Original Article

Glaucoma burden and its profile in a tertiary care centre of North-East India: A retrospective hospital-based study

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Abstract

Purpose: To estimate the proportion and pattern distribution of glaucoma disease in a teaching hospital of North-East India. **Materials and Methods:** Retrospective hospital-based study of glaucoma cases from January 2014 to December 2022. **Results:** Out of a total of 89725 new patients, 449 patients had glaucoma with a prevalence of 0.50% (95% CI: 0.46%-0.55%) of which 361 (80.4%) were ≥40 years and 88 (19.6%) were <40 years. The commonest type was POAG (32.1%) followed by PACG (17.6%) while JOAG was 7.8%. Males (67.2%) were predominant with a male: female ratio of 2.0:1. The mean age of patients was 53.4 (17.1) years. PACG was found to be significantly higher among females (p=0.001) whereas POAG was higher among males (p=0.003). There was no association of either age or systemic conditions with the prevalence of POAG and PACG. Hypertension and diabetes were present among 139 (31.0%) and 103 (23.0%) respectively while 13 (2.9%) had chronic obstructive pulmonary disease (COPD), 5 had coronary artery disease (CAD) and 5 hypothyroidism. **Conclusion:** The prevalence of glaucoma though lower compared to other parts of the country, the number was significant, warranting screening activities owing to its silent nature. PACG was significantly higher among females while POAG was higher among males. Systemic factors like COPD, CAD and hypothyroidism require further studies for better understanding of the temporal association with glaucoma.

Keywords: Glaucoma, burden, proportion, pattern, profile, North-East India, POAG, PACG, COPD, JOAG, less than 40 years, <40 years, CAD, hypothyroidism

Introduction

Glaucoma is an optic neuropathy associated with characteristic structural damage to the optic nerve and associated visual dysfunction that may be caused by various pathological processes.[1]

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Received: 04-12-2023 **Revised:** 30-03-2024
Accepted: 03-04-2024 **Published:** 11-09-2024

Access this article online

Quick Response Code:

Website: http://journals.lww.com/JFMPC

DOI: 10.4103/jfmpc.jfmpc_1908_23

A systematic review and meta-analysis of published and unpublished population-based data of 288 studies from 98 countries between 1980 and 2014 by Flaxman reported in the Lancet that glaucoma was the fourth leading cause of moderate to severe impairment at 4.5 million after uncorrected refractive error (UCRE) 127.7 million, cataract 57.1 million and age-related macular degeneration (ARMD) 8.8 million, and the third leading cause of blindness at 3.2 million after cataract (13.4 million) and UCRE (8.0 million).[2] Tham *et al.*[3] estimated that the global burden of glaucoma (aged 40–80 years) would be 111.8 million by 2040. In India, glaucoma was estimated to be among 11.2 million individuals aged 40 years and above,

How to cite this article: Nongrum B, Thangkhiew L, Natung T, Pandey I, Shullai W, Wahlang JB, *et al*. Glaucoma burden and its profile in a tertiary care centre of North-East India: A retrospective hospital-based study. J Family Med Prim Care 2024;13:3766-72.

with primary open-angle glaucoma (POAG) at 6.48 million people and primary angle-closure glaucoma (PACG) at 2.54 million.[4] There have been several population-based surveys carried out to estimate the prevalence of glaucoma in the general population in India, the first being in Vellore, the Vellore Eye Study (VES), followed subsequently by other population-based studies such as the Andhra Pradesh Eye Disease Study (APEDS), Aravind Comprehensive Eye Survey (ACES), West Bengal Glaucoma Study (WBGS), Chennai Glaucoma Study (CGS), Central India Glaucoma Survey 2001 (CIGS), Central India Eye and Medical Study (CIEMS) and the Hoogly River Glaucoma Study (HRGS).[5-18] There were few hospital-based studies from the northern and southern parts of India.[19-21]

Glaucoma poses a significant public health challenge due to its progressive nature and irreversible vision loss if left untreated. Primary care physicians serve as the first point of contact for many individuals seeking healthcare. By providing insights into the prevalence, risk factors and management patterns of glaucoma, this study empowers primary care physicians to deliver more targeted and effective eye care services. Ultimately, it contributes to the broader goal of reducing the burden of preventable blindness and improving the overall health outcomes of individuals in North-East India. Hence, we conducted this study to determine the burden of glaucoma and its types in a tertiary care centre of north-eastern India.

Materials and Methods

This retrospective observational hospital-based study included consecutive cases of glaucoma treated in the department of ophthalmology from January 2014 to December 2022. The study was conducted in a teaching hospital located in the north-eastern part of India where the majority of the patients/participants were from the seven states of the region representing diverse ethnicities. The study was approved by the Institutional Ethics Committee and followed the Declaration of Helsinki 1964.

Study design and sampling

Consecutive sampling was performed and all patients diagnosed with glaucoma were included in the study.

Techniques for determination of clinical indices of glaucoma

The medical records of all patients diagnosed and treated with glaucoma in the department of ophthalmology were retrieved consecutively for inclusion in the study. Demographic characteristics such as age, gender, state-wise distribution, systemic risk factors, ocular risk factors, family history, occupation, ethnicity, education, visual acuity (VA), intraocular pressure (IOP), vertical cup-to-disc ratios (VCDR), gonioscopic findings, central corneal thickness (CCT), type of glaucoma, visual field (VF) defect and management method were extracted from the case record files. The patients were divided into two age groups (<40 years and ≥ 40 years) to better understand the patterns and types of glaucoma.

Experienced optometrists recorded the VA and carried out the refraction tests. Ophthalmologists with over 10 years of experience in glaucoma performed comprehensive ocular examinations, including slit lamp biomicroscopy, applanation tonometry, gonioscopy and dilated pupil indirect ophthalmoscopy, following standardized procedures.

IOP measurements were taken using the Goldmann applanation tonometer mounted on a slit lamp during office hours between 9 am and 4 pm when IOP is most stable.[22] CCT was measured using a pachymeter (*Sonomed 200P+, USA*).

Gonioscopy was performed on non-dilated pupils using a Sussman four-mirror diagnostic gonioscope (*Ocular Instruments, Bellevue, WA, USA*) and a dilated indirect ophthalmoscopic fundus examination was conducted using a slit lamp biomicroscope with + 90 dioptre lens (*Volk USA, and Haag-Streit BQ900, Switzerland*). Gonioscopic grading was based on the modified Shaffer grading system, where Grade 0 was considered closed, Grade I narrow and Grade IV open. The cup-disc ratio (CDR) was measured and recorded in its widest axis. Additional features such as notching on the disc rim and violations of the inferior superior nasal temporal (ISNT) rule were also noted. The VCDR was used as an index for structural glaucomatous damage. Retinal nerve fibre layer (RNFL) loss was assessed using spectral domain optical coherence tomography (OCT) (*Cirrus HD 500, Carl Zeiss, Germany*).

Automated VF testing 24-2 SITA standard programme using Humphrey Field Analyser *(HFA 750i, Carl Zeiss, Germany*) was scheduled based on specific indications, including IOP >21 mmHg, CDR ≥0.7 in either eye, CDR asymmetry ≥0.2 between the two eyes and/or the presence of glaucomatous features. In cases where advanced field defects hindered a successful 24-2 examination, the macular programme or a 10-2 programme was employed.

Operational definitions

The diagnostic criteria for identifying glaucoma were derived from the recommendations of the International Society of Geographical and Epidemiological Ophthalmology (ISGEO) by Foster *et al.*[1] with some modifications similar to that of the WBGS by Raychaudhuri *et al.*[9] and the CGS by Vijaya *et al.*[11] as there was no database available for the population study while the diagnosis for congenital glaucoma was adapted from Childhood Glaucoma Network Research (CGRN).[23]

Glaucoma was classified into three categories based on the levels of evidence

a. This category included cases with both structural and functional evidence of glaucoma. It required the presence of a VCDR of ≥0.7 or asymmetry of VCDRs between both eyes of ≥0.2 and a VF defect consistent with glaucoma.

b. A VCDR of ≥0.9 in either eye or asymmetry of VCDRs between both eyes of ≥0.3 and a reliable VF test result could not be obtained.
c. This category comprised individuals with IOP >26 and VA <3/60 who were unable to undergo optic disc examination due to ocular media opacities.

For the purpose of this study, the definitions of different types of glaucoma were as follows:

1. **POAG:** An open and normal-appearing angle with IOP of ≥22 mmHg, accompanied by either glaucomatous optic disc abnormalities (cupping) or glaucomatous VF abnormalities, or both and no evidence of a secondary cause.
2. **Normal tension glaucoma (NTG):** An open and normal-appearing angle with IOP consistently ≤21 mmHg, along with glaucomatous optic neuropathy or IOP measurements on record that were always ≤21 mmHg.
3. **Ocular hypertension (OHT):** An IOP >21 mmHg, the absence of glaucomatous disc features, the absence of demonstrable glaucomatous field defects and open-angles with no evidence of a secondary cause.
4. **PACG:** An eye with an occludable drainage angle and features indicating trabecular obstruction by the peripheral iris, such as peripheral anterior synechiae (PAS), irido-corneal contact, elevated IOP of ≥22 mmHg, along with evidence of glaucomatous optic nerve damage and VF loss.
5. **Secondary glaucoma (SG):** It was defined as raised IOP with glaucomatous optic neuropathy or IOP of ≥ 22 mmHg, associated with a positive history and ocular findings of pathologies such as trauma, previous surgery, neovascularization, inflammation or any other abnormal ocular or systemic findings that could have caused IOP elevation. Additionally, patients with a history of using topical steroids for 6 months or more, a history of trauma or ocular surgery, chronic uveitis, evidence of pseudoexfoliation (PXE) or pigment dispersion on slit lamp examination and those with hypermature or intumescent cataract were grouped under SG.
6. **Juvenile Open-Angle Glaucoma (JOAG):** Defined as that of POAG but whose onset occurs after 3 years but before 40 years of age without any ocular enlargement or corneal changes.
7. **Congenital Glaucoma:** Defined as glaucoma occurring before 3 years of age whose IOP > 21 mmHg, optic nerve glaucomatous changes with signs of corneal enlargement (>12 mm for less than 1 year of age and >13 mm for any age) and/or presence of Haab's striae.

Statistical analysis

Data was analysed using Statistical Software Package for Social Sciences, *IBM SPSS Statistics for Windows, Version 21.0. (IBM Corp., Armonk, N.Y., USA*). Categorical variables were presented as frequency and percentages. Continuous variables were presented as mean (standard deviation, SD) or median (interquartile range, IQR). The prevalence of glaucoma was presented as a percentage with 95% confidence interval (95% CI). The Chi-square test was used to determine the association between the categorical variables and the type of glaucoma. Independent sample *t*-test was used to determine the association of age, gender, diabetes and hypertension with the type of glaucoma. The level of statistical significance was set at 5%.

Results and Observations

A total of 89725 new patients of all age groups attended the ophthalmology outpatient department from January 2014 to December 2022, of which 451 patients were diagnosed with glaucoma hence the prevalence of 0.50% (95% CI: 0.46%–0.55%).

Table 1 shows the distribution of the patients (demographic profile of patients) based on the age category (less than 40 years and ≥40 years). Out of 449 patients with glaucoma, 361 (80.4%) were of 40 years and above and the remaining 88 (19.6%) were of <40 years. The mean age of the study participants was 53.4 (17.1) years with a minimum of 2 years and a maximum of 89 years. There were more males (67.2%) than females (32.7%) with a male: female ratio of 2.0:1. The most common type of glaucoma among the study patients was POAG (32.1%) followed by PACG (17.6%), OHT (9.4%) and NTG (8.7%). Glaucoma in patients aged less than 40 years accounted for 19.6% of which JOAG and secondary open-angle glaucoma (SOAG) accounted for 7.8% and 4.9%, respectively.

Table 2 shows that 4.7% of patients had a family history of medical illness. With respect to systemic co-morbidities,

Table 1: Distribution of participants according to type of glaucoma (*n*=449)

Type of Glaucoma*	Frequency (*n*)			Percentage
	Male	Female	Total	
Glaucoma in ≥40 years (*n*=361, 80.4%)				
POAG	107	37	144	32.1
PACG	39	40	79	17.6
OHT	27	15	42	9.4
NTG	20	19	39	8.7
Secondary OAG	22	7	29	6.5
Secondary ACG	17	5	22	4.9
PAC	1	3	4	0.9
Mixed Glaucoma	2	0	2	0.4
Glaucoma <40 years (*n*=88, 19.6%)				
JOAG	29	6	35	7.8
Secondary OAG	19	3	22	4.9
PACG	5	5	10	2.2
OHT	6	2	8	1.8
Congenital glaucoma	4	2	6	1.3
NTG	3	3	6	1.3
Secondary ACG	1	0	1	-
Total	302	147	449	100

*Primary open-angle glaucoma (POAG), Primary angle-closure glaucoma (PACG), Ocular Hypertension (OHT), Normal Tension Glaucoma (NTG), Secondary open-angle glaucoma (Secondary OAG), Juvenile onset open-angle glaucoma (JOAG), Secondary angle-closure glaucoma (Secondary ACG), Primary angle-closure (PAC)

hypertension and diabetes were present among 139 (31.0%) and 103 (23.0%) patients, respectively. Both hypertension and diabetes were present among 61 (13.6%) patients. About 13 patients (2.9%) had chronic obstructive pulmonary disease (COPD), 5 had coronary artery disease (CAD) and hypothyroidism each. Ocular risk factors were present among 70 (15.5%) patients. Among the patients with ocular risk factors, angle recession following trauma was seen in 15 patients followed by uveitis, high myopia of >6D spherical equivalent and steroid-induced with 7 each. PXE, central retinal vein occlusion (CRVO) and pigment dispersion syndrome (PDS) were present in four each. Posner-Schlossman and aphakia were seen in three patients each. Congenital aniridia and Sturge-Weber syndrome were seen in two patients each.

Table 2: Clinical characteristics of the study participants (*n*=449)

Variable	Frequency (*n*)	Percentage
Family history of medical illness		
Yes	21	4.7
No	428	95.3
Systemic co-morbidities (multiple co-morbidities allowed)		
Nil	247	55.0
Hypertension	139	31.0
Diabetes mellitus	103	23.0
Chronic Obstructive Pulmonary Disease (COPD)	13	2.9
Coronary Artery Disease (CAD)	5	1.1
Hypothyroidism	5	1.1
Others*	10	2.2
Ocular risk factors** (angle recession, uveitis, high myopia of >6DSE, PXE, CRVO)		
Yes	70	15.5
No	379	84.5

*Others include chronic kidney disease, migraine, herpes zoster, seizure disorder, polyarthritis, dermatomyositis, Chiari type I malformation, Sturge-Weber syndrome, spondylosis and tuberculosis. **angle recession following trauma, uveitis, high myopia of >6D spherical equivalent, pseudoexfoliation (PXE) and central retinal vein occlusion (CRVO)

Table 3: Association of sociodemographic and clinical history with primary (open-angle and angle-closure) glaucoma

Variables	Type of Glaucoma		*P*
	Yes *n* (%)	No n (%)	
Primary Open-Angle Glaucoma (*n*=361)			
Gender			
Males	107 (45.5)	128 (54.5)	0.003
Females	37 (29.4)	89 (70.6)	
Age in years [Mean (SD)]	59.9 (11.3)	60.2 (10.4)	0.842
Other systemic conditions			
Yes	72 (40.0)	108 (60.0)	0.966
No	72 (39.8)	109 (60.2)	
Primary Angle-Closure Glaucoma (*n*=449)			
Gender			
Males	44 (14.6)	258 (85.4)	<0.001
Females	45 (30.6)	102 (69.4)	
Age in years [Mean (SD)]	55.9 (13.0)	52.8 (18.0)	0.119
Other systemic conditions			
Yes	34 (16.8)	168 (83.2)	0.151
No	55 (22.3)	192 (77.7)	

Table 3 shows that PACG was found to be significantly higher among females ($P = 0.001$)* and POAG was found to be significantly higher among males ($P = 0.003$). However, there was no association of either age or other systemic conditions with the prevalence of POAG and PACG ($P > 0.05$).

Table 4 shows that there was no significant association identified between SOAG and secondary angle-closure glaucoma (ACG) with either gender, age or other systemic conditions.

Discussion

Glaucoma, a chronic condition requiring lifelong management, exhibits diverse prevalence and characteristics across populations and regions, necessitating distinct approaches for diagnosis and treatment. Given its progressive and vision-threatening nature, glaucoma poses a significant public health challenge, emphasizing the need for effective management strategies. Primary care physicians, often the first point of contact for healthcare seekers, play a crucial role in addressing glaucoma. Considering the fact that the studies examining glaucoma in the north-eastern region of India are scarce, assessing the prevalence and management patterns will empower primary care physicians to deliver efficient care which in turn will help in reducing the burden of blindness in this geographical area.

The prevalence of all types of glaucoma in our study was 0.50% (95% CI: 0.46%–0.55%). The prevalence in our study was comparatively lesser than in other studies because we have included all age groups in the population and of different ethnicities. It is also noteworthy to mention the other possible reasons; for instance, lower atmospheric pressure at higher altitudes could potentially result in decreased IOP and a reduced risk of glaucoma and this hypothesis was supported by a meta-analysis conducted by Yang *et al.*[24] and also other studies by Xie *et al.*[25] and Bruttini *et al.*[26] However, this hypothesis has not been very conclusive and requires a quantitative analysis and meta-analysis review of all available evidence to ascertain the association between IOP and high-altitude exposure.

The most common type of glaucoma among the study patients was POAG (32.1%) followed by PACG (17.6%), OHT (9.4%) and NTG (8.7%). The findings of this study concurred with those of other population-based studies in India, namely, the APEDS, WBGS, CGS rural, CGS urban, CIEMS, HRGS urban, HRGS rural and also in other neighbouring Asian countries of Singapore, Japan and South Korea with the only exception being the VES from India and China.[7-18,27-30] The hospital based

Table 4: Association of sociodemographic and clinical history with secondary (open-angle and angle-closure) glaucoma

Variables	Type of Glaucoma		*P*
	Yes *n* (%)	No *n* (%)	
Secondary Open-Angle Glaucoma (*n*=449)			
Gender			
Males	41 (13.6)	261 (86.4)	0.034
Females	10 (6.8)	137 (93.2)	
Age in years [Mean (SD)]	46.6 (23.3)	54.36 (16.0)	0.003
Secondary Angle-Closure Glaucoma (*n*=449)			
Gender			
Males	18 (6.0)	284 (94.0)	0.248
Females	5 (3.4)	142 (96.6)	
Age in years [Mean (SD)]	59.4 (10.2)	59.4 (10.2)	0.084
Other systemic conditions			
Yes	8 (4.0)	194 (96.0)	0.312
No	15 (6.1)	232 (94.9)	

study by Seth *et al*[31] showed that POAG was the most common type of glaucoma. A study by Khandelwal *et al*[32] concluded that PACG was found to be higher among females. This also concurred with the study findings from the reports of APEDS by Dandona *et al*,[6] the CGS by Vijaya *et al*,[10] and meta-analysis by two different authors,[29,30] where PACG was more common in females. The meta-analysis also showed that the proportion of PACG was higher in females of Japanese and Chinese groups when compared to Indian group,[30] in contrast to the reports from the WBGS by Raychaudhuri *et al*[9] and the HRGS by Paul *et al*.[17] POAG was found to be significantly higher among males ($P = 0.02$) as was also reported in the WBGS and the ACES in contrast to the APEDS and the CGS.[7,8,9,13]

However, there was no association of either age or other systemic conditions with the prevalence of POAG and PACG ($P > 0.05$). There was no significant association identified between SOAG and secondary ACG with either gender, age or other systemic conditions.

Interestingly, there were 12 (3.3%) glaucoma patients who also had COPD. This was also reported by Soriono that individuals with COPD were at a relatively higher risk (risk ratio of 1.3 in the first year) of developing glaucoma than non-COPD ones.[33] Miłkowska-Dymanowska reported that glaucoma was an under-recognized co-morbidity of COPD.[34] Seth *et al*.[31] reported that 0.26% of their glaucoma patients had asthma. The reason for the observed effect could be attributable to shared risk factors between COPD and glaucoma like advanced age, smoking, vascular dysfunction and steroid usage for COPD. However, because there was no comparator in our study and being cross-sectional in nature, the temporal association could not be ascertained coupled with the fact that the exact mechanisms underlying this association were not yet fully understood. Hence, further research is needed to explore the relationship between these two conditions and to identify the specific factors contributing to their co-occurrence.

With respect to other systemic co-morbidities, studies by Marshall *et al*., Chen *et al*. and Cha *et al*. had concluded that glaucoma patients may have a higher risk of developing CAD than those without glaucoma.[31,35-37] Similarly, studies by Seth *et al*.,[31] Cross JM *et al*.,[38] a systematic review and meta-analysis by Wang *et al*.,[39] McDaniel *et al*.[40] and Lin *et al*.[41] had also reported that patients with hypothyroidism have a higher risk of developing glaucoma. McDaniel *et al*.[40] suggested that hyaluronic acid deposition within the trabecular meshwork may be the reason for an increase in outflow resistance and hence increased IOP. Smith demonstrated a reduction in facility outflow in the hypothyroid state which subsequently improved with treatment.[42] It has also been hypothesized that the mucopolysaccharides deposition might be one of the reasons for increased resistance to aqueous outflow.[38] Our study results found that CAD and hypothyroidism were seen in five (1.1%) patients which were also reported by Seth *et al*.[31] However, to understand the temporal association, further longitudinal studies are warranted.

This study found that 4.7% of patients had a family history of medical illness. Hypertension and diabetes were present among 139 (31.0%) and 103 (23.0%) patients, respectively. Both hypertension and diabetes were present among 61 (13.6%) patients. The patients with hypertension had an odds ratio of 1.78 (95% CI: 1.17–2.71) for POAG while diabetes was 1.25 (95% CI: 0.79–1.99). There are several theories and observations explaining this association of hypertension with POAG. The potential explanation could be vascular theory which states that elevated blood pressure contributes to the development or progression of POAG, through its effects on blood vessels in the eye. Moreover, increased blood pressure could also lead to excess fluid production or reduced fluid drainage resulting in increased IOP. The CGS and HRGS reported that diabetes and hypertension may have an association with ACG which was also reported in the Blue Mountains Eye Study.[11,17,43] However, our study did not observe any association between diabetes and hypertension with ACG. The ACES by Ramakrishna *et al*.[8] and the CGS did not find any association between hypertension and diabetes with POAG.[13] The discrepancies could be attributable either to the fact that the different studies employed different study settings and varying sample sizes.

Among the patients with ocular risk factors, angle recession following trauma was seen in 15 patients followed by uveitis, high myopia of >6D spherical equivalent and steroid-induced with 7 each. PXE, CRVO and PDS were present in four each. This was similar to the one reported by Gadia *et al*.[20] The major limitation of our study was that it was a hospital-based study and population-based studies would give a better understanding of the prevalence and distribution of the disease in the north-eastern part of India.

Conclusion

PACG was found to be significantly higher among females while POAG was found higher among males. The distribution of glaucoma has been seen to vary with gender and other systemic co-morbidities like hypertension and diabetes. This study, though, highlights some information on systemic factors like COPD, CAD and hypothyroidism, they require further studies for a better understanding of the temporal association with glaucoma. This study also adds to the overall data on glaucoma prevalence in the country and provides useful information for screening and treatment planning in our target population for glaucoma.

Acknowledgements

The authors would like to thank Mr. Wanslempor Kshiar for his contribution to the collection of data and to Dr. Sharon Uniki Lyngdoh for editing the manuscript.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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