



Original article

Results of the Bhaktapur Glaucoma Study, Nepal

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Abstract

Introduction: The Bhaktapur Glaucoma Study is a population-based, cross-sectional and longitudinal study undertaken in one of the districts of Nepal. **Objectives:** To determine the prevalence of glaucoma in Bhaktapur district, Nepal. **Materials and methods:** Thirty clusters were randomly selected and a door-to-door census was conducted to identify citizens 40 years of age and older. Four thousand eight hundred individuals fulfilling the eligibility criteria were referred to the base hospital in Kathmandu for a detailed clinical examination. The diagnosis of glaucoma was based upon criteria described by the International Society for Geographic and Epidemiological Ophthalmology (ISGEO). **Results:** Complete data was available on 3991 subjects (response rate 83.15 %). The mean IOP was 13.3 mm Hg (97.5th and 99.5th percentiles, 18 and 20 mm Hg, respectively) and mean VCDR 0.26 (97.5th and 99.5th percentiles, 0.6 and 0.8 mm Hg, respectively). Seventy-five subjects had glaucoma, an age-sex-standardized prevalence of 1.80 (95 % confidence interval (CI), 1.68 - 1.92). The age-and sex-standardized prevalence of POAG was 1.24 % (CI, 1.14 - 1.34), PACG 0.39 % (CI, 0.34 - 0.45) and secondary glaucoma 0.15 % (CI, 0.07-0.36). The prevalence of glaucoma increased with increase in age and there was no significant difference in gender. Nine eyes were blind and two subjects bilaterally blind from glaucoma. **Conclusion:** The overall prevalence of glaucoma was 1.9%. POAG was the most common form of glaucoma. Visual morbidity from PACG, however, was higher. A large majority of the subjects with POAG had not been previously diagnosed and had intraocular pressure within the normal range.

Key-words: glaucoma, epidemiology, Nepal

Introduction

Cataract is the major cause of blindness worldwide. It is estimated that 41.8% of all global blindness is caused by cataract (Thylefors, 1995). Glaucoma is the second leading cause of blindness in the world and the leading cause of irreversible

blindness. The number of people with glaucoma is expected to increase due to the aging of the population. Quigley and Broman (2006) have estimated that there will be 60.5 million people with glaucoma in 2010. Asians are expected to represent 47% of those with glaucoma and 87% of those with angle closure glaucoma (Quigley & Broman, 2006).

The World Health Organization (WHO) estimates that 3.4% of people aged 50 years and older are blind in the Southeast Asian sub-region that includes

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Nepal. In this sub-region, WHO estimates that approximately 9% of blindness in all age groups is due to glaucoma (Resnikoff et al, 2004). These estimates are very crude, given the paucity of visual epidemiology work conducted in Nepal. Only two studies of the adult Nepalese population were reviewed by WHO, neither of which was designed to measure glaucoma prevalence (Brilliant et al, 1985; Pokharel et al, 1998). Instead, the estimate relied heavily on population-based studies in India, Bangladesh, and Pakistan, along with assumptions based on the population age distribution and mortality rate in this sub-region (Pascolini, 2002).

Nepal is a South Asian country with approximately 27 million people from a multitude of ethnic groups. In 1981, it was found that cataract accounted for 66.8% of all blindness in Nepal, with glaucoma responsible for 3.2% (Brilliant et al, 1985). The prevalence of various subtypes of glaucoma has not been delineated in Nepal.

Research objectives

The objectives of the Bhaktapur Glaucoma Study (BGS) were:

1. To estimate the prevalence of glaucoma in subjects more than 40 years of age in this population and investigate the risk factors that could have an association with glaucoma (such as age, sex, intraocular pressure, central corneal thickness, refractive error, hypertension and diabetes).
2. To estimate the prevalence of visual impairment (VI) and blindness in subjects more than 40 years of age in this population and to evaluate the visual outcome after cataract surgery.
3. To compare the anterior chamber depth and axial length between normal, primary open angle glaucoma, primary angle suspects and primary angle closure glaucoma.
4. To determine the awareness of eye diseases such as cataract and glaucoma in the community.

5. To investigate the genetic risk factors for the development of glaucoma and other common blinding diseases.

Materials and methods

Study design

Bhaktapur is one of the three districts of Kathmandu valley which represents a metropolitan city with a predominantly agrarian rural periphery. It is situated approximately 15 kilometers from Kathmandu, the capital city of Nepal. We selected this district because it does not have an eye hospital to serve its population.

The study was designed as a population based cross-sectional study involving the selection of 4,800 subjects aged 40 years and above residing in Bhaktapur district. A sample size of 4,758 was calculated after assuming a prevalence of 3 % for glaucoma, a relative precision of 25%, 85% compliance and a design effect of 2 (Lwanga & Lemeshow, 1991; Bennet et al, 1991; Carlin & Hocking, 1999). The 3% prevalence of glaucoma was derived from studies undertaken in the region such as the Andhra Pradesh Eye Disease Study (APEDS), (Dandona et al, 2000a; Dandona et al, 2000b), Vellore Eye Study (Jacob et al, 1998; Thomas et al, 2001), Chennai Glaucoma Study (Vijaya et al, 2005; Vijaya et al, 2006) and West Bengal Glaucoma Study (Raychaudhuri et al, 2005).

A two-stage World Health Organization 30 cluster sampling procedure was adopted for patient selection (WHO, 1991). The sampling frame comprised of 161 wards and an estimated population of 48,223 people above the age of 40 years (National census of Nepal, 2001). In the first stage, 30 wards were selected and field workers conducted a census. In the second stage, a database was prepared and names of all eligible subjects were recorded. From this list, 4,800 subjects were selected using EPI-INFO software, version 3.5.1 (www.cdc.gov/epiinfo). Selected subjects were revisited by field workers and referred to Tilganga Institute of Ophthalmology (TIO) for a comprehensive eye examination.



Clinical examination

Two fellowship trained glaucoma specialists were involved in the clinical evaluation. The distance and near visual acuities (VA) were measured using logarithm of minimum angle of resolution tumbling E charts placed at 4 meters. Slit-lamp biomicroscopy was performed to identify ocular abnormalities. Attention was drawn particularly towards abnormalities such as ischemic sequelae of previous acute angle closure, secondary glaucoma and signs of past glaucoma surgery. Peripheral anterior chamber depth was graded according to the van Herick's technique (van Herick et al, 1969). Intraocular pressure (IOP) was measured with a Goldmann applanation tonometer and a median of three consecutive recordings was taken as the IOP for each eye (Kass, 1996). Gonioscopy was done on all subjects with a Zeiss 4 mirror lens in ambient light conditions using a shortened slit beam that did not fall upon the pupil. The angle was graded according to the Shaffer system (Shaffer, 1960). Subjects with occludable angles underwent indentation gonioscopy to establish whether peripheral anterior synechia were present.

All subjects had their pupils dilated unless contraindicated because of risk of angle closure. The lens was examined and cataract graded according to Lens Opacities Classification System II (Chylack et al, 1989). Fundus examination included evaluation of the optic disc and macula with a 90 Diopter lens. A measuring eyepiece graticule was used to measure the vertical cup-disc diameter. Optic disc photographs were taken and evaluated.

All subjects underwent ultrasonic pachymetry to measure the central corneal thickness (CCT). Ocular biometry was performed on every fifth subject, with the first subject being randomly selected. Measurements of axial length and the anterior chamber depth were taken. Those subjects with occludable angles, primary angle closure and with primary angle-closure glaucoma (PACG) also underwent ocular biometry measurements. Frequency Doubling Perimetry was performed on

all subjects with a visual acuity of Log MAR 0.6 or better, using the C-20-1 program. Automated perimetry SITA 24-2; Humphrey Field Analyzer was performed on glaucoma suspects and repeated if the test reliability was not satisfactory or when there was a glaucomatous field defect. Laser Peripheral Iridotomy was performed on subjects with occludable angles. A total of 2 ml peripheral blood was collected in 9 ml EDTA tubes from all subjects. Using this resource, we aim to screen for identified disease causing genetic variants, as well as identify potential novel disease associated genes.

Diagnostic definitions

Glaucoma cases were defined according to the International Society of Geographical and Epidemiological Ophthalmology (ISGEO) scheme (Foster et al, 2002). The distribution of vertical cup to disc ratio (VCDR) from subjects with a normal result on suprathreshold field screening in both eyes of the non glaucomatous population was calculated. We used a more lenient definition to define occludable angles. An occludable angle was diagnosed when the posterior trabecular meshwork was not seen for $> 180^\circ$ on non-indentation gonioscopy. A provisional diagnosis of glaucoma suspect was made when the subject had one or more of the following: IOP ≥ 21 mmHg in either eye; VCDR ≥ 0.7 in either eye or CDR asymmetry ≥ 0.2 ; and focal thinning, notching or splinter hemorrhage. A glaucomatous visual field defect was considered to be present, when a) a glaucoma hemifield test result was outside normal limits, and b) a cluster of three or more non edge, contiguous points, not crossing the horizontal meridian, with a probability of $< 5\%$ of age matched normal on the pattern deviation plot was noted.

Visual impairment, blindness and low vision were defined as per International Classification of Diseases 10th edition (WHO, 1992). The International Classification of Diseases 10th edition (ICD -10) defines visual impairment as VA of less than 6/18 (20/60, 0.3) in the better eye with the best correction (WHO, 1992). Visual impairment has been categorized to blindness and low vision.

A VA of less than 3/60 (20/400, 0.05) with best correction or a visual field less than 10° from fixation in the better eye has been considered blindness. Low vision has been defined as a best corrected VA of less than 6/18 (20/60, 0.3), but not less than 3/60 (20/400, 0.05) in the better eye.

Results

The demographic details of 4,800 subjects are presented in Table 1. The mean age of participants was 55.4 ± 12.3 years (range: 40 - 99) and 51.8% were female. 64.8% of our cohort was aged less than 59 years and 60.5% were illiterate. Among the various ethnic races, 69.7% belonged to the Newar ethnic group.

Table 1: Baseline demographic profile of the sample population

Age Group	Female No. (%)	Male No. (%)	Total (%)
40-49	965(20.1)	893(18.6)	1858(38.9)
50-59	649(13.5)	596(12.4)	1245(25.9)
60-69	450(9.4)	451(9.4)	901(18.8)
70-79	313(6.5)	278(5.8)	591(12.3)
> 80	109(2.3)	96(2.0)	205(4.3)
Total	2486(51.8)	2314(48.2)	4800(100)

Table 2: Demographics of the glaucoma cases

	All (n)	Males (n)	Females (n)	M:F Ratio	Median Age	Diagnostic Category (%)			Previously diagnosed (%)
						1	2	3	
POAG	51	26	25	1.04	68.53	45(88.24)	5(9.80)	1(1.96)	2(3.92)
PACG	17	4	13	0.30	71.23	12(70.59)	5(29.41)	0(0.00)	5(29.41)
Secondary Glaucoma	7	6	1	6.0	64.00	2(28.57)	4(57.14)	1(14.29)	4(57.14)
Total	75	36	39	0.92	70.00	59(78.67%)	14(18.67)	2(2.66)	11(14.67)

The mean CCT was 539.10 μm (SD ± 33.73) and IOP 13.33 mmHg (SD ± 2.26). For male and female, the mean CCT was 540.54 μm (SD ± 34.60) and 537.84 μm (SD ± 32.91) respectively. CCT was not significantly different between genders (p = 0.06). A considerable difference in CCT values across different age groups for both genders (male: p = 0.017 and female: p = 0.002) was noted. The mean IOP in males was 13.36 mmHg (SD ± 2.27) and in females was 13.32 mmHg (SD ± 2.25). This

The median IOP in this population was 13.0 mm Hg. The median VCDR was 0.20 and 97.5th percentile 0.6. We recommend that a VCDR of > 0.6 should be viewed with suspicion for glaucoma in our population. The age - and sex adjusted standardized prevalence of glaucoma was 1.9 (95% confidence interval (CI), 1.68 - 1.92). Age - and sex-standardized prevalence of POAG and PACG was 1.24% (CI, 1.14 - 1.34) and 0.39 % (CI, 0.34 - 0.45) respectively. There was an increase in the prevalence of glaucoma with increase in age. There was no significant difference in gender. No subjects in the age group of 40 - 59 years had PACG. PACG was three times more common in females. Those with hypertension and diabetes were not at risk for developing POAG and PACG.

The demographics of the glaucoma cases are presented in Table 2. Nine eyes were blind from glaucoma; POAG, PACG and secondary glaucoma contributing to 3 eyes each. Two subjects were bilaterally blind, 1 each from PACG and POAG. Among POAG subjects, 96.08 % had not been previously diagnosed. There were 42 (85.71%) out of 49 undiagnosed POAG subjects that had IOP ≤ 97.5th percentile cut off (18.00 mm Hg). They were classified as having normal tension glaucoma (NTG).

value was not significantly different across genders (p = 0.74).

Linear regression analysis suggests that CCT measurements decreases by 2.67 μm, (95% CI 2.21- 4.13) per decade changes in age. A 100 μm increase in the central corneal thickness was associated with a 1.03 mmHg (CI 0.79 - 1.26) increase in intraocular pressure after adjusting for age and gender. The relationship between IOP and CCT is depicted in Figure 1.

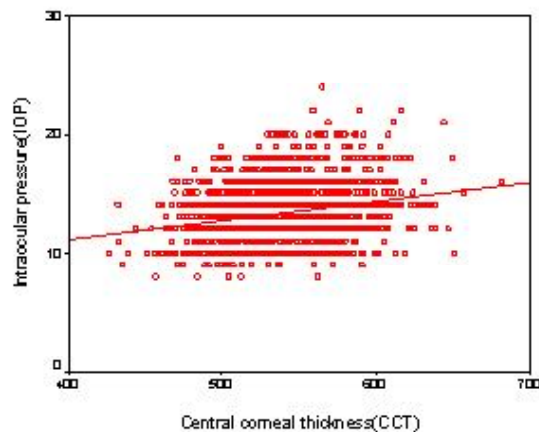


Figure 1: Scatter plot of IOP and CCT with linear regression line.

As the number of subjects in the PACG group was very small and the demography was significantly different among the three groups, we compared the anterior chamber depth (ACD) and axial length between the normal and occludable angle group. In the occludable angle group, the ACD (2.55 ± 0.69) was significantly different ($p < 0.001$) from that of the normal group (2.85 ± 0.39). The axial length (22.08 ± 0.83) in the occludable angle group was also considerably different ($p < 0.001$) when compared to the normal group (22.62 ± 0.90). In PACG group, the ACD and axial length was 2.48 ± 0.22 and 22.02 ± 0.59 respectively.

The risk of having occludable angle was higher (OR: 4.92, 95% CI 2.50 - 9.70) in the 60 - 69 age group when compared to the 40 - 49 age group. The females were found to be at a higher risk (OR: 2.81, 95% CI 1.67- 4.74) when compared with males. After applying multivariable logistic regression analysis adjusting for age and sex, we found that the risk of having an occludable angle decreases with per unit millimetre increase in ACD (OR 0.24, 95% CI 0.12 - 0.50) and axial length (OR 0.49, 95% CI 0.36 - 0.67).

The age -sex adjusted prevalence of blindness (best corrected $< 3/60$) and low vision (best corrected $< 6/18 \geq 3/60$) was 0.43 % (95 % C.I. 0.25- 0.68) and 3.97 % (95% C.I. 3.40 - 4.60) respectively. Cataract (53.3%) was the principal cause of blindness. The leading cause of low vision was cataract (60.8%) followed by refractive error

(12%). The cataract surgical coverage was 90.36% and was higher in the younger age group, in females and illiterate subjects. Pseudophakia was seen in 94%. Awareness of cataract (6.7%) and glaucoma (2.4%) was very low. Among subjects who were aware, 70.4% had knowledge of cataract and 45.5% of glaucoma. Cataract was commonly known to be a 'pearl like dot' white opacity in the eye while glaucoma was known to cause blindness. Awareness remained unchanged in different age groups for cataract while for glaucoma there was an increase in awareness with age. Women were significantly less aware (odds ratio (OR): 0.63; 95%, confidence interval (CI): 0.54 - 0.74) for cataract and (OR: 0.64; 95% CI: 0.50 - 0.81) for glaucoma. Literacy was also correlated with awareness. The causes of visual impairment are represented in Table 3.

Table 3: Causes of visual impairment (best corrected, better eye)

Cause	Low vision	Unilateral blindness	Bilateral blindness
Cataract	96 (60.8%)	53 (37.1%)	16 (47.1%)
Retinal disorder	18 (11.4%)	21 (14.7%)	5 (14.7%)
Corneal scar	4 (2.5%)	18 (12.6%)	5 (14.7%)
Refractive error	19 (12.0%)	10 (7.0%)	3 (8.8%)
Phthisis bulbi	0 (0.0%)	14 (9.8%)	2 (5.9%)
Trauma	0 (0.0%)	11 (7.7%)	1 (2.9%)
Glaucoma	4 (2.5%)	5 (3.5%)	2 (5.9%)
Surgical complication	5 (3.1%)	4 (2.8%)	0 (0%)
Amblyopia	1 (0.6%)	3 (2.1%)	0 (0%)
Optic atrophy	1 (0.6%)	3 (2.1%)	0 (0%)
Undetermined	2 (1.3%)	1 (0.7)	0 (0%)
PCO	6 (3.8%)	0 (0%)	0 (0%)
Aphakia	2 (1.3%)	0 (0%)	0 (0%)
Total	158 (100%)	143 (100%)	34 (100%)

The mean age (SD) of subjects that underwent cataract surgery was 70.3 (10.2) years. Pseudophakia was present in 142 (94.0%) while aphakia in 9(6%) subjects. Presenting and best corrected visual acuity of $\geq 6/18$ was achieved in 123 (54.4%) and 164 (72.4%) eyes respectively. Among pseudophakics, at presentation 122 (57.5%), 72 (33.9%), 18 (8.5%) eyes and after best correction 162(76.2%), 33 (15.8%), and 17(8.0%) eyes had visual acuity $\geq 6/18$, $< 6/18$ -

$\geq 6/60$ and $<6/60$ respectively. Retinal disease 22 (35.5%), surgical complications 17 (27.4%) and PCO 9 (14.5%) were the principle causes of visual impairment after best correction in all operated eyes (Table 4). There was no significant association in visual outcome based on age (except age group ≥ 80 years), sex, literacy and the duration of surgery. Altogether, 89(58.9%) subjects had undergone surgery 5 years before the survey was undertaken.

Table 4: Principal cause of visual impairment / blindness in cataract operated eyes by best corrected visual acuity*

	<6/18 - $\geq 6/60$	<6/60	Total	<6/18 - $\geq 6/60$	<6/60	Total
Principal cause	Pseudophakia			Aphakia		
Retinal pathology	9	6	15 (30)	6	1	7(58.3)
Surgical complication	7	7	14 (28)	3	0	3(25)
PCO	7	2	9 (18)	0	0	0(0)
Corneal pathology	3	1	4(16)	0	0	0(0)
Optic atrophy	2	1	3(6)	0	0	0(0)
Glaucoma	2	0	2(4)	1	1	2(16.7)
Amblyopia	1	0	1(2)	0	0	0(0)
Phthisis bulbi	0	0	0(0)	0	0	0(0)
Undetermined/Others	2	0	2(4)	0	0	0(0)
Total	33	17	50(100)	10	2	12(100)

*Data are given as number (%) of eyes.

Four *Hepatocyte Growth Factor (HGF)* Single Nucleotide Polymorphisms were found to be significantly associated with ACG. In addition, haplotype analysis showed one haplotype to be significantly associated with ACG ($p=0.001$) in Nepalese individuals.

Discussion

The BGS is the first study in Nepal to report the prevalence of glaucoma based on the ISGEO criteria and is therefore comparable to other studies from the world that follow the same criteria (Thapa et al, 2011). The prevalence of glaucoma in this Nepalese population was 1.9 % (Thapa et al, 2012). The prevalence of glaucoma was lower than studies from south Asia as shown in Table 5. POAG was the most common form of glaucoma. Among

the POAG subjects who were not previously diagnosed 85.71% had NTG. A high prevalence of NTG similar to our study has also been reported from other populations in Asia (Shen et al, 2008; Iwase et al, 2004). Although the prevalence of PACG was low (0.43%), the visual impairment was more than POAG reiterating findings from studies in Asia that most morbidity caused by glaucoma was from PACG. Majority of POAG subjects (95.4%) had not been previously diagnosed. Similar rates ($>90\%$) have been reported from several studies in India (Dandona et al, 2000; Vijaya et al, 2005; Ramakrishnan et al, 2003). Glaucoma therefore is an undiagnosed and blinding disease in Nepal which demands eye care programs to prioritise their effort towards promoting awareness and finding novel ways of screening for the disease.

Table 5: Prevalence of glaucoma in population –based studies in South Asia

Study Population	Age	Prevalence %			
		All	POAG	PACG	Ratio of POAG to PACG
Bangladesh, Dhaka	40 +	3.1	2.5	0.4	6.3
West Bengal, East India	50 +	3.3	3.1	0.2	10.00
*ACES, South India	40 +	2.6	1.2	0.5	2.4
†APEDS, South India	40 +	-	2.6	1.1	2.4
§CGS, South India	40 +	-	1.6	0.9	1.4
BGS, Nepal	40 +	1.9			

*ACES: Aravind Comprehensive Eye Survey, †APEDS: Andhra Pradesh Eye Disease Study, § CGS: Chennai Glaucoma Study

The mean IOP and CCT were 13.33 mmHg (SD \pm 2.26) and 539.10 μ m (SD \pm 33.73) respectively. The mean IOP of 13.33 mmHg was similar to some studies from the region (Raychaudhuri et al, 2005; Foster et al, 2003; Rahman et al, 2004; Bourne et al, 2003) but lower than reports from the Caucasian population (Tielsch et al, 1991; Mitcheel et al, 1996). In Table 8, the CCT from different population-based studies conducted in Asia has been presented.

The Nepalese had thicker corneas when compared

to most of these populations and our finding was almost similar to the Singapore Malay Eye Study (Su et al, 2008). Males and females had similar CCT measurements, which correlated negatively with increasing age and positively with IOP (Thapa et al, 2011). A positive association between IOP with CCT reinforces the fact that CCT can influence recordings of IOP while using applanation tonometry, thus suggesting that CCT should be measured in subjects with glaucoma in this population.

Table 6: CCT from different Asian population-based studies

Country	Number of participants	Age group	Instrument used	Mean \pm SD (μ m)
Singapore (Su et al, 2008)	3239	\geq 40 years	Ultrasound Pachymetry	541.2
Nepal (BGS)*	2330	\geq 40 years	Ultrasound Pachymetry	539.10 \pm 33.73
Burma (Casson et al, 2008)	1909	\geq 40 years	Ultrasound Pachymetry	521.9 \pm 33.3
Japan (Suzuki et al, 2005)	7313	\geq 40 years	Specular Microscopy	517.5 \pm 29.8
South India (Vijaya et al, 2010)	6754	\geq 40 years	Ultrasound Pachymetry	511.4 \pm 33.5
Mongolia (Foster et al, 1998)	1242	10- 87 years	Optical Pachymetry	495 \pm 32

*BGS (Bhaktapur Glaucoma Study), current study

A striking finding of our study on biometric measurements was that the eyes of the normal Nepalese population were significantly shorter than

that of south Indian, Chinese, White, or African-American populations (Thapa et al, 2011; George et al, 2003; Congdon et al, 1997; Table 7).

Table 7: Comparison of Nepalese ocular biometric measures with that of different populations

	Nepalese (n = 685)	South Indian (n = 419)	Chinese (n = 531)	White Americans (n = 170)	African-Americans (n = 188)
Sex (M : F)	315 : 370	210: 209	236 : 295	82 : 88	55 : 133
Axial length (mm), mean (SD)	22.62 (0.90)	22.76(0.78)	23.32(1.38)	23.35(1.38)	23.14(0.87)
95% CI difference in means		- 0.24 to - 0.03	- 0.83 to - 0.57	- 0.90 to - 0.56	- 0.66 to - 0.37
p- value		0.008	< 0.001	< 0.001	< 0.001

Our study also confirmed to findings from several other studies where eyes with occludable angles and PACG had shallower ACD and shorter axial length than that of the normal population. Subjects in the occludable angle and PACG groups were older than those in the normal group. There was a significant difference in age between the occludable (mean 59.64 years) and the PACG (mean 71.23 years) groups. This finding could suggest that angle closure glaucoma can occur at a later age in our population and could be related to the thickening of the lens with an increase in age. A shorter axial length in females with PACG than in males could probably be one of the factors responsible for PACG to be more common among females.

The overall prevalence of visual impairment was low in Bhaktapur (Thapa et al, 20011). It was associated with advancing age, female sex prior to best correction of vision and was not associated with literacy. After best correction there was no difference between the sexes. The prevalence of blindness and low vision in Bhaktapur district is lower than in reports from other studies undertaken in Nepal. The prevalence of blindness at presentation (VA <3/60) in our study was 0.73 % which is lower than the 1981 Nepal Blindness Survey (3.4%) (Brilliant et al, 1985), 1995 Lumbini survey (3%) (Pokharel et al, 1998), 2002 Gandaki Zone study (1.4%) (Sapkota et al, 2006), 2010 Lumbini and Chitwan Zone study (2.3%) (Sherchan et al, 2010, and 2010 Rautahat district study (VA <6/60, 17.4 %) (Kandel et al, 2010). This is also lower than in studies conducted in neighbouring countries and the estimate of 3.4% for the South East Asian region (Resnikoff et al, 2004; Vijaya et al, 2006; Dandona et al, 2001; Thulisiraj et al, 2003;

Dunzhu et al, 2003). However, there are several studies in Asia that have also reported a low prevalence of blindness (Liang et al, 2008; Wong et al, 2008, Zainal et al, 2010, Michon et al, 2002; Iwase et al (2006). After best correction the prevalence of blindness was 0.43% in our study.

Cataract remains the principal cause of blindness. The prevalence of cataract blindness was 1.5 %, which is almost similar to that in the Gandaki Zone study (Sapkota et al, 2006) where the outcome of the study was from the area best served by the local eye hospital. The major cause of bilateral blindness (53.3%) was cataract, which was comparable to other studies in Nepal. Together, cataract (60.8%) and refractive error (12.0%) contributed 72.8% of the total burden of low vision that was curable. There were more women with low vision due to uncorrected refractive error. The 1981 Nepal Blindness Survey (Brilliant et al, 1985) and the 1995 Lumbini survey (Pokharel et al, 1998) have also reported that females were more likely to have visual impairment. This finding in our population could suggest that women were not seeking eye care for reasons such as unequal access, social stigma related to wearing spectacles and others. In the future, rehabilitation programs will need to target women among this population.

A cataract surgical coverage (CSC) of 90.36% was highest in comparison to all the other studies of Nepal. Since 1994, Tilganga Institute of Ophthalmology has held numerous cataract screening programs in Kathmandu valley particularly focusing on Bhaktapur. These services could have lead to the high CSC. Among subjects that had undergone cataract surgery, 94% had pseudophakia. This was very high compared to



16.4 % seen in Lumbini district (Pokharel et al, 1998). The Fred Hollows Intraocular Lens Laboratory at TIO has been manufacturing intraocular lenses since 1994. The availability and affordability of intraocular lenses could also have lead to a high prevalence of pseudophakia in Bhaktapur.

The visual outcome following cataract surgery in our subjects did not fulfil the standards proposed by the WHO. It has been suggested by the WHO that 85% of eyes undergoing cataract surgery should result in good outcome (6/6–6/18), 10% borderline outcome (6/18–6/60), while less than 5% poor outcome (6/60) (Resnokoff et al, 2004). After best correction 76.2% subjects had good visual outcome while 15.8% and 8% had borderline and poor visual outcomes respectively (Thapa et al, 2011). When compared to the Lumbini zone and Chitwan district study that was conducted in 2006 (the same year as our study), our study had poorer visual outcomes following cataract surgery. The Lumbini study reported a presenting VA of more than or equal to 6/18 in 61.4% of eyes when compared to 54.5% in our study. The likely explanation for this disparity is that one institution primarily serves Lumbini zone and most of the subjects in the study had undergone surgery in the institution. Bhaktapur district does not have an eye hospital and subjects that had undergone surgery had probably attended several eye centers and institutions in Kathmandu, which could have made a difference to the outcome of cataract surgery.

The commonest cause of visual impairment was uncorrected refractive error following cataract surgery. The visual acuity in eyes of a large number of subjects improved after refraction (18.9% \geq 6/18 and altogether 37.7%). This reiterates findings from studies conducted in this region (Murthy et al, 2001; Dandona et al, 1999; Vijaya et al, 2010; Nirmalan et al, 2002) for proper use of corrective lenses to improve visual outcome following cataract surgery. After best correction, coincident retinal disease (35.5%) was the most common cause of

visual impairment and blindness. The average age of 70.3 years of our study subjects and the possibility of incorrect patient selection could have lead to this finding. The other common causes were surgical complications (27.4%) and posterior capsule opacification (PCO) (14.5%). Our rate of PCO was less than reports from Pakistan (Rupert et al, 2007), Rajasthan study (Murthy et al, 2001) and Sivangana study (Thulasiraj et al, 2002). The causes for PCO could not be identified in our patients. However, it can be concluded that an improvement in the surgery technique, selection of the type of IOL and careful postoperative follow up after cataract surgery are necessary to lower the incidence of PCO in the future. The vision of 9 (4.2%) of the 212 eyes with PCO could have possibly improved to more than 6/18 had they received laser treatment thus emphasizing the need of lasers to be made available at the community centers.

Awareness and knowledge of cataract and glaucoma was very poor (Thapa et al, 2011). We are alarmed and unable to explain the reason for such a low awareness on cataract despite there being several cataract screening programs held in the past several years in Bhaktapur. Subjects mostly understood cataract as a 'pearl like dot' white appearance in the eye while glaucoma was known to cause blindness. Previous studies on cataract surgery undertaken in Nepal (Brilliant & Brilliant, 1985) and south India (Brilliant et al, 1991) have reported that males, literates and those affluent were more likely to be aware of cataract surgery. Similarly in our study males, literates and the affluent Brahmin and Chettri (Population monograph of Nepal, 2003) classes were more aware of both conditions. Majority of the subjects (55.8%) had never undergone an eye examination. It is well known that patient education programs have been successful in decreasing the morbidity of diseases (The sixth report of the joint National Committee on prevention, detection, evaluation, and treatment of high blood pressure, 1997; Cleeman & Lenfant, 1998) and have also helped improve compliance in glaucoma



patients (Zimmerman & Zalta, 1983). A novel approach to screening and patient education has been adopted by the TIO to promote awareness, screening and follow up of patients (Thapa et al, 2008). Therefore, it need not be stressed that patient education programs will have to be incorporated in cataract intervention programs to raise awareness and encourage the people to come forth for an eye examination.

The results of the genetic study suggest that *HGF* may play a role in the etiology of ACG in the Nepalese population (Awadalla et al, 2011). Future replication studies in different ethnic populations are necessary to confirm this firm association and to further explore the role of *HGF* in the pathogenesis of this blinding disease.

The required sample size of 4758 subjects could not be fulfilled as we were not able to contact or convince all subjects to undergo an eye examination at the hospital, besides seventy five subjects had also died during the time of the survey. The major strength of our study was the large sample size, the high response rate (83.39%) and the comprehensive eye examination at the base hospital, which resulted in an accurate diagnosis. We were unable to perform visual field testing on all subjects, which could have lead to an underestimation of the prevalence of glaucoma. We were also unable to comment on the visual status of the non-respondents. The principal reason for non-attendance was occupation related. Hence, it was unlikely that the non-respondents were blind from glaucoma and other eye diseases suggesting that the prevalence of glaucoma and visual impairment in them was less than the respondents.

Conclusion

Bhaktapur district was selected for logistical reasons and not randomly, therefore our findings regarding glaucoma are not representative of Nepal. However, Bhaktapur district has socioeconomic conditions and geographic terrains that are similar to the two neighbouring districts, suggesting that our findings could be representative of Kathmandu valley. In the future, other population-based studies conducted

in different parts of the country will be necessary to comment further on the scenario of glaucoma in Nepal.

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