-2.6 mm^2) and large (>2.6 mm^2).[29]
4. Criteria 4- C:D Asymmetry of more than 0.2.[3]
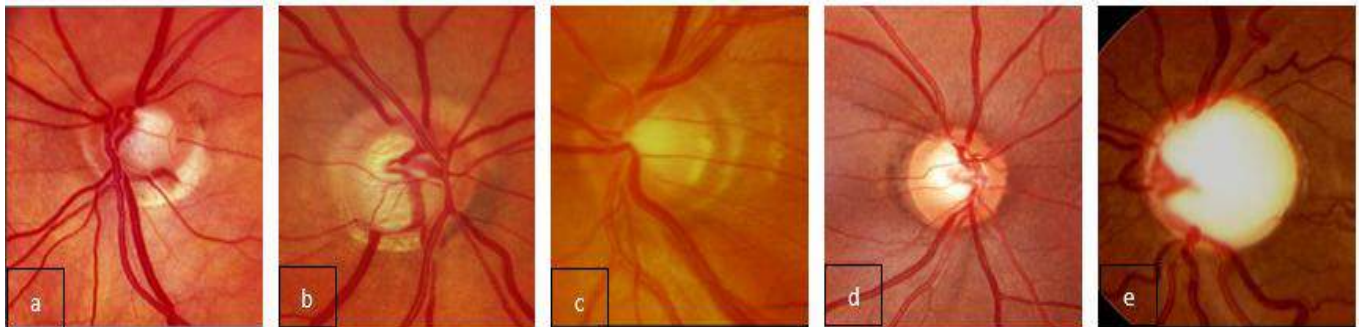
Figure 4 a) Disc hemorrhage; b) Inferior rim thinning; c) Focal nerve fiber loss; d) superior rim notching; e) beta zone atrophy and diffuse nerve fiber loss

If only **one criterion** out of the above given 4 criteria was present the patient was labelled as a **'Glaucoma Suspect'**. If **two criteria** out of the above given 4 criteria were present the patient was labelled as '**Glaucoma Diagnosed'**.

Outcome results of Visual field reports had so many errors and considered as majority were not reliable (poor subjective responses because there were no ideal settings for the test at the data collecting centers). Therefor results of visual field test were excluded from the diagnostic criteria.

Associated retinal comorbidities were identified by clinical examination and at fundus photo analysis.

Central corneal thickness (CCT) was measured by a hand-held pachymeter to analyze any correlation of CCT with the glaucoma suspect or diagnosed cases.

Patients who were suspected or diagnosed as glaucoma were referred for further specific investigations like gonioscopy, Humphry visual fields analysis, OCT imaging to the closest eye care unit in a government hospital which is manned by a consultant ophthalmologist.

Ethics approval

Ethical approval was obtained from the Ethical Review Committee, National Eye Hospital, Colombo, Sri Lanka. (ERC/NEH/2018/43)

Data collection

Ground planning for the selection of sample was done by the co-investigator (AC) and a research assistant by communicating with the relevant Grama Niladhari (Village Head) of the randomly selected cluster (GND). The list of selected participants (based on the voters list) was given to the regional public health midwife, who visited their houses. Public health midwife gave a brief self-introduction and explained the purpose of the study to the participants and made them aware about glaucoma by distributing an awareness leaflet (Figure 5). If a selected participant was not at home on the day of sample collection, the data collectors returned to the house on another day. If the participant was not at home on the third consecutive visit, another person who are

falling with in the inclusion criteria was included to this survey.

Figure 5 Public awareness leaflet

The people of the selected sample were given a brief introduction of importance of the survey and procedure of the data collection (Figure 6a). Written informed consent was obtained from all the participants while registering them for this survey (Figure 6b).

Figure 6 a) Briefing the program; b) Registration

Data for section A, the demographic data were collected by trained research assistants, who are graduate officers (Figure 7). The research assistants underwent comprehensive training provided by the principal investigator.

Figure 7 Demographic data collection

Two Medical officers collected the data on clinical history and ocular history (Figure 8a). Medical officer of eye did the relevant clinical examination of the eye (Figure 8b).

Figure 8 Clinical Data Collection a) Principal Investigator b) Medical Officer

Figure 9 Fundus photography using hand-held digital retinal camera

Fundus photographs were taken (Figure 9) and stored as soft copies by a well-trained technical officer (research assistant) for detailed analysis.

Figure 10 Visual Acuity testing

Visual acuity testing (data sheet section D 17 and 18) and drop instillation were done by Volunteered Research assistants, a nursing officer and a minor Staff (Figure 10). Measurement of Central Corneal Thickness (Figure 11a) and Intra Ocular Pressure readings (Figure 11b) were done by two research assistants who are trained technical officers.
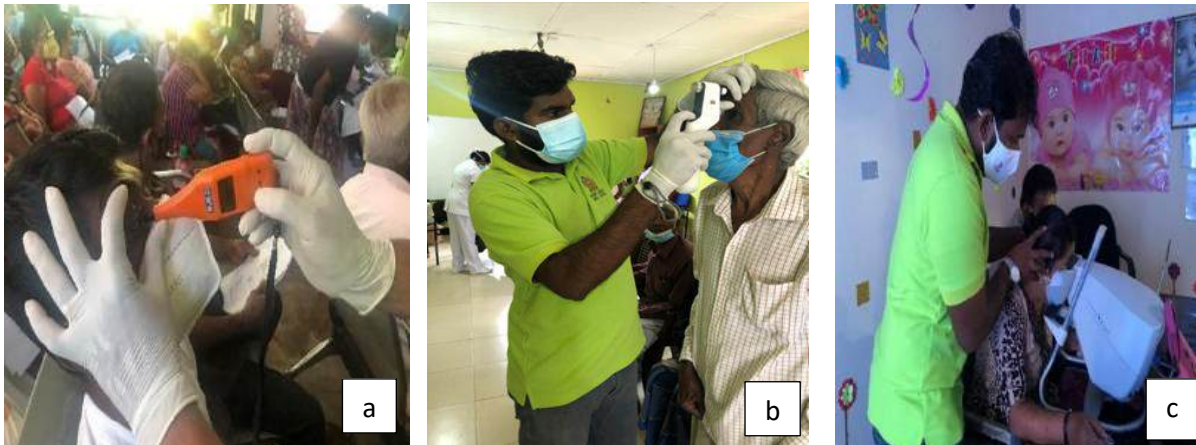
Figure 11 a) measuring CCT; b) Measuring IOP; c) Visual field testing

Participants who had glaucoma clinical signs or other ocular comorbidities which were confirmed by principal investigator on site were referred to the closest eye care unit for further investigation and management.

Data entry and analysis

Data were entered into Microsoft Excel (Version 2308-July 2022) data sheets by research assistants. Fundus photo analysis data were confirmed and entered by the principal investigator and by research assistant. Analysis of the data was carried out using SPSS statistical software (Version 25) by a statistician. Relevant descriptive statistics and associations were calculated based on the primary data.

Ethical issues and administrative requirements

Ethical clearance to conduct this study was obtained from Ethic Review Committee National Eye Hospital of Sri Lanka. The study was conducted through Teaching Hospital Karapitiya as the coordinating center.

Participants were assured that their participation in the study was voluntary and only for those over 40 years of age and that they were free to withdraw from the study at any point. They were also assured that if they chose not to participate, or to withdraw from the study, it would not adversely affect their access to health services in the future.

No details pertaining to intimate issues of subjects were obtained except basic socio-demographic characteristics. No information leading to personal identification were extracted, and therefore posed minimal risk of breaching the confidentiality of participants. Confidentiality and anonymity of the data set was maintained throughout the survey.

The concept of *"Tender Loving Care"* (TLC) approach was followed during data collection and investigations, and every possible step was taken to minimize discomfort and errors.

The participants benefited from taking part in the study by undergoing a free detailed eye check-up and through other investigations. Appropriate follow up was arranged in the eye units of nearest Government (Public Sector) Hospital for those participants suspected or diagnosed with glaucoma or any other eye condition needing treatment. Meanwhile patients and family received a health education awareness on glaucoma.

Administrative clearance for this study was obtained from the relevant authorities (District Secretariats of selected Districts) and support for the research was obtained through the DGHS, Deputy Director General Public Health Services and Deputy Director General Non-Communicable Diseases of the Ministry of Health, Sri Lanka, as well as the Glaucoma Interest Group of College of Ophthalmologists and Vision 2020 country program in Sri Lanka.

RESULTS

Demographic profile of the survey sample

Most of the survey sample (n=1891, 59.4%) was female and belonged to the age group of 50-59. Mean age was 58.7 years with a SD of 10.0. This age and sex distribution differed from the age and sex distribution in the country and thus the interpretation of the finding was done cautiously. Most of the participants were from the rural areas (n=2503, 82.5%) followed by urban and estate sector participants (15.4% and 2.1% respectively). Majority were Sinhalese 85.1% while Tamils 13.5% and Muslims 1.3% represented the rest. The following Table 3 summarizes basic demographic characteristics of the survey sample.

Table 3 Basic demographic characteristics of the participants

Characteristic	Frequency	%
Gender (missing data n=80)		
Male	1295	40.6
Female	1891	59.4
Total	3266	
Age category (missing data n=30)		
Age 39	8	0.2
40-49	694	21.5
50-59	1039	32.1
60-69	954	29.5
70-79	485	15.0
80-89	54	1.6
90-99	2	0.1
Total	3266	
Sector (missing data n=233)		
Estate	64	2.1
Village	2503	82.5
Urban	466	15.4
Total	3266	
Ethnicity (missing data n=43)		
Sinhala	2744	85.1
Tamil	436	13.5

Muslim	42	1.3
Burghers	1	0
Total	3266	

Socio-economic characteristics of the sample

More than three forth (n=1931, 77.6%) were married and majority of the sample had been educated up to GCE Ordinary Level (n=1037 32.2%). Average monthly income was below LKR 30,220 for most of the participants (n=2334, 72.8%). Nearly half of the sample were unemployed (n=1537, 47.5%) and 17.1% of participants had retired from their jobs. Table 4 describes socio-economic characteristics of the survey sample.

Table 4 Basic socio-economic characteristics of the participants

Characteristic	Frequency	%
Marital status **(missing data n=778)**		
Married	1931	77.6
Unmarried	69	2.8
Widowed	488	19.6
Total	3266	
Level of education **(missing data n=45)**		
No schooling	79	2.5
Primary	576	17.9
Secondary	834	25.9
GCE (O/L)	1037	32.2
GCE (A/L)	612	19.0
Degree and above	83	2.6
Total	3266	
Average monthly income **(missing data n=61)**		
LKR <30,220	2334	72.8
LKR 30,220 -69,880	809	25.2
LKR >69,880	62	1.9
Total	3266	
Employment status **(missing data n=32)**		

Employed	1144	35.4
Unemployed	1537	47.5
Retired	553	17.1
Total	3266	

General health status and health related behaviors

Analysis of co-morbidities of the population showed more than 35% (n=1212 37.1%) is having hypertension and nearly 1/5th of the population was having diabetes and dyslipidemia (n=718 22% and n=688 21.1% respectively). Nearly two percent of participants reported to be partaking alcohol consumption and smoking. Table 5 and 6 summarize general health status and health related behaviors.

Table 5 Prevalence of systemic co-morbidities of participants

Co-morbidity (N= 2905, missing data n= 361)	Frequency	%
Diabetes	718	22
Hypertension	1212	37.1
Dyslipidemia	688	21.1
Ischemic heart disease	174	5.3
Renal disease	42	1.3
Steroid treatment	71	2.2

Table 6 Health related behaviours of participants

Health related behavior (N=3266)	Frequency	%
Consumption of alcohol		
Yes	56	1.7
No	3210	98.3
Smoking		
Yes	54	1.7
No	3212	98.3

History of eye diseases and family history of glaucoma

One third of the participants (n=1080, 33.7%) had undergone some form of glaucoma screening and nearly eight percent (n=260, 8.1%) had had cataract surgery. All other ophthalmological conditions reported less than one percent among survey participants. Table 7 describes history of eye diseases and family history of glaucoma

Table 7 History of eye diseases and family history of glaucoma

Characteristic	Frequency	%
History of anti-glaucoma medication (missing data n=71)		
Yes	24	0.8
No	3137	99.2
Total	3266	
Had previous glaucoma screening (missing data n=59)		
Yes	1080	33.7
No	2127	66.3
Total	3266	
Had cataract Surgery with IOL (missing data n=64)		
Yes	260	8.1
No	2942	91.9
Total	3266	
History of surgery trabeculectomy (missing data n=74)		
Yes	4	0.1
No	3188	99.9
Total	3266	
History of penetrating keratoplasty (PKP) (missing data n=77)		
Yes	8	0.3
No	3181	99.7
Total	3266	
Family history for glaucoma (missing data n=77)		
Yes	18	0.6
No	3171	99.4
Total	3266	

Visual acuity

Nearly quarter of the survey sample (24.1% in right eye and in left eye) had normal visual acuity of six by six for both eyes. However around 15% were found to have visual acuity of 6/12, 6/18 and 6/24. Table 8 describes the visual acuity of both eyes.

Table 8 Visual acuity

Visual acuity	Right eye (missing data n=16)		Left eye (missing data n=17)	
	Frequency	**%**	**Frequency**	**%**
6/6	788	24.1	787	24.1
6/9	298	9.1	325	10.0
6/12	538	16.5	505	15.5
6/18	460	14.1	448	13.7
6/24	540	16.5	582	17.8
6/36	220	6.7	210	6.4
6/60-4/60	191	5.8	189	5.8
3/60- CF	97	3.0	101	3.1
HM	81	2.5	73	2.2
PL	14	0.4	15	0.5
NPL	13	0.7	14	0.5
Total	3266		3266	

Intra ocular pressure (IOP)

Intraocular pressure was assessed for both eyes separately. Mean IOP in right eye was 12.99 (SD: 5.69). Figure 12 is the histogram for the distribution of IOP in right eye

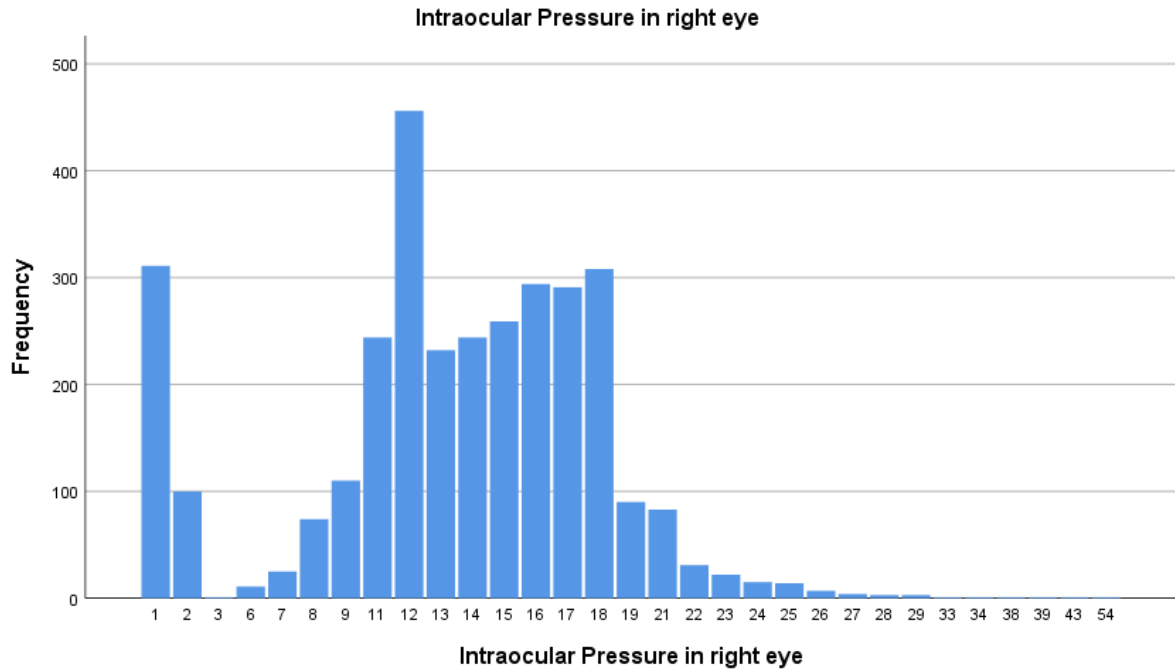**Figure 12 Histogram for distribution of IOP in right eye**

Mean IOP in left eye was 13.61 (SD: 5.83) and Figure 13 is the histogram for the distribution of IOP in left eye.
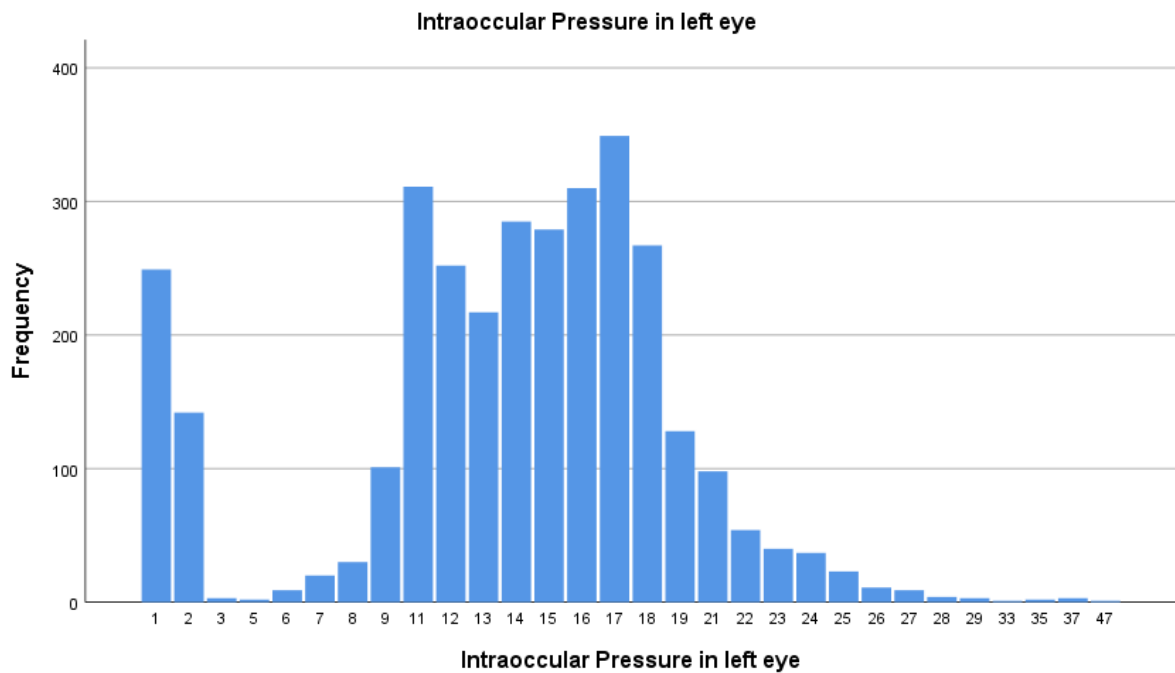

Figure 13 Histogram for distribution of IOP in left eye

IOP was categorized according to the standard categorization. For the right eye there were 3.2% of participants (n=105) with glaucoma level IOP whereas there were

5.8% (n=188) participants with glaucoma level IOP for the left eye. Table 9 summarizes categories of IOP for right and left eyes.

Table 9 Categories of IOP for right and left eyes

IOP	Right eye (missing data n=28)		Left eye (missing data n=26)	
	Frequency	%	Frequency	%
< 12	876	27.1	867	26.8
12 – 15	1191	36.7	1033	31.8
16 – 18	893	27.6	926	28.6
19 – 21	173	5.4	226	7.0
>21	105	8.6	188	5.8
Total	3266		3266	

Anterior chamber depth (Van Herick grading)

Majority (right eye - 88.9%, left eye - 87.8%) of the participants had Van Herick grading of three and four which is categorized as open angle and around 12% of them had narrow angle. Table 10 summarizes the type of glaucoma according to anterior chamber depth assessed by Van Herick Grading

Table 10 The type of glaucoma according to anterior chamber depth assessed by Van Herick Grading

Van Herick Grading	Right (missing data n=39)		Left (missing data n=41)	
	Number	%	Number	%
Open	2839	88.9	2830	87.8
Narrow	288	12.9	395	12.2

Glaucoma related anterior segment findings

Pseudoexfoliation was the commonest anterior segment finding related to glaucoma and it accounts for 1.3% among positive findings in both right and left eyes. Table 11 describes positive glaucoma associated findings in the anterior chamber.

Table 11 Glaucoma related anterior segment findings

Clinical Sign (n=3266, missing data n= 246)	Right		Left	
	Number	%	Number	%
Pseudo exfoliation	40	1.3	38	1.3
Traumatic and surgical Iris atrophy	27	0.9	20	0.7
New vessels	2	0.1	1	0.0
Peripheral Iridotomy	4	0.1	2	0.1

Disc size and vertical cup to disc (VCD) ratio

Table 12 describes the frequency and percentage of C:D ratios. Majority had C:D ratios of 0.5 while there were around 200 of the sample had C:D ratios that are compatible with diagnosing as glaucoma.

Table 12 Vertical cup to disc (C:D) ratio

CD ratio (n=3266)	Right eye (missing data n=146)		Left eye (missing data n=128)	
	Frequency	%	Frequency	%
0.1	0	0.0	1	0.0
0.2	28	0.9	34	1.1
0.3	270	8.7	246	7.8
0.4	705	22.6	764	24.3
0.5	1333	42.7	1347	42.9
0.6	590	18.9	548	17.5
0.7	161	5.2	171	5.4
0.8	27	0.9	21	0.7
0.9	6	0.2	6	0.2

Central corneal thickness

More than half of the people were in the 501-550 mm category of corneal thickness. Figure 14 and 15 describes the categories of corneal thickness.
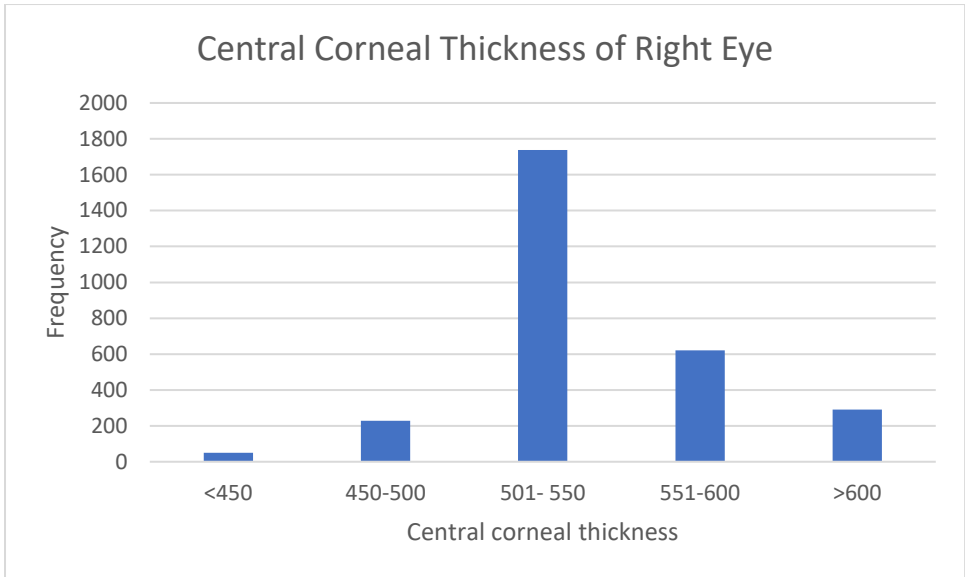
Figure 14 Central Corneal Thickness of Right eye
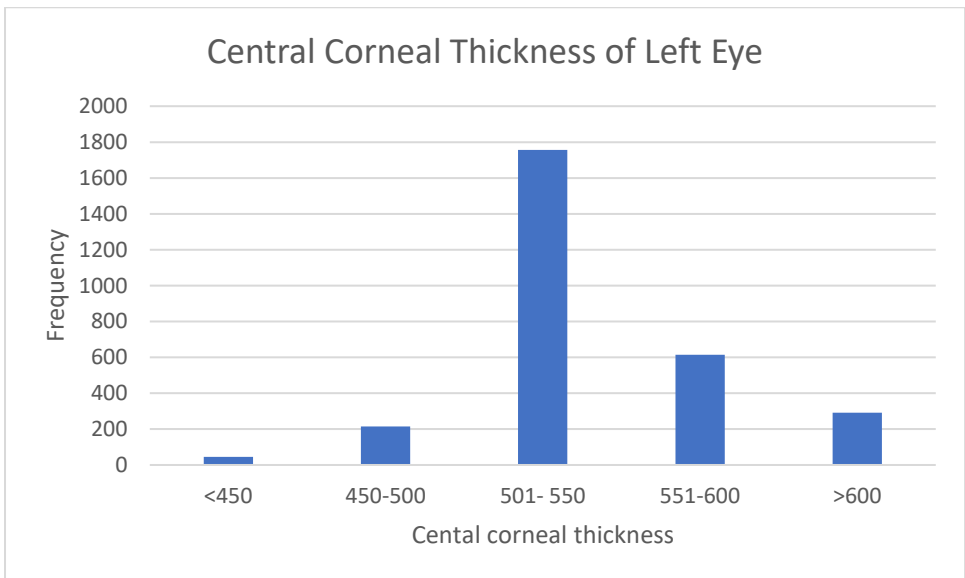
Figure 15 Central Corneal Thickness of Left Eye

Abnormal signs

Polar notching was the commonest abnormal finding noted in the disc examination followed by diffuse nerve fiber layer loss and beta zone atrophy. Table 13 summarizes glaucoma disc signs in right and left eyes.

Table 13 Presence of Glaucoma Disc signs

Disc signs	Right (n=69)		Left (n=87)	
	Frequency	%	Frequency	%
Polar notching	28	40.6	42	48.3
Diffuse nerve fiber layer defect	21	30.4	24	27.6
Focal nerve fiber layer defect	21	30.4	20	23.0
Beta zone atrophy	6	8.7	6	6.9
Disc haemorrhage	2	2.9	0	0
LDS (Lamellar Dot Sign)	1	1.4	2	2.3
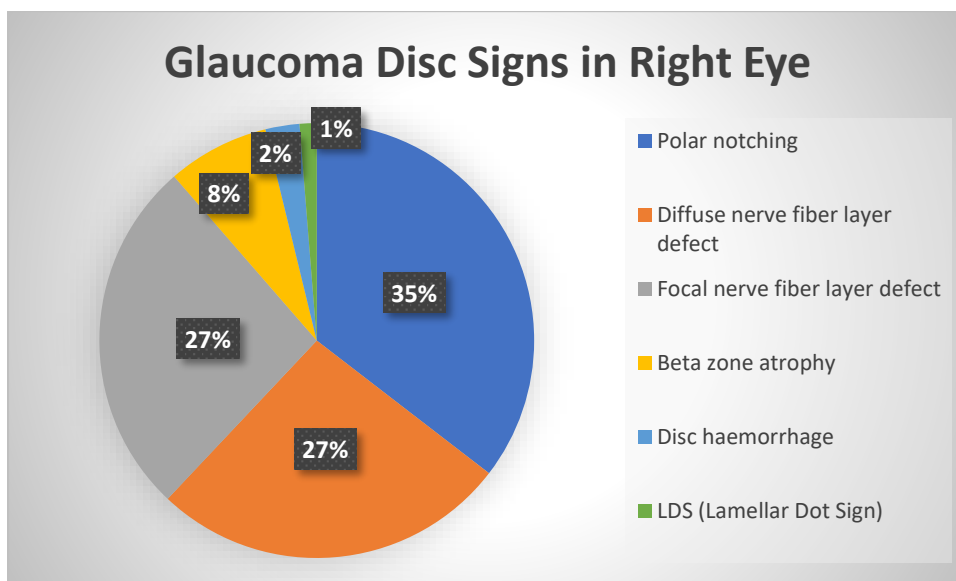
Figure 16 Glaucoma Disc Signs of Right Eye
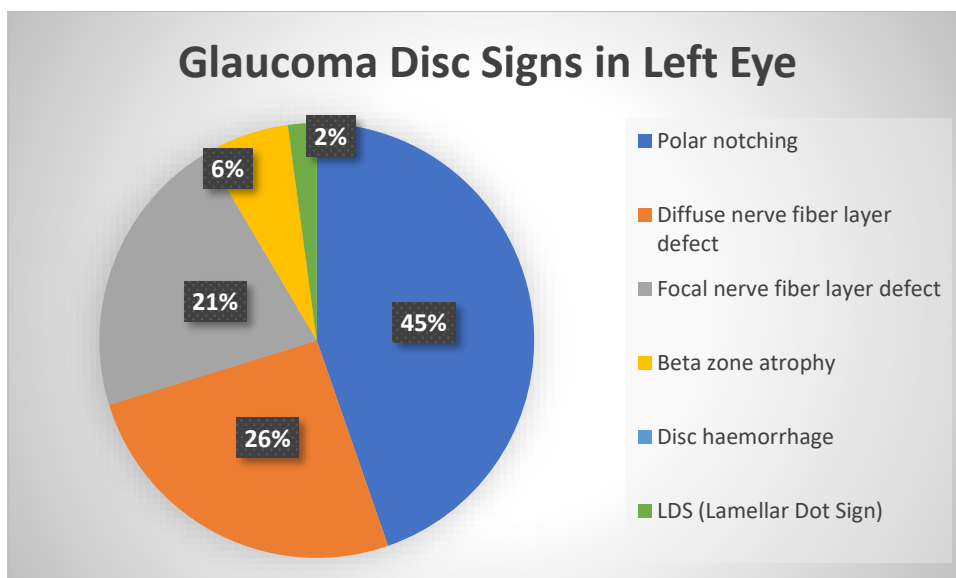
Figure 17 Glaucoma Disc Signs of Left Eye

Associated comorbidities

Table 14 Associated Retinal comorbidities with glaucoma

Comorbidity	Right	Left
DR	33	38
RVO	2	6
RAO	1	1
ARMD	20	20

Glaucoma prevalence

123 (3.8%) were diagnosed as having glaucoma. 113 (3.45%) of these were diagnosed as having primary glaucoma while 13 (0.4%) were secondary glaucoma. Of the 113 patients with primary glaucoma, 43 patients had primary glaucoma in both eyes while 26 had it only in the right eye and 44 had it only in the left eye. Therefore, there were 69 right eyes and 87 left eyes (total of 156 eyes) fulfilling the diagnostic criteria for primary glaucoma while 70 eyes did not fulfil the diagnostic criteria for glaucoma among these 113 patients. There were 145 subjects (4.43%) with risk factors for secondary glaucoma and 13 (0.4%) of them fulfilled the criteria to diagnose glaucoma. Of them, six had secondary glaucoma in both eyes while four had it only in the right eye and the other three had it only in the left eye.

Table 15 Prevalence of glaucoma among survey sample

	Right eye	Left eye	Both eyes	Total
Glaucoma suspected	293	337	146	484
Glaucoma confirmed	26	44	43	113

Central corneal thickness in glaucoma and normal participants

Central Corneal Thickness (CCT) showed no difference among Glaucoma diagnosed, Glaucoma suspected and normal groups. Table 16 shows median CCT with interquartile range for each eye between Glaucoma, suspected and normal groups.

Table 16 CCT among Glaucoma, suspected and normal groups

	Right eye	Left eye
Glaucoma diagnosed	546.0 (31.5) (n=60)	542.4 (36.1) (n=87)
Suspected	549.2 (47.4) (n=427)	548.4 (41.5) (n=427)
Normal	540.6 (41.5) (n=2604)	540.7 (40.9) (n=2542)

Table 17 Provincial breakdown of confirmed and suspected glaucoma cases and prevalence

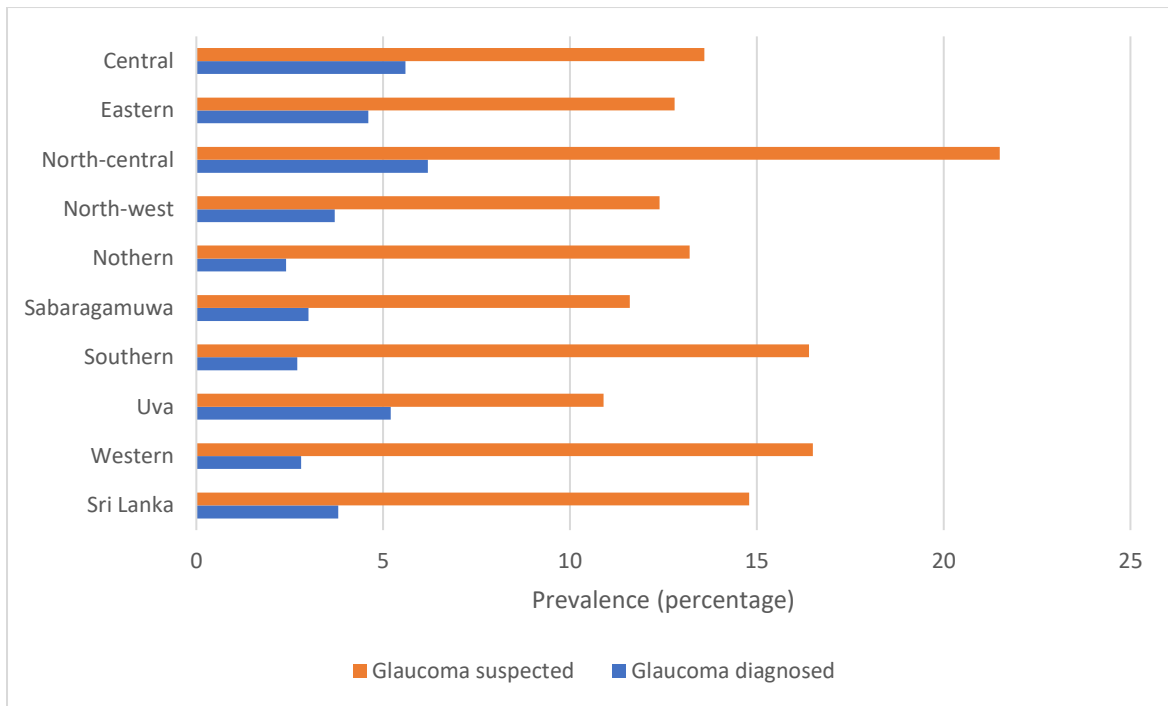|	Central	Eastern	North-central	North-western	Northern	Sabaragamuwa	Southern	Uva	Western	Sri Lanka (n=3266)
Suspected Glaucoma (n=)	41	36	56	47	22	35	67	25	155	**484**
Suspected Glaucoma (%)	8.5	7.4	11.6	9.7	4.5	7.2	13.8	5.2	3.2	**14.8**
Glaucoma diagnosed (n=)	17	13	16	14	4	9	11	12	27	**123**
Glaucoma diagnosed (%)	13.8	10.6	13	11.3	3.2	7.3	8.9	9.8	22	**3.8**

Figure 18 Provincial breakdown of confirmed and suspected glaucoma cases and prevalence

Discussion

This is the first national glaucoma prevalence survey conducted in Sri Lanka. This study provides valid scientific evidence on the burden of glaucoma at population level which will help planning delivery of services for diagnosis and management of glaucoma. The study was conducted from December 2019 to March 2022 covering all nine provinces of the country. It took slightly longer than expected to complete the study partly as a result of restrictions due to COVID-19 pandemic.

The glaucoma prevalence in the current study (3.8%) is nearly equal to the corresponding global glaucoma prevalence rates (3.54%). The prevalence of glaucoma-suspect persons is 14.8% in the current study while the prevalence reported in a previous study was slightly lower (10.1% in a study conducted in Bangladesh). Data on country-wide glaucoma-suspect prevalence is not available from any country. As no previous national prevalence study on glaucoma is available from Sri Lanka, comparison with past data was not possible. The commonest type of glaucoma was primary open angle glaucoma. Pseudo exfoliation was the commonest cause for secondary glaucoma in this study.

Findings of this study can be used to develop health strategies to prevent visual disability and blindness due to glaucoma in Sri Lanka and in other similar settings. As this study was conducted on a meticulously drawn, nationally representative sample, findings can be extrapolated to the general population of Sri Lanka aged 40 years and above.

This glaucoma prevalence survey was conducted in 25 administrative districts using cluster randomized sampling. VOD division, which is the smallest administrative demarcation in the country was identified as the cluster. Essentially, each cluster is a mini representation of the entire population. Using voter's list (electoral register) as the sampling frame was a particular strength as the voter's list is considered as the most accurate and up to date adult population database in Sri Lanka. Using a well-defined clinical diagnostic criterion for glaucoma and glaucoma-suspect was a particular strength of the study. The equipment used in this study were standard and portable. Throughout the survey the same equipment and the same technical officers were employed to collect data. When there is a corneal irregularity, the IOP measurements and central corneal thickness measurements were unable to obtain. All subjects were clinically assessed and examined by a medical officer of Ophthalmology and a specialist in Ophthalmology (the principal investigator). Fundus photograph analysis was done by the principal investigator using the same computer settings throughout. When there is a media opacity due to cataract or corneal pathology, the fundus photograph data were not possible to obtain.

Most of this study population had primary open angle glaucoma which is an asymptomatic disease. The disease could only be diagnosed in its early stage by regular screening of the high-risk population. High risk people include age over 40 years, diabetes mellites, family history of glaucoma, High myopia, steroid users and

patients with ocular trauma and complicated eye surgery. The glaucoma prevalence increases with the rising elderly population as aging is the commonest cause for glaucoma. Furthermore, patients with risk factors for secondary glaucoma need special attention14. Identifying the glaucoma-suspects and following them up is also important as it will allow early diagnosis and management of this irreversible vision threatening disease.

As this study shows the national prevalence of glaucoma is very similar to global prevalence, it is important to try and implement the strategies used by other countries in the world for early detection of glaucoma15-17. Raising awareness of glaucoma among general population is very important in improving the early detection rates. Using mobile clinics with equipment and trained staff covering the well-established MOH office network of the country can improve the detection rates. With the increasing popularity of health insurance services in the country, an advertisement campaign for early detection of glaucoma through these services could be another practical approach.

Strengths of the survey

This is the first national glaucoma prevalence survey in Sri Lanka. All 25 administrative districts were covered by using cluster randomized sampling. As this study included a meticulously drawn, nationally representative sample, the study findings can be satisfactorily applied to the general population of Sri Lanka aged 40 years and above. GN division, which is the smallest administrative demarcation in the country was identified as the cluster. Essentially, each cluster is a mini representation of the entire population. Consequently, using GN division it was practically feasible and appropriate in obtaining a representative sample of the entire population

At the time of sample collection primary health care workers went to the doorstep of the individuals and meanwhile raised awareness of glaucoma among the families as well.

Using voter's list (electoral register) as the sampling frame was a particular strength as the voter's list is considered as the most accurate adult population data base in Sri Lanka. This is widely used in community-based studies as the sampling frame (Vote register). It was last renewed in 2016 and can be considered as a satisfactorily updated list. Easy accessibility and completeness are two of the favorable factors. The list is available with the GN, and information is arranged in an orderly manner, making it easier to locate a person in a given address. High participation rates were noted in almost all the district as people enthusiastically took part in the study.

Having objective and standardized criteria in determining the primary outcome was a particular strength. The diagnosis of glaucoma was clearly described in the methodology as three explicit criteria. In this study the diagnosis of glaucoma was based on: IOP >21mmHg, presence of abnormal optic disc as defined by vertical

C/D 0.7 with average disc size, C:D 0.8 in Large disc size and C:D 0.6 in small disc size or above, any optic disc changes compatible with glaucoma optic neuropathy such as notching of the neuro-retinal rim, disc hemorrhage, diffuse or sectoral nerve fiber loss and asymmetry of cup to disc ratio more than 0.2 between the two eyes.

The method used to measure Intra ocular pressure was rebound tonometry (iCare), which is one of the most accurate portable tonometer. Fundus photography was taken with dilated pupil to get an accurate value of C:D ratio. It was done with the same software, same fundus camera, same caliper by the same examiner (Principal Investigator) to minimize subjective variation. All subjects were clinically assessed and examined by MO Eye and the principal Investigator to record clinical data. To minimize both intra-observer and inter-observer variability each instrument was handled by an individual research assistant (allocated technical officer). Additionally, this risk was further minimized by following standard protocol. Timely calibrations were done for the instruments to ensure validity of measurements.

Employing the same team to collect data was a definite strength of this study. This ensured minimal inter-observer variation. Most of the critical variables of the study intraocular pressure, central corneal thickness, visual field analysis, and assessment of optic disc changes were assessor dependent as ascertainment of distinct variables were done by observation. Therefore, minimum observer variation became a critical issue to ensure validity of data.

Limitations

The lengthening of the study period is more than originally planned due to COVID pandemic and health restrictions.

Ascertainment of certain variables related to past medical history and past ocular history were dependent on participants self-declaration rendering the risk of recall bias inevitable. Though participants were requested to bring medical records, some of them did not bring any valid record. However, this information did not significantly impact the primary outcome of the survey.

Missing data is due to leaving the subject before completing the questionnaire or missed to enter to the data sheet by the data collectors/ research assistant.

Smart automated visual field analysis was done for subjects who had any glaucoma optic neuropathy features, and in subjects with C:D ratio above 0.6. Outcome of the results however were high on subjective errors in more than 50% hence it was excluded as a diagnostic criterion in this survey.

Conclusion

This is first National Survey concluded in Sri Lanka. Prevalence of glaucoma in Sri Lanka is closely similar the global prevalence. The commonest type is primary open angle glaucoma which is usually asymptomatic highlighting the necessity for active surveillance for early detection. Glaucoma-suspect prevalence of 14.8% is higher comparatively that of Bangladesh (10.1%).

The study shown, glaucoma and Glaucoma suspect prevalence increases with the age as well as the diagnosed diabetes and hypertension.

The result of this survey provides valuable information on the importance of diagnosis of glaucoma at its early stage and intervening on management to prevent glaucoma blindness in our country. Therefore, implementing a health strategy by incorporation as non-communicable disease category for regularize screening of all suspected people, helps in early diagnosis and prevent Glaucoma blindness. The findings from the survey can be extrapolated to the entire country as the sample was represented with the demographic characteristics of Sri Lanka.

There is a need for developing easily accessible, comprehensive screening and intervention programs to detect glaucoma-suspects who are at a high risk for developing glaucoma and to prevent or manage their ocular and systemic risk factors.

Recommendations

The number of Sri Lankan population affected by glaucoma is about 1.1 million people at present and the aging population will increase this substantially in the years to come, which needs taken into consideration when planning eye care services at national level.

This population-based study that reports glaucoma prevalence provide important information. The Sri Lankan population has considerable risk for POAG with the additional risk of angle closure disease as well as secondary glaucoma especially the pseudo exfoliative syndrome highly associated with increasing age. This assumes greater importance as the risk of all forms of glaucoma increases substantially with age. Most of the Sri Lankan population is less than 40 years of age. With increasing life expectancy, the number of those at risk of glaucoma will grow exponentially over time.

Improving our case detection rates is of utmost importance if we are to make an impact on the burden of disease in the country. Though our country has very good health care system still the majority of glaucoma in Sri Lanka is hidden and undiagnosed until its late stages of the disease which causes irreversible blindness. There is an urgent need to adopt comprehensive eye examinations in high-risk population, which include IOP measurement, gonioscopy and optic disc evaluation with fundus-copy, as a routine. Early detection and cost-effective, safe, and early interventions are needed to minimize the impact that glaucoma could cause on our aging population.

In the light of the existing manpower and resource constraints, we evaluate options for improving case detection rates in the country and recommend the following.

- Regular Sustainable Community outreach screening programs linked with secondary and tertiary level specialists eye clinics for the entire population above age of 40years. This should be centrally coordinated by NCD Unit MOH and the PSSP project in a regular manner.

- Implement a proper primary screening method to detect glaucoma suspects at primary care level

- If there is a resource scarcity, simple, cost-effective, and feasible screening criteria should be introduced with the basic screening equipment.

- A Proper referral system should be introduced to the people who are labelled as Glaucoma and Glaucoma suspected individuals with missing or failure to attend for clinical care and follow up.

- Locally validate structural and functional assessment tests which are the gold standards to identify the clinically diagnosed patient for further follow up and for glaucoma suspects for confirmation of diagnosis.

- Provision of equipment for glaucoma diagnostic tests at least for provincial and tertiary level and eye care units.

- Capacity building should be done to develop awareness about initial presentations and screening of glaucoma for primary care medical staff to detect the high-risk group. This can be incorporated with National NCD program such as HLC screening or PSSP population screening

- Detect the barriers to access glaucoma services by service users.

- To overcome the barriers, it is imperative to develop a software to link with optometrist, trained medical officer or a technical staff who could do primary assessment and communicate with the eye care team for their diagnosis and management

- Make available the glaucoma medicine without financial burden to the patient. Should have an insurance scheme to cover the cost of glaucoma management

- Revise the glaucoma guideline as which was published in "Practice pearls for glaucoma management" published in 2021. Rename according to the national data as **National Glaucoma guidelines**

- Establish a Glaucoma Clinic at each eye unit once a week.

- Have sustainable continuous medical education (CME) programme on Glaucoma from primary care level health workers up to the higher rank officials.

- Maintain proper patient record (a hard copy and a soft copy record) at eye care centers. Regularize their clinic follow up visits by a reminder

- Should counsel the patient and relative.

- Make a public awareness software app (QR code) about basics of Glaucoma, its management and proper way of instilling treatment

List of references

Murthy GVS, Gilbert C, Schmidt E, Mahipala PG, Gamage KMK, Banagala C, Abeydeera AP, Jeza A (2018) The Sri Lanka National Blindness, Visual Impairment and Disability Survey. *Ceylon Medical Journal* **63**(S2): s3-s9

1.   Agrawal, A., Singh, A., & Mittal, S. K. (2017). Glaucoma in Asia- An epidemiological perspective. *Nepal J Ophthalmol,* **9**(18), 208-211. https://doi.org/10.3126/nepjoph.v9i2.19273

2.   International Council of Ophthalmology guidelines for glaucoma eye care. [Internet] Available from https://icoph.org/eye-care-delivery/glaucoma/

3.   Banagala, C., Gilbert, C., Murthy, G. V. S., Schmidt, E., Mahipala, P. G., Edussuriya, K., ... & Wimalarathne, S. A. H. K. (2018). Prevalence, causes, magnitude and risk factors of visual impairment and blindness in Sri Lanka. *Ceylon Medical Journal,* **63**(5), 10-10.

4.   Buhrmann, R. R., Quigley, H. A., Barron, Y., West, S. K., Oliva, M. S., & Mmbaga, B. B. (2000). Prevalence of glaucoma in a rural East African population. *Invest Ophthalmol Vis Sci*, **41**(1), 40-48.

5.   Chapman, A. R., & Dharmaratne, S. D. (2019). Sri Lanka and the possibilities of achieving universal health coverage in a poor country. *Glob Public Health*, **14**(2), 271-283. https://doi.org/10.1080/17441692.2018.1501080

6.   Foster, P. J., Buhrmann, R., Quigley, H. A., & Johnson, G. J. (2002). The definition and classification of glaucoma in prevalence surveys. *Br J Ophthalmol*, **86**(2), 238-242. https://doi.org/10.1136/bjo.86.2.238

7.   Garudadri, C., Senthil, S., Khanna, R. C., Sannapaneni, K., & Rao, H. B. (2010). Prevalence and risk factors for primary glaucomas in adult urban and rural populations in the Andhra Pradesh Eye Disease Study. *Ophthalmology,* **117**(7), 1352-1359. https://doi.org/10.1016/j.ophtha.2009.11.006

8.   Kiendrébéogo, J. A., De Allegri, M., & Meessen, B. (2020). Policy learning and Universal Health Coverage in low- and middle-income countries. *Health Res Policy Syst*, **18**(1), 85. https://doi.org/10.1186/s12961-020-00591-z

9.   Kumar, R. (2019). Public-private partnerships for universal health coverage? The future of "free health" in Sri Lanka. *Global Health*, **15**(Suppl 1), 75. https://doi.org/10.1186/s12992-019-0522-6

10.   Lešták, J., Pitrová, Š., & Marešová, K. (2020). HIGHLIGHTS OF HYPERTENSIVE AND NORMOTENSIVE GLAUCOMA. *Cesk Slov Oftalmol*, **76**(5), 222-225. https://doi.org/10.31348/2020/31 (Hypertenzní a normotenzní glaukomy - novinky.)

11.   Orzalesi, N., Rossetti, L., & Omboni, S. (2007). Vascular risk factors in glaucoma: the results of a national survey. *Graefes Arch Clin Exp Ophthalmol*, **245**(6), 795-802. https://doi.org/10.1007/s00417-006-0457-5

12. Pallegedara, A., & Grimm, M. (2018). Have out-of-pocket health care payments risen under free health care policy? The case of Sri Lanka. *Int J Health Plann Manage*, **33**(3), e781-797. https://doi.org/10.1002/hpm.2535

13. Perera, S., Nieveras, O., de Silva, P., Wijesundara, C., & Pendse, R. (2019). Accelerating reforms of primary health care towards universal health coverage in Sri Lanka. *WHO South East Asia J Public Health*, **8**(1), 21-25. https://doi.org/10.4103/2224-3151.255345

14. Piyseana, M., & Murthy, G. V. S. (2020). Availability of eye care infrastructure and human resources for managing diabetic retinopathy in the western province of Sri Lanka. *Indian J Ophthalmol*, **68**(5), 841-846.

    https://doi.org/10.4103/ijo.IJO_1754_18

15. Registrar General Department. (2022). *Population Data*

    https://www.rgd.gov.lk/web/index.php/en/

16. Rewri, P., & Kakkar, M. (2014). Awareness, knowledge, and practice: a survey of glaucoma in north Indian rural residents. *Indian J Ophthalmol*, **62**(4), 482-486. https://doi.org/10.4103/0301-4738.132105

17. Saha, A. K., Gunaratnam, N., Patil, R., Choo, M., Bagchi, D. P., Jhaveri, E., . . . Herman, W. H. (2018). A new model for diabetes-focused capacity building - lessons from Sri Lanka. *Clin Diabetes Endocrinol*, **4**, 22. https://doi.org/10.1186/s40842-018-0074-3

18. Tham, Y. C., Li, X., Wong, T. Y., Quigley, H. A., Aung, T., & Cheng, C. Y. (2014). Global prevalence of glaucoma and projections of glaucoma burden through 2040: a systematic review and meta-analysis. *Ophthalmology*, **121**(11), 2081-2090. https://doi.org/10.1016/j.ophtha.2014.05.013

19. Vijaya, L., George, R., Baskaran, M., Arvind, H., Raju, P., Ramesh, S. V., . . . McCarty, C. (2008). Prevalence of primary open-angle glaucoma in an urban south Indian population and comparison with a rural population. The Chennai Glaucoma Study. *Ophthalmology*, **115**(4), 648-654.e641.

    https://doi.org/10.1016/j.ophtha.2007.04.062

20. Weinreb, R. N., Aung, T., & Medeiros, F. A. (2014). The pathophysiology and treatment of glaucoma: a review. *JAMA*, 311(18), 1901-1911. https://doi.org/10.1001/jama.2014.3192

21. UNDP. Human Development Report 2014. Sustaining Human Progress: Reducing vulnerabilities and building resilience –Sri Lanka. http://hdr.undp.org/sites/all/themes/hdr_theme/countrynotes/LKA.pdf

22. Sri Lanka-Addressing the Needs of an Aging Population –Document of the World bank May 28, 2008 [Internet]. [cited 2014 Aug 19]. Available from: https://microdata.worldbank.org/index.php/catalog/2857/download/40350

23. Vijaya L, *et al.* (2006) Prevalence and causes of blindness in the rural population of the Chennai Glaucoma Study. *Br J Ophthalmol* **90**: 407-410.

24. Garudari C, Senthil S, Khanna RC, Sannapaneni K, Rao HBL. (2010) Prevalence and risk factors for primary glaucoma in adult urban and rural populations in the Andra Pradesh Eye Disease Study. *Ophthalmology* 117(7):1352

25. Edussuriya K, *et al.* (2009) The prevalence and causes of visual impairment in Central Sri Lanka: The Kandy Eye Study. *Ophthalmology* **116**: 52-56.

26. Medical Statistics Unit, Ministry of Health, Sri Lanka. Annual Health Bulletin 2012. file:///Q:/Sri%20Lanka%20Blindness%20Survey/back%20ground%20material/Annual%20Heal th%20 Bulletin%20-%202012.pdf

27. Department of Census and Statistics, Sri Lanka. Census of Population and Housing2012. http://www.statistics.gov.lk/PopHouSat/CPH2011/index.php?fileName=Activities/Tentativelisto publications

28. Harsha B L Rao, G C Sekhar, Ganesh J Babu, and Rajul S Parikh. (2009) Clinical measurement and categorization of optic disc in glaucoma patients. *Indian J Ophthalmol.* **57**(5):361-4

29. Garway-Heath DF, Ruben ST, Ananth Viswanathan A, Hitching RA. (1998) Vertical cup/disc ration in relation to optic disc size: its value in the assessment of glaucoma suspect. *Br J Ophthalmol.* **82**(10):1118-24

Investigators Signature Sheet

1. **Dr Lalitha L. C. Senarath: Principal Investigator**
   Consultant Ophthalmologist, Teaching Hospital Karapitiya,
   Chairperson Glaucoma Interest Group - College of Ophthalmologists of Sri Lanka,
   Focal Point Glaucoma Vision 2020, and the provincial coordinator - Vision 2020

   Signature   Date: 20.12.2022

2. **Dr Amila Chandrasiri: Co-Investigator and Ground coordinator**
   Consultant Community Physician, RDHS office, Galle

   Signature   Date: 20.12.2022

3. **Dr Pradeepa K Siriwardana, Co-Investigator**
   Consultant Ophthalmologist - National Eye Hospital Colombo, Focal Point Primary Eye Care - Vison 2020,

   Signature……………………….   Date: 19/12/2021

4. **Dr Dilruwani Aryasinghe: Co-Investigator**
   Consultant Ophthalmologist, Golden Key Eye and ENT Hospital, Colombo

   Signature……………………….   Date: 20.12.2022

5. **Dr Prabath Piyasena: Co-Investigator**
   Medical Officer and Postdoctoral research Fellow in Global Eye Health, Queen's University Belfast, United Kingdom

   Signature……………………….   Date: 19.12.2022.