The Prevalence of Glaucoma in Tehran, Iran

Heydar Amini, MD[1]; Mohammad-Ali Javadi, MD[2]; Shahin Yazdani, MD[2]; Mohammad Pakravan, MD[2]; Farid Karimian, MD[2]; Amir Rezaei, MD[2]; Kouros Nouri-Mahdavi, MD[3]; Reza Zarei, MD[1]; Arezoo Miraftabi, MD[2]; Alireza Baradaran Rafiee, MD[2]; Yadollah Eslami, MD[1]; Mahmoud Jabarvand, MD[1]; Naser Valaie, MSc[2]

[1]Tehran Medical University, Tehran, Iran; [2]Shaheed Beheshti Medical University, Tehran, Iran; [3]Iran Medical University, Tehran, Iran

Purpose: To determine the prevalence of glaucoma in adults 40 years of age or older in Tehran, Iran.

Methods: This stratified random-sampling cross-sectional population survey was performed on residents of Tehran, the capital of Iran, aged 40 years and older in the year 2001. Refraction, best-corrected visual acuity, slitlamp biomicroscopy, Goldmann applanation tonometry, funduscopy, and gonioscopy were performed in all subjects. Automated perimetry was performed in selected cases.

Results: Out of 4418 sampled subjects, 2184 individuals (49.4%) participated in the survey. Eventually data from 2160 individuals including 814 (38%) male and 1346 (62%) female subjects with mean age of 55.1±10.2 (range 40-92) years were analyzed. The overall prevalence of glaucoma was 1.44% (95% confidence interval, 0.94-1.94) including primary open angle glaucoma 0.46%, chronic angle closure glaucoma 0.33%, normal tension glaucoma 0.28%, pseudoexfoliation glaucoma 0.23%, and other types of glaucoma 0.14%. More than 80% of affected subjects were unaware of their condition.

Conclusion: The prevalence of glaucoma in adults 40 years of age or older in Tehran is 1.44%, which is in the lower range reported in other populations. The large majority of cases are unaware of their condition.

Iran J Ophthalmic Res 2007; 2 (2): 93-100.

Correspondence to: Shahin Yazdani, MD. Assistant Professor of Ophthalmology; Ophthalmic Research Center, Labbafinejad Medical Center, Boostan 9 St., Pasdaran Ave., Tehran 16666, Iran; Tel: +98 21 22585952, Fax: +98 21 22590607, e-mail: shahinyazdani@yahoo.com

INTRODUCTION

The glaucomas comprise of a group of disorders with different pathophysiology, manifestations and treatment. However, common features including optic nerve atrophy and cupping, variable levels of intraocular pressure (IOP) elevation and visual field defects have led to categorization of these disorders under one entity. Based on new concepts, glaucoma is defined as a characteristic optic neuropathy of multifactorial etiology which is dependent on many risk factors, the most common and prominent of which is elevated intraocular pressure.[1,2] Glaucoma is the second leading cause of blindness globally.[3] Some types remain asymptomatic up to the terminal stages of the disease. The importance of early diagnosis and treatment of glaucoma cannot be overemphasized because the ensuing structural and functional damages are irreversible.[4]

The prevalence of glaucoma in adults over 40 years of age has been reported from 2% to 8.8% in different parts of the world.[5-13] Almost

all studies have reported open-angle glaucoma to be more common.[5,7,10,13,14] The prevalence and distribution of glaucoma in Iran is still undetermined and not many studies have addressed this issue. The present survey was undertaken to determine the prevalence of glaucoma in adults 40 years of age or older in Tehran, the capital of Iran.

METHODS

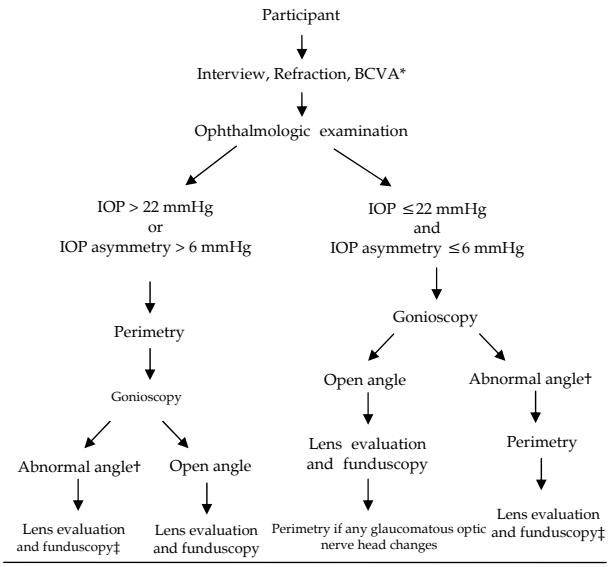
This cross-sectional study was performed on citizens of Tehran who were at least 40 years of age in the year 2001. Based on the most recently performed census,[15] this population was estimated to be about 2 million. Sample size was based on an estimated prevalence of 2% yielding a total number of 2100 subjects. Assuming a response rate of 50% (participation rate was 54.9% in the Tehran lipid and glucose study[16]), the initial sample size was doubled to achieve the desired number of cases. Eligible subjects were randomly selected by stratified cluster sampling. The city was stratified according to municipal districts into 21 areas. Health centers in each area were considered as blocks. Two blocks were randomly selected in each area summing up to 42 blocks in the city. A comprehensive list of family units and individuals 40 years of age or older was prepared and 50 family units were randomly selected from each block. After discussing study objectives and procedures by field interviewers, subjects over 40 years of age were invited to attend a local center for transportation to the study location. The design of the study met the principles of the Declaration of Helsinki. The ethics committee at the Ophthalmic Research Center approved the project. Each subject was adequately informed and individuals who consented to participation were enrolled in the study.

Figure 1 summarizes examinations and procedures performed after enrollment. First, an optometrist completed the information sheet and determined best-corrected visual acuity (BCVA) after performing refraction. Thereafter, enrolled subjects underwent a comprehensive ophthalmologic examination by a group of nine ophthalmologists with subspecialty training and experience in glaucoma. The examination included slitlamp biomicroscopy, Goldmann applanation tonometry, gonioscopy and stereoscopic optic nerve head and fundus examination. The tonometer was calibrated every week. Gonioscopy was performed using a Sussman goniolens and the angle was categorized as occludable (primary angle closure suspect, PACS) if the posterior pigmented trabecular meshwork was not visible in at least 180° in primary position without compression using a slit beam of minimum length. Eyes with structural (peripheral anterior synechiae) or functional (elevated IOP) evidence of trabecular dysfunction but no glaucomatous damage were classified as primary angle closure. Primary angle closure glaucoma was diagnosed in eyes with a closed angle, and glaucomatous optic disc changes.[17,18] Pupillary dilation was achieved with tropicamide 1% in eyes with a normal open angle and was followed by re-evaluation of the crystalline lens and stereoscopic evaluation of the optic nerve head and posterior pole with a +90 D lens. Vertical cup to disc (C/D) ratio was estimated clinically and recorded in decimal notations (0.05 steps). Dilated fundus examination followed peripheral iridotomy in eyes with occludable angles.

Automated perimetry was performed in presence of IOP>22 mmHg, IOP asymmetry >6 mmHg, angle abnormalities or glaucomatous optic nerve head changes. In case of IOP >22 mmHg or IOP asymmetry >6 mmHg, automated perimetry was performed prior to gonioscopy. Perimetry preceded pupillary dilation and stereoscopic funduscopy in eyes with narrow or closed angles or with peripheral anterior synechiae. The Humphrey Field Analyzer (HFAII 750, USA) was used to obtain central 24° visual fields using the SITA-fast strategy. Eyes with pupil diameter < 3 mm were dilated with phenylephrine 5% in order to achieve adequate pupil size prior to perimetry. Unreliable or abnormal visual fields were repeated at a separate session. Two independent observers evaluated each perimetry. Individuals requiring further management were referred to

the tertiary center to which the examiner was affiliated with.

Figure 1 Study Protocol



*BCVA: best-corrected visual acuity

†Abnormal angle included occludable angle or peripheral anterior synechiae.

‡ In case of occludable angle, lens evaluation and funduscopy would be performed after Nd: YAG laser peripheral iridotomy.

Glaucoma was diagnosed in the presence of at least 2 of the 3 following criteria:[13]
1) Glaucomatous optic nerve head changes including C/D ≥0.6, C/D asymmetry greater than 0.2, neural rim thinner than 0.2, rim notching, or splinter hemorrhages at or adjacent to the optic nerve head.
2) IOP greater than 22 mmHg.
3) Presence of at least two of the following findings on a reliable automated perimetry: abnormal glaucoma hemifield test, abnormal pattern standard deviation with P<0.05 or a cluster of 3 points on the pattern deviation plot with P<0.05 including at least one point with P<0.01.

Ocular hypertension was defined as IOP >22 mmHg with an open anterior chamber angle, normal optic disc, and normal visual fields. Glaucoma suspects were defined as individuals with either glaucomatous optic nerve head changes or abnormal visual fields in the presence of an open angle and normal IOP.[19] Primary angle closure suspects were defined as mentioned above.[17]

RESULTS

Out of 4418 sampled individuals, 2184 participated in the survey (response rate of 49.4%). Twenty-four individuals were excluded due to incomplete data. Eventually data from 2160 subjects including 814 (38%) men and 1346 (62%) women were analyzed. Mean age was 55.1±10.2 (range 40-96) years and median age was 54 years. Table 1 details age and gender distribution of enrolled subjects compared to the latest census.[15]

Table 1 Age and gender distribution of participants compared with Tehran population*

Age Group (yr)	Participants No (%)	Tehran Population No (%)
40-49	729 (33.8)	717701 (43.7)
50-59	692 (32.0)	431675 (26.3)
60-69	481 (22.3)	304455 (18.5)
70-79	217 (10.0)	151037 (9.2)
≥ 80	41 (1.9)	38735 (2.4)
Gender		
Male	814 (37.7)	857691 (52.2)
Female	1346 (62.3)	785912 (47.8)
Total	2160 (100)	1643603 (100)

* The 1996 National Census

Twenty-seven individuals (1.2%) reported a personal history of glaucoma. Positive family history of glaucoma was present in 112 participants (5.2%), which was a first-degree relative in 67 subjects (3.1%). Sixty-four individuals (3%) reported taking ophthalmic medications including 20 subjects (0.9%) receiving anti-glaucoma medications. Overall, 171 individuals (7.9%) reported history of ocular surgery including 112 cases (5.2%) of cataract surgery and 2 cases (0.1%) of trabeculectomy. BCVA ranged from no light perception to 20/20. BCVA better or equal to 20/20, 20/25 and 20/32 was present in 40.6%, 74.2% and 85.7% of the population, respectively (Fig. 2). Mean C/D ratio was 0.25±0.13. Mean IOP was 14.3±3.5

(range 6-68) mmHg. IOP distribution in the sampled population is shown in figure 3.

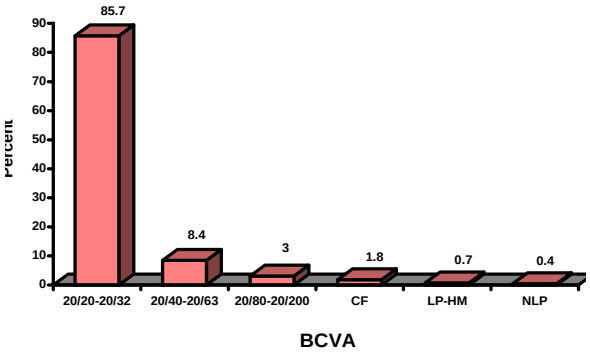


Figure 2 Distribution of best-corrected visual acuity (BCVA) in the study population

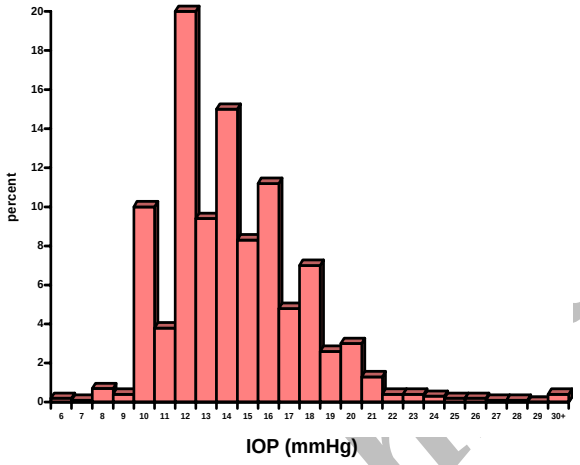


Figure 3 Distribution of intraocular pressure (IOP) in the study population

IOP was normal in 96.2%, the angle was classified as normal in 95.1% and the optic nerve head appeared normal in 95.1% of the eyes. Table 2 details abnormal ocular findings related to glaucoma. Abnormal IOP included 25 (1.1%) cases with glaucoma, 53 (2.4%) cases of IOP > 22 mmHg (ocular hypertension) and 23 (1.0%) cases of IOP asymmetry > 6 mmHg. Only four cases with IOP asymmetry > 6 mmHg did not have IOP > 22 mmHg and none of these subjects was affected by glaucoma. Abnormal angle findings included 82 (3.8%) cases of occludable angle (PACS), 17 (0.8%) cases of primary angle closure (occludable angle with peripheral anterior synechiae formation [13 cases] or high IOP [4 cases]) and 7 cases (0.3%) of angle closure glaucoma. Of 107 eyes (4.9%) with glaucomatous optic nerve head changes, 91 (4.2%) had rim notching, rim thinning, or splinter hemorrhage at or adjacent to the optic nerve head, 77 (3.6%) had C/D ≥0.6 or C/D asymmetry greater than 0.2. Of subjects with glaucomatous optic nerve head changes, 20 (0.9%) were finally diagnosed with glaucoma and the remaining 87 (4%) were classified as glaucoma suspects based on optic nerve head findings. There were 52 cases (2.4%) of pseudo-exfoliation including 43 normal participants, four glaucoma suspects and five patients with glaucoma.

Table 2 Abnormal ocular findings related to glaucoma in the study population

IOP	ONH	Angle	VF*
Normal 2078 (96.2%)	Normal 2053 (95.1%)	Normal 2054 (95.1%)	Normal 189 (8.7%)
Glaucoma 25 (1.1%)	Glaucoma 20 (0.9%)	PACS 82 (3.8%)	Glaucoma 26 (1.2%)
OHT 53 (2.4%)	GS 87 (4%)	PAC 17 (0.8%)	GS 8 (0.4%)
Asym IOP 23 (1.0%)†		PACG 7 (0.3%)	

IOP, intraocular pressure; ONH, optic nerve head; VF, visual fields; OHT, ocular hypertension; GS, glaucoma suspect; PACS, primary angle closure suspect; PAC, primary angle closure; PACG, primary angle closure glaucoma

* Obtained in 223 cases (10.3%)

† Only 4 cases of asymmetric IOP were not ocular hypertensive

Overall glaucoma was diagnosed in 31 subjects, indicating an overall prevalence of 1.44% (95% confidence interval [CI], 0.94-1.94). Table 3 details the distribution of glaucoma

subtypes. Two subjects (6.5% of glaucoma cases) had history of previous glaucoma surgery. The most common glaucomatous abnormalities in cases with glaucoma were IOP >22 mmHg in 25 (80.6%) followed by optic nerve head changes in 20 (64.5%) and abnormal angle in 7 (22.6%) cases. BCVA in glaucomatous eyes ranged from light perception to 20/20. BCVA better or equal to 20/20, 20/25 and 20/32 was present in 15%, 57.5% and 72.5% of these eyes (Fig. 4).

Automated perimetry was performed for 223 individuals (10.3% of the study population) of which, 34 (1.6%) demonstrated a glaucomatous abnormality and 26 (1.2%) were eventually diagnosed with glaucoma. The remaining 8 subjects (0.4%) were classified as glaucoma suspects based on abnormal visual fields.

Overall, 230 (10.6%) cases were categorized as glaucoma suspects including abnormal optic nerve head appearance (87 cases, 4.0%), primary angle closure suspects (82 cases, 3.8%), ocular hypertension (53 cases, 2.4%) and visual field suspects (8 cases, 0.4%).

Table 3 Distribution of glaucoma subtypes in the study population

Glaucoma	No.	%	95%CI
POAG	10	0.46	0.17-0.75
CACG	7	0.33	0.08-0.56
NTG	6	0.28	0.06-0.5
PXG	5	0.23	0.03-0.43
Other types	3	0.14	0.0-0.3
Total	31	1.44	0.94-1.94

POAG, primary open-angle glaucoma; CACG, chronic angle-closure glaucoma; NTG, normal tension glaucoma; PXG, pseudoexfoliation glaucoma

Age and sex adjusted distribution of glaucoma based on the 1996 Tehran population is shown in table 4. The 31 subjects affected with glaucoma included 18 men and 13 women. The prevalence of glaucoma was higher in males (1.15%, 95% CI, 0.42-1.82%) than females (0.46%, 95% CI, 0.10-1.94%) (P=0.18). Out of 31 glaucomatous subjects, 25 (80.6%) were unaware of their condition. Of the 27 individuals reporting a personal history of glaucoma and 20 subjects with prior anti-glaucoma medication use, only 6 cases in each group were diagnosed to have glaucoma.

Logistic regression analysis was performed to assess the association of age, sex, PXF, high IOP (>22 mmHg) and blindness (BCVA $\leq$20/400, ICD_{10}^{20}) with glaucoma and revealed that only age (OR=1.06, P<0.001) and high IOP (OR=78.9, P<0.001) were significantly correlated with glaucoma.

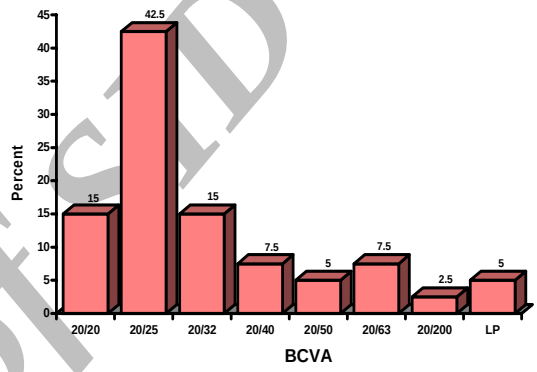


Figure 4 Best-corrected visual acuity (BCVA) in eyes with glaucoma

Table 4 Prevalence of Glaucoma by Age and Gender*

Age Group (yr)	No	%	95% CI
40-49	4	0.24	0.00-0.59
50-59	5	0.19	0.00-0.51
60-69	16	0.62	0.00-1.32
70-79	4	0.17	0.00-0.72
≥ 80	2	0.12	0.00-1.18
Gender			
Male	18	1.15	0.42-1.88
Female	13	0.46	0.10-0.82
Total	31	1.44	0.94-1.94

CI: confidence interval

* Age and gender standardized to the 1996 Tehran population

DISCUSSION

This study revealed that the overall prevalence of glaucoma in adults 40 years of age or older in Tehran is 1.44%. Based on the above-mentioned prevalence and estimating the over-

40 population of Tehran to be 2 million, the total number of individuals affected by glaucoma would be 28,800 (95% CI 18,800–38,800). A great majority of affected individuals (80.6%; 95% CI, 78.9-82.3%) were unaware of their condition. According to previous assumptions, more than 23,000 undiagnosed cases of glaucoma exist in this city.

The overall prevalence of glaucoma suspect was 10.6% in the present study. Similar figures range from 1.53% in southern India[21] to 18.4% in blacks.[1,4] In addition to race dependent variations, another cause for such discrepancy may be definitions for glaucoma suspects, for instance in the mentioned studies IOP >21 mmHg was considered as high, which slightly differs from our 22 mmHg limit.

Since glaucoma is considered as a disorder of older individuals, most population-based surveys have been performed on individuals over 40 years of age.[5-11,13,14,22] The reported figures vary significantly which may be due to racial differences: 1.4% in Sicily-Italy,[23] 1.97% in Spanish residents of Arizona, USA,[14] 2.1% in the Beaver Dam Eye Study in USA,[22] 2.8% in northern Italy,[13] 3.7% in Maryland, USA,[8] 3.7% in Chinese residents of Singapore,[7] and 3.8% in Bangkok, Thailand.[24] The study in Sicily was performed on an age and sex stratified basis, therefore the prevalence could have changed if a different method of randomization had been employed. The Maryland study was performed on a non-homogenous population of whites and African-Americans, furthermore, the reported figure comprised the overall prevalence of definite glaucoma and glaucoma suspects. In a survey on a mainly black population in St. Lucia Island with a reportedly high prevalence of glaucoma, 8.8% of the over 30 population were affected.[12] Another case of differences in reported rates of glaucoma is the diversity of the disorder and the lack of uniformity in diagnostic criteria and definitions.

The influence of gender on the prevalence of glaucoma has been variable. Glaucoma was more common in males in the central Swedish[25] and the Singapore[7] studies. In contrast, the Sicily,[23] northern Italy,[13] and St. Lucia[12] studies reported a higher prevalence of glaucoma in females. However no significant gender dependent trend was shown in the Melbourne,[5] Beaver Dam,[22] and Arizona[14] studies. The present study revealed a 2.3 fold higher rate of glaucoma in male subjects. Of note, the age and sex distribution of the sampled population in our study was different from that reported in the latest census in the city of Tehran. There was a significant discrepancy in this survey such that male subjects under age 50 participated less than men over age 50. This fact may explain the higher prevalence of glaucoma in men, which may be due to a higher proportion of older male subjects. The current survey reconfirmed the age dependent trend in glaucoma: the prevalence of glaucoma was almost 9 fold greater in subjects over 80 as compared to the 40-49 year age group.

A number of population based glaucoma surveys initialize the screening process by IOP measurement. Setting an IOP limit above which further work-up is undertaken will cause a selection bias, which may be termed exclusion by tonometry. According to the Arizona study,[14] screening results with an IOP>22 mmHg would miss 80% of open angle glaucoma cases. Some studies have demonstrated that nearly 50% of patients with established glaucomatous visual field defects may have initial IOP readings in the normal range.[26] In other words, the sensitivity of IOP measurement as a screening tool for glaucoma detection is limited to 50%. The current study also revealed that only 61% of cases with definite glaucoma had initial IOP> 22 mmHg. In comparison, glaucomatous optic nerve head changes were observed in 64.5% of subjects with glaucoma. This figure exceeds the 49% sensitivity reported in the Maryland study[8] with limits set at C/D ratio> 0.50 and neural rim< 0.15. Combining IOP measurement and optic nerve head changes for detecting glaucoma probably increases the efficiency of the screening process and may be considered as one of the strong points of this survey. Another strong point of the current survey was that all subjects underwent gonioscopy.

One limitation of this study was the parti-

cipation rate (49.4%), which is less than the 71.8-90.1% range reported in similar surveys.[5,7,9-14] Response rate was lower in males, which is similar to the trend observed in some other studies.[12,13] The higher observed prevalence of glaucoma in male subjects is probably secondary to the selection bias introduced by lower participation of younger male subjects. The issue of low response rate may raise the question whether this sample was truly representative of the general population. However, we were not surprised by the response rate because other similar population based studies in fields other than glaucoma showed a similar response rate, which is the reason the calculated sample size was doubled at the time of project planning. Another limitation is the failure to obtain central corneal thickness measurements, which could have affected diagnostic categorization of our subjects. This issue is of particular importance in patients with normal tension glaucoma and ocular hypertension. However we should keep in mind that no general consensus exists for application of IOP correction factors and some investigators apply no correction at all. Nevertheless, the importance of central corneal thickness measurements in diagnosis and prognostication of glaucoma cannot be overlooked.

The last point to be stressed is that over 80% of affected subjects were unaware of the condition. The corresponding figure in the Arizona study[14] was 62%. In developed countries, fewer than 50% of glaucoma patients are aware of their disease. The rate is even lower in the developing world.[27] These alarming figures bring out the importance of screening programs for early glaucoma detection bearing in mind that glaucoma is the second cause of irreversible blindness worldwide[28] and has even been reported as the leading cause in some studies.[7] The prevalence of glaucoma in Tehran is in the lower range reported in other studies. A nationwide screening program is required to determine the overall prevalence of glaucoma in the country.

REFERENCES

1. The glaucoma suspect: When to treat? In: Allingham RR, Damji K, Freedman S, Moroi S, Shafranov G. Shields' text book of glaucoma. 5th ed. Philadelphia: Lippincott Williams & Wilkins; 2005: 191-196.
2. Weinreb RN, Khaw PT. Primary open-angle glaucoma. Lancet 2004;393:1711-1720.
3. Resnikoff S, Pascolini D, Etya'ale D, Kocur I, Pararajasegaram R, Pokharel GP, et al . Global data on visual impairment in the year 2002. Bull World Health Organ 2004;82:844-851.
4. Becker-Shaffer S. Diagnosis and therapy of the glaucomas. 7th ed. St. Louis: Mosby; 1999.
5. Wensor MD, McCarty CA, Stanislavsky YL, Livingston PM, Taylor HR. The prevalence of glaucoma in the Melbourne visual impairment project. Ophthalmology 1998;105:733-739.
6. Arkell SM, Lightman DA, Sommer A, Taylor HR, Korshin OM, Tielsch JM. The prevalence of glaucoma among Eskimos of northwest Alaska. Arch Ophthalmol 1987;105:482-485.
7. Foster PJ, Oen FTS, Machin D, Ng TP, Devereux JG, Johnson GJ, et al. The prevalence of glaucoma in Chinese residents of Singapore: a cross-sectional population survey of the Tanjong Pagar District. Arch Ophthalmol 2001;118:1105-1111.
8. Tielsch JM, Katz J, Singh K, Quigley HA, Gottsch JD, Javitt J, et al. A population-based evaluation of glaucoma screening: the Baltimore Eye Survey. Am J Epidemiol 1991;134:1102-1110.
9. Buhrmann RR, Quigley HA, Barron Y, West SK, Oliva MS, Mmbaga BB. Prevalence of glaucoma in a rural east African population. Invest Ophthalmol Vis Sci 2000;41:40-48.
10. Rotchford AP, Johnson GJ. Glaucoma in Zulus: a population-based cross-sectional survey in a rural district in South Africa. Arch Ophthalmol 2002;120:471-478.
11. Rotchford AP, Kirwan JF, Muller MA, et al. Temba glaucoma study: a population-based cross-sectional survey in urban south Africa. *Ophthalmology* 2003;110:376-382.
12. Mason RP, Kosoko O, Wilson MR, Martone JF, Cowan CL, Gear JC, et al. National survey of the prevalence and risk factors of glaucoma in St. Lucia, West Indies: part 1- prevalence findings. *Ophthalmology* 1989;96:1363-1368.
13. Bonomi L, Marchini G, Marraffa M, Bernardi P, Franco ID, Perfetti S, et al. Epidemiology of angle-closure glaucoma: prevalence, clinical types, and association with peripheral anterior chamber depth in Egna-Neumarkt Glaucoma Study. *Ophthalmology* 2000;107:998-1003.

14. Quigley HA, West SK, Rodriguez J, Munoz B, Klein R, Snyder R. The prevalence of glaucoma in a population-study of Hispanic subjects: Proyecto VER. *Arch Ophthalmol* 2001;119:1819-1826.
15. Iranian Statistics Center. Report of the 1996 population census. (http://amar.sci.or.ir, accessed 4 June 2006).
16. Emami H, Rad S, Ghaffari H, Azizi F. Difference between respondents and non-respondents in the Tehran Lipid and Glucose Study (TLGS). *Iranian Journal of Endocrinology and Metabolism* 2005;4:319-323,372. [Language: Farsi]
17. Foster PJ, Buhrmann R, Quigley HA, Johnson GJ. The definition and classification of glaucoma in prevalence studies. *Br J Ophthalmol* 2002;86:238-242.
18. Dandona L, Dandona R, Mandal P, Srinivas M, John RK, McCarty CA, et al. Angle-closure glaucoma in an urban population in southern India: the Andra Pradesh Eye Disease Study. *Ophthalmology* 2000;107:1710-1716.
19. American Academy of Ophthalmology. Basic and clinical science course: Glaucoma. USA: The Academy; 2002-2003.
20. World Health Organization. International statistical classification of diseases and related health problems (10th Revision). 2nd ed. Geneva: WHO; 2005.
21. Dandona L, Dandona R, Mandal P, Srinivas M, John RK, McCarty CA, et al. Open-angle glaucoma in an urban population in southern India: the Andra Pradesh Eye Disease Study. *Ophthalmology* 2000;107:1702-1709.
22. Klein BEK, Klein R, Sponsel WE, Franke T, Cantor LB, Martone J, et al. Prevalence of glaucoma: the Beaver Dam Eye Study. *Ophthalmology* 1992;99:1499-1504.
23. Giuffre G, Giammanco R, Dardanoni G, Ponte F. Prevalence of glaucoma and distribution of intraocular pressure in a population: the Casteldaccia Eye Study. *Acta Ophthalmol Scand* 1995;73:222-225.
24. Bourne RRA, Sukudom P, Foster PJ, et al. Prevalence of glaucoma in Thailand: a population based survey in Rom Klao District, Bangkok. *Br J Ophthalmol* 2003;87:1069-1074.
25. Ekstrom C. Prevalence of open-angle glaucoma in Central Sweden: the Tierp glaucoma survey. *Acta Ophthalmol Scand* 1996;74:107-112.
26. Sponsel WE. Tonometry in question: can visual screening tests play a more decisive role in glaucoma diagnosis and management? *Surv Ophthlalmol* 1989;33(suppl):291-300.
27. Quigley HA. The number of persons with glaucoma worldwide. *Br J Ophthalmol* 1996;80:389-393.
28. Quigley HA, Broman AT. The number of people with glaucoma worldwide in 2010 and 2020. *Br J Ophthalmol* 2006;90:262-270.