

Prevalence of Glaucomatous Blindness

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Abstract

Glaucoma is now estimated to be the second most common cause of blindness worldwide after cataract and the most irreversible blindness.

Objective: To determine the prevalence, demographic and clinical characteristics of blindness in glaucoma patients.

Design: Descriptive retrospective study

Material & Methods: The study was performed in glaucoma patients who received ophthalmic examination in the Ophthalmologic Outpatient Department in Angthong Hospital between October 1st, 2014 and September 30th, 2019. All glaucoma patients were examined and diagnosed by the ophthalmologist. Data recorded included gender, age, initial intraocular pressure, duration of treatment, type of glaucoma, underlying diseases and type of treatment. Descriptive analysis was used for reporting the prevalence of glaucoma blindness. The risk factors were analyzed by Chi-square test.

Results: One-thousand one hundred and seven glaucoma patients were studied during the study period. The prevalence of glaucomatous blindness was 23.8%, which were 136 males (51.5%) and 128 female (48.5%). The prevalence of glaucomatous blindness increased with age, with the highest prevalence (35.6%) in the age range 71 to 80 years old. Open-angle glaucoma: OAG was the predominant form of glaucomatous blindness (n=143 [54.2%]), angle-closure glaucoma: ACG (n=78 [29.5%]), and secondary glaucoma (n=43 [16.3%]). The main associated diseases were hypertension, diabetes mellitus, dyslipidemia and cardiovascular disease, which affect daily life activities and visions.

Conclusion: The prevalence of glaucomatous blindness was 23.8% among patients diagnosed with glaucoma. Glaucomatous blindness prevalence was higher in men than in women and shows typically increases with age. As Sex (P = 0.018), Age (P = 0.000), type of glaucoma (P = 0.000), hypertension (P = 0.044), diabetes mellitus (P = 0.000), dyslipidemia (P = 0.016) and cardiovascular diseases (P = 0.001) were the risk factors for developing glaucomatous blindness.

Conflicts of interest: The author declares no conflicts of interest

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Introduction

Glaucoma is now estimated to be the second most common cause of blindness worldwide after cataract¹ and the most irreversible blindness. Most of patients were asymptomatic in the early stages; leading to delayed diagnosis and inappropriate treatments for preventing blindness. Disability of visual function can affect lifestyle

and compromise overall quality of life.^{2,3}

Data from population based studies showed that there were 60.5 million people with OAG and ACG in 2010, which increased to 79.6 million by 2020³, and this number is expected to increase to 111.8 million by 2040.⁴ Asians experience a wide spectrum of glaucoma subtypes. Population based study in an urban population in Thailand showed that the prevalence of glaucoma was 3.8% which significantly higher in elderly population and predominantly in primary open angle glaucoma.⁶ A cross-sectional survey in Singapore presented that the age-standardized prevalence of glaucoma was 3.2% in the population 40 years and older.

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Primary angle closure and secondary glaucoma were most visually destructive form of disease.⁷ Population based survey in Bangladesh showed that the prevalence of definite glaucoma was 2.1% and primary open angle glaucoma was the most common form of glaucoma⁸. Risk factors for glaucoma included gender,^{9,10,11} age,^{8,9,10,11} race, family history of glaucoma, history of eye trauma, history of steroid use, systemic disease such as hypertension, diabetes mellitus, cardiovascular disease, initial increase intraocular pressure, optic disc hemorrhage indicated glaucoma progression.¹¹

Risk factors for progression to blindness from glaucoma include advanced visual field loss at the presentation, noncompliance with treatment, age and race.^{13,14} Understanding these risk factors in glaucoma patients could help prevent blindness. Despite the many groups of glaucoma medications, new and advance techniques in laser and surgeries, glaucoma currently cannot be cured.^{15,16,17} The purpose of this study is to determine the prevalence, demographic and clinical characteristics of blindness in glaucoma patients in Anghong hospital as primary level hospital.

Material and Method

The present study was approved by the Ethical Review Committee for Human Research of Anghong Hospital (ATGEC15-2563). The retrospective chart review of glaucoma patients treated in ophthalmologic outpatient department in Anghong Hospital between October 1st, 2014 and September 30th, 2019 was performed. The ICD-10 glaucoma diagnosis codes were used in HoMC database: H40.11, H40.10, H40.2, H40.89 and H40.9. The medical records of 1,212 patients were reviewed. There were 4 ophthalmologists in the period of data collection. All 1,212 patients were examined and diagnosed by ophthalmologists in Anghong hospital. Demographic information, initial best-corrected visual acuity, the last visit best-corrected visual acuity, initial intraocular pressure, duration of treatment, type of glaucoma, underlying diseases and type of treatment were obtained by medical record. When multiple glaucoma diagnoses were listed, the more specific code was used for analysis.

Open-angle glaucoma was diagnosed with gonioscopy by ophthalmologist, which absence of an occludable angle and the absence of secondary cause for glaucoma. Angle closure glaucoma was diagnosed in person with occludable angle. This determination was made without indentation gonioscopy. Peripheral anterior synerchia were identified by indentation gonioscopy and were considered to be evidence of angle closure. Open angle glaucoma or angle closure glaucoma that was thought to have resulted from another ocular or systemic conditions were labeled as secondary glaucoma.

The exclusion criteria were conditions which obscure vision such as advanced pterygium, cloudy cornea, corneal scar, vitreoretinal diseases, patients who cannot visit or loss follow up.

For each patient, the initial and the last visit best-corrected visual acuity were record. The visual field was not available in Anghong hospital. Some patients had referred the tertiary eye center for visual fields assessment. Definition of blindness according to WHO criteria was defined as presenting distance visual acuity of worse than <3/60 to no light perception in the better eye. Patients who met criteria for only one eye were categorized as unilateral blindness. Also, patients who met criteria for both eye were categorized as bilateral blindness.

The chart review was completed by author. After initial chart review, 105 patients were excluded due to lack of glaucoma diagnosis. 1,107 glaucoma patients remain in this study.

Statistical Methods

Descriptive analysis was used for reporting the prevalence of glaucomatous blindness. The prevalence of glaucomatous blindness is presented as a percentage. Baseline glaucoma patients were presented with qualitative data. i.e. sex, age, type of glaucoma, duration of treatment, underlying disease and type of treatments. Quantitative data such as intraocular pressure reported as mean and standard deviation. The risk factors were analyzed by Chi-square test. A probability value less than 0.05 was considered statistically significant. All statistical analysis was performed using commercially available software SPSS (version 13.0, SPSS Inc., Chicago, IL)

Results

One thousand one hundred and seven glaucoma patients were included in this study. Five hundred glaucoma patients (45.2%) were male and 607 glaucoma patients (54.8%) were female. Age ranged from 6 years to 94 years, mean age was 68.5 ± 13.43 years. Most glaucoma patients have more than 5 years of glaucoma treatment, the means duration of treatment was 6 ± 4.62 years. The mean initial intraocular pressure was 21.63 ± 10.32 mmHg. The most common

type of glaucoma was open angle glaucoma (OAG). There were 730 patients of OAG (66%), 288 patients of ACG (26.0%) and 89 patients of Secondary glaucoma (8.0%), respectively. Underlying diseases were 609 (55%) patients of hypertension, 356 (32.2%) patients of diabetes mellitus, 334 (30.2%) patients of dyslipidemia, 93 (8.4%) patients of cardiovascular disease and 17 (1.5%) patients of cerebrovascular disease. (Table1)

Table 1 Demographics of glaucoma patients in Anghthong hospital (n=1,107)

Demographics	Number	Percent
Sex		
Male	500	45.2
Female	607	54.8
Age		
≤ 50 years	95	8.6
51-60 years	167	15.1
61-70 years	314	28.4
71-80 years	322	29.1
> 80 years	209	18.8
Mean age \pm SD 68.5 ± 13.43 years		
Duration of treatment		
≤ 5 years	530	47.9
> 5 years	577	52.1
Mean duration of treatment 6 ± 4.62 years		
The mean initial intraocular pressure was 21.63 ± 10.32 mmHg.		
Type of glaucoma		
Open angle glaucoma (OAG)	730	66.0
Angle closure glaucoma (ACG)	288	26.0
Secondary glaucoma	89	8.0
Underlying diseases		
Hypertension	609	55.0
Diabetes mellitus	356	32.2
Dyslipidemia	334	30.2
Cardiovascular disease	93	8.4
Cerebrovascular disease	17	1.5
Type of treatment		
Glaucoma medications	973	87.9
Laser peripheral iridotomy	141	12.7
Phaco+IOL+GSL	150	13.6
Trabeculectomy	42	3.8

Phaco+IOL+GSL = Phacoemulsification and intraocular lens implantation with goniosynechialysis

Prevalence of glaucomatous blindness

In the present study, the prevalence of glaucomatous blindness was 23.8%. Two hundred and thirty five glaucoma patients

(21.2%) had unilateral blindness and 29 (2.6%) had bilateral blindness according to World Health Organization criteria. (Table 2)

Table 2 Prevalence of glaucomatous blindness

Glaucomatous blindness	Number	Percent
Blindness	264	23.8
Unilateral blindness	235	21.2
Bilateral blindness	29	2.6
None blind	843	76.2

Prevalence of glaucoma and prevalence of glaucomatous blindness

Among 1,107 glaucoma patients, 264 (23.8%) had been diagnosed glaucomatous blindness. Most of glaucomatous blindness was open angle glaucoma. Open angle glaucoma was diagnosed glaucomatous blindness in 143 (54.2%) patients. Angle closure glaucoma was diagnosed glaucomatous blindness in 78 (29.5%)

patients. Secondary glaucoma was diagnosed glaucomatous blindness in 43 (16.3%) patients. (Table 3)

With respect to visual blindness from glaucoma, 235 (89%) glaucoma patients had unilateral blindness and 19 (11%) glaucoma patients had bilateral blindness according to World Health Organization criteria. (Table 4)

Table 3 Prevalence of glaucoma and prevalence of glaucomatous blindness

Diagnosis	Glaucoma patients		Glaucomatous blindness patients	
	Number	Percent	Number	Percent
OAG	730	66.0	143	54.2
ACG	288	26.0	78	29.5
Secondary	89	8.0	43	16.3
Total	1107	100.0	264	100.0

Table 4 Distribution of blindness on glaucoma subtypes (n=264)

Diagnosis	Unilateral blindness		Bilateral blindness	
	Number	Percent	Number	Percent
OAG	130	55.3	13	44.8
ACG	66	28.1	12	41.4
Secondary	39	16.6	4	13.8
Total	235	100.0	29	100.0

Two hundred and sixty-four (23.8%) of 1,107 glaucoma patients were diagnosed with glaucomatous blindness. One hundred and thirty-six (51.5%) were male and 128 (48.5%) were female. The mean age of glaucomatous blindness patients was 71.7 ± 13.03 years. For the duration of treatment, 144 (54.5%) glaucomatous blindness patients received treatment over 5 years. The mean duration of treatment was 7 ± 5.4 years. The mean initial intraocular pressure was 24.21 ± 12.71 mmHg. The most common type of glaucomatous blindness was open angle glaucoma (OAG). There were 143 (54.2%) open angle glaucoma, 78 (29.5%) were angle closure glaucoma (ACG) and 43 (16.3%)

were secondary glaucoma. The prevalence of glaucomatous blindness increased with age, from 6.5% in age under 50 years, to 12.5% in age range from 51 to 60 years, to 18.9% in age range 61 to 70 years, to 35.6% in age range from 71 to 80 years. Regarding the systemic underlying diseases, glaucomatous blindness was significantly associated hypertension ($P = 0.000$), diabetes mellitus ($P = 0.000$), dyslipidemia ($P = 0.016$), and cardiovascular disease ($P = 0.001$). For the treatment, glaucoma patients who received glaucoma medications ($P = 0.005$) and trabeculectomy ($P = 0.010$) were associated glaucoma blindness. (Table 5)

Table 5 Demographics of glaucomatous blindness patients in Angthong hospital (n=264)

Demographics data	Glaucomatous blindness		Chi. Square	P
	Not blind (percent)	Blind (percent)		
Sex			5.636	0.018
Male	364 (43.2)	136 (51.5)		
Female	479 (56.8)	128 (48.5)		
Age			30.018	0.000
≤ 50 years	78 (9.3)	17 (6.5)		
51-60 years	134 (15.9)	33 (12.5)		
61-70 years	264 (31.3)	50 (18.9)		
71-80 years	228 (27.0)	94 (35.6)		
> 80 years	139 (16.5)	70 (26.5)		
Mean age of glaucomatous blindness patients were 71.7 ± 13.03 years				
Duration of treatment			0.815	0.367
≤ 5 years	410 (48.6)	120 (45.5)		
> 5 years	433 (51.4)	144 (54.5)		
Mean duration of treatment was 7 ± 5.4 years				
Mean initial intraocular pressure was 24.21 ± 12.71 mmHg				
Type of glaucoma			34.334	0.000
Open angle glaucoma (OAG)	587 (69.6)	143 (54.2)		
Angle closure glaucoma (ACG)	210 (24.9)	78 (29.5)		
Secondary glaucoma	46 (5.5)	43 (16.3)		
Underlying disease				
Hypertension			4.069	0.044
Yes	478 (56.7)	131 (49.6)		
No	365 (43.3)	133 (50.4)		

Table 5 Demographics of glaucomatous blindness patients in Anghong hospital (n=264) (Cont.)

Demographics data	Glaucomatous blindness		Chi. Square	P
	Not blind (percent)	Blind (percent)		
Diabetes mellitus			15.540	0.000
Yes	298 (35.3)	59 (22.3)		
No	545 (64.7)	205 (77.7)		
Dyslipidemia			5.780	0.016
Yes	270 (32.0)	64 (24.2)		
No	573 (68.0)	200 (75.8)		
Cardiovascular disease			10.616	0.001
Yes	58 (6.9)	35 (13.3)		
No	785 (93.1)	229 (86.7)		
Cerebrovascular disease			0.001	0.975
Yes	13 (1.5)	4 (13.3)		
No	830 (98.5)	260 (86.7)		
Type of treatment				
Glaucoma medications			7.841	0.005
On glaucoma medications	728 (86.0)	245 (92.8)		
Not have glaucoma medications	115 (14.0)	19 (7.2)		
Laser peripheral iridotomy			0.002	0.963
Laser peripheral iridotomy	114 (13.5)	36 (13.6)		
Not have Laser peripheral iridotomy	729 (86.5)	228 (86.4)		
Phaco+IOL+GSL			0.855	0.355
Phaco+IOL+GSL	103 (12.2)	38 (14.4)		
Not have Phaco+IOL+GSL	740 (87.8)	226 (85.6)		
Trabeculectomy			6.640	0.010
Trabeculectomy	25 (3.0)	17 (6.4)		
Not have Trabeculectomy	818 (97.0)	247 (93.6)		

Phaco+IOL+GSL = Phacoemulsification and intraocular lens implantation with goniosynechialysis

Discussion

In the present study, one thousand one hundred and seven glaucoma patients were included. The prevalence of glaucomatous blindness was 23.8%. It was consistent with Sriphon¹⁸ reported the prevalence of glaucomatous blindness in Chaiyaphum hospital was 35.57%, which studied in 506 glaucoma patients. Internationally, the prevalence of glaucoma blindness range very low in Sweden to

greater more than 20% in South Africa.¹⁹ Jordan S et al²⁰ reported 13% of glaucoma patients at the Tertiary Eye Care Center in North Carolina met criteria for blindness. In Israel (8) showed the prevalence of glaucomatous blindness was 14%, which was studied in 329 glaucoma patients in glaucoma clinic. The prevalence of glaucomatous blindness varies in hospitals and many countries probably because of difference study designs, difference population groups, medical records

and advance technology of diagnosis and treatments.

Regarding gender, we found that males were affected with blindness related glaucoma more than female statistical significantly. There were similar findings across Thai⁶, Chinese Singapore⁷, and Bangladesh study⁸ which reported glaucoma prevalence was higher in men than in women. Bourne et al⁶, Sothornwit et al²¹ reported the prevalence of glaucoma increased with age, as we found in this study that most of glaucomatous blindness patients were in the age range 71 to 80 years. Mean age of glaucomatous blindness patients were 71.7 ± 13.03 years. Similarly, Jordan S et al²⁰ found mean age of glaucomatous blindness patients were 71 ± 17 years. Some of population-bases data on the prevalence of glaucoma among person of European²², East Asia²³ and African^{22, 24}, showed that the prevalence of glaucoma increased with age.

With respect to visual blindness from glaucoma, two hundred and sixty-four were diagnosed glaucoma blindness in present study. Two hundred and thirty-five (21.2%) glaucoma patients had unilateral blindness and twenty-nine (2.6%) glaucoma patients had bilateral blindness according to World health organization criteria. Similarly to Sriphon¹⁸ reported the unilateral glaucomatous blindness in Chiayaphum hospital was 30%. Bourne et al⁶ reported glaucoma was the second most common cause of unilateral blindness (n=5 [12%] in Thailand). Sothornwit et al²¹ reported 31 (29%) glaucoma patients had unilateral blindness in Priest hospital. Internationally, an estimate of glaucoma blindness in the United States based on cross-sectional data for unilateral blindness is approximately 15% for patients and 4.3% for bilateral glaucoma related blindness.²⁵ Foster et al⁷ reported glaucoma was a leading cause of unilateral and bilateral blindness, affecting 19 (34%) and 6 (60%) patients in Singapore, respectively. Rahman et al⁸ also reported that unilateral glaucomatous blindness in Bangladesh was 20.1%. The constriction of vision impacted to daily life activities and the living of glaucoma patients and families such as, driving activities limitation. It is essential to provide ophthalmic health education with systemic disease control and emphasize to have comprehensive ophthalmic examination

regularly. The multidisciplinary approach in managing patients with chronic medical conditions who having risk of developing glaucoma, associated ophthalmic diseases may play an important role in reducing the prevalence of visual loss.

In this study, the type of glaucoma was statistically significant with glaucomatous blindness. Open angle glaucoma is the predominant form of glaucomatous blindness. There were open angle glaucoma (n=143 [54.2%]), angle closure glaucoma (n=78 [29.5%]), and secondary glaucoma (n=43 [16.3%]). Jordan S et al²⁰ also report primary open angle glaucoma was common glaucoma related blindness. In contrast to the prevalence of glaucomatous blindness patients in Chiayaphum hospital¹⁸, which found secondary glaucoma, was the most common glaucomatous blindness. Foster et al⁷ and Rahman et al⁸ also found that angle closure glaucoma and secondary glaucoma were the most visually destructive form of the disease. Many studies reported that angle closure glaucoma was main cause of visual morbidity in the Asian population while prevalence of open angle glaucoma varies widely might because of difference races and ethnicities. As difference of natural history, mechanisms, progression of diseases include underlying diseases cause difference visual outcomes.

Regarding underlying diseases, hypertension, diabetes mellitus, dyslipidemia and cardiovascular diseases were associated with glaucomatous blindness statistically significant in this study. Jordan S et al²⁰ studied in Tertiary Eye Care Center in North Carolina reported hypertension and diabetes mellitus were higher among visually impaired patients. Vaidya et al²⁵ studied in Nepal reported people suffering from POAG, hypertension, and diabetes mellitus exhibited adequate knowledge of hypertension and diabetes mellitus. Chopra et al²⁶ also revealed that a longer duration of type 2 diabetes mellitus was associated with a higher prevalence of open angle glaucoma. Implement in knowledge and understanding about general health to control non-communicable diseases and its complications were essential for patients and families. Early detection, investigation and treatment are currently powerful tools to prevent

blindness and low vision in glaucoma, which was asymptomatic disease in early stages. However, the barriers to access treatment were financial condition and transportation.

Currently, controlled target intraocular pressure^{15,16,17} is aimed as treatment to decrease visual threatening in glaucoma patients. Even though there are many groups of glaucoma medications, laser and surgical treatment include trabeculectomy and advance new technique to decrease intraocular pressure, glaucoma still cannot be cured. In this study found that glaucoma patients with glaucoma medications and underwent trabeculectomy patients were associated glaucomatous blindness as statistically significant. This suggests the disease was progressing faster and required more aggressive treatment. Some of glaucoma patients were late presentation or poor compliances. In addition, delayed diagnosis and treatment played important role for visual impairment. Development of optic neuropathy and progression of glaucoma can be challenging to control. Encouragement of ophthalmic examinations regularly with knowledge of visual-threatening disease was essentials to both patients.

Limitation

The goal of this study was to provide data on current glaucoma patients and blindness. However, there are limitations to retrospective charts reviews, the potential of multiple confounding factors such as decision of diagnosis and treatment, the consistency of glaucoma medications, family history of glaucoma and patient education may lack information. The determination of blindness was made by only recording visual acuity and was confirmed diagnosis code by ophthalmologist. If special investigational equipments such as visual field is available in Anghong hospital, we can have more informative data to evaluate and monitor the visual potential in glaucoma patients. For future study should conduct prospective for follow up on disease progression in subgroup analysis.

Conclusion

The prevalence of glaucomatous blindness was 23.8% among patients diagnosed with glaucoma. Glaucomatous blindness prevalence was higher in men than in women

and shows typically increases with age. As Sex (P = 0.018), Age (P = 0.000), type of glaucoma (P = 0.000), hypertension (P = 0.044), diabetes mellitus (P = 0.000), dyslipidemia (P = 0.016) and cardiovascular diseases (P = 0.001) were the risk factors for developing glaucomatous blindness. Conflicts of interest: The author declares no conflicts of interest

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References

1. Pascolini D, et al. Global estimates of visual impairment: 2010. *Br J Ophthalmol* 2012;96:614-618.
2. Skalicky S, Goldberg I 2008. Depression and quality of life in patients with glaucoma: a cross-sectional analysis using the Geriatric Depression Scale-15, assessment of function related to vision, and the Glaucoma quality of Life-15. *J Glaucoma*, 17(7):546-51.
3. Quigley HA, Broman AT. The number of people with glaucoma worldwide in 2010 and 2020. *Br J Ophthalmology* 2006;9-:262-7.
4. Tham YC, Li X, Wong TY, Quigley HA, Aung T, Cheng CY. Global prevalence and projections of glaucoma burden through 2040: a systematic review and meta-analysis. *Ophthalmology* 2014;121:2081-90.
5. Foster PJ, Johnson GJ. Glaucoma in China: How big is the problem? *Br J Ophthalmol*. 2001;85(11):1277-82.
6. Bourne RR, Sukdom P, Foster PJ, Tantisevi V, Jitapunkul S, Lee PS, et al. Prevalence of glaucoma in Thailand: a population based survey in Rom Klao District, Bangkok. *Br J Ophthalmol* 2003;87:1069-74.
7. Foster PJ, Oen FTS, Machin D, et al. The prevalence of glaucoma in Chinese residents of Singapore: a cross-sectional population survey of the Tanjong Pagar district. *Arch*

- Ophthalmol 2000;118:1105-11.
8. Rahman M, Rahman N, Foster PJ, et al. The prevalence of glaucoma in Bangladesh: a population based survey in Dhaka division. *Br J Ophthalmol* 2004;88:1493-1497.
 9. Sommer A. Glaucomatous risk factors observed in the Baltimore Eye Survey. *Curr Opin Ophthalmol*, 7(2):93-8.
 10. David R, Dan Y, Stone DH. Glaucomatous blindness in the Negev: a descriptive study of age, sex, and ethnic patterns. *Br J Ophthalmol*. 67(8): 535-7.
 11. Pan Y, Varma R. Natural history of glaucoma. *Indian J Ophthalmol*, 59 (Suppl): S19-23.
 12. Spry PG, Sparrow JM, Diamond JP, Hariis HS. Risk factors for progressive visual field loss in primary open angle glaucoma. *Eye (Lond)*, 19(6):643-51.
 13. American Academy of Ophthalmology. Basic and clinical science course section 10: glaucoma. San Francisco: American Academy of Ophthalmology; 2019.
 14. Chen PP. Risk and risk factors for blindness from glaucoma. *Curr Opin Ophthalmol*. 2004;15(2):107-111.
 15. Collaborative Normal-Tension Glaucoma Study Group. The effectiveness of intraocular pressure reduction in treatment of normal tension glaucoma. *Am J Ophthalmol* 1998;126:498-505.
 16. Heiji A, Leske MC, Bengtsson B, Hyman L, Bengtsson B, Hussein M. Reduction of intraocular pressure and glaucomatous progression: result from the Early Manifest Glaucoma Trial. *Arch Ophthalmol* 2002;120:1268-79.
 17. Kass MA, Heuer Dk, Higginbotham EJ, Johnson CA, Keltner JL, Miller JP, et al. The Ocular Hypertension Treatment Study: a randomized trial determine that topical ocular hypotensive medication delays or prevents the onset primary open-angle glaucoma. *Arch Ophthalmol* 2002;120:701-13.
 18. Sriphon P. Prevalence of glaucoma blindness. *Chaiyaphum medical journal* 2018: 46-55.
 19. Cook C, Foster P. Epidemiology of glaucoma: what's new? *Can J Ophthalmol*. 2012;47(3):223-226.
 20. Jordan S, Kelly W, Sandra S, Jullia A. Glaucoma Blindness at a Tertiary Eye Care Center. *N C Med J*. 2015 Sep-Oct; 76(4): 211-218.
 21. Sothornwit N, Jenchitr W, Pongprayoon C. Glaucoma care and Clinical Profile in Priest Hospital, Thailand. *J Med Assoc Thai*. 2008;91 Suppl 1:S111-8.
 22. Teilsch JM, Sommer A, Katz J, Royall RM, Quigley HA, Javitt J. Racial variations in the prevalence of primary open-angle glaucoma: the Baltimore Eye Survey. *JAMA*. 1991;266:369-374.
 23. Shiose Y, Kitazawa Y, Tsukuhara S, et al. Epidemiology of glaucoma in Japan: a nationwide glaucoma survey. *Jpn J Ophthalmol*. 1991;35:133-155.
 24. Leske MC, Connell AM, Schachat AP, Hyman L. The Barbados Eye Study: prevalence of open-angle glaucoma. *Arch Ophthalmol*. 1994;112:821-829.
 25. Broman AT, Quigley HA, West SK, et al. Estimating the rate of progressive visual field damage in those with open-angle glaucoma, from cross-sectional data. *Invest Ophthalmol Vis Sci*. 2008;49(1):66-76.
 26. Vaidya S, Povlsen L, Shrestha B, Grjibovsk Ai, Krettek A. Understanding and living with glaucoma and non-communicable diseases like hypertension and diabetes in the Jhaukhel-Duwakot Health Demographic Surveillance Site: a qualitative study from Nepal *Glob Health Action*. 2014; 7: 10.3402/gha.v7.25358.
 27. Chopra V, Varma R, Francis BA, Wu J, Torres M, Azen SP, Los Angeles Latino Eye Study Group. Type 2 diabetes mellitus and the risk of open-angle glaucoma the Los Angeles Latino Eye Study. *Ophthalmology*. 2008 Feb; 115(2):227-232.e1.