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Prevalence and Causes of Visual Impairment and Blindness in Older Adults in an Area of India with a High Cataract Surgical Rate

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Abstract

Background—The cataract surgical rate (CSR) in Gujarat, India is reported to be above 10,000 per million population. This study was conducted to investigate the prevalence and causes of vision impairment/blindness among older adults in a high CSR area.

Methods—Geographically defined cluster sampling was used in randomly selecting persons 50 years of age in Navsari district. Subjects in 35 study clusters were enumerated and invited for measurement of presenting and best-corrected visual acuity and an ocular examination. The principal cause was identified for eyes with presenting visual acuity < 20/32.

Results—A total of 5158 eligible persons were enumerated and 4738 (91.9%) examined. Prevalence of presenting visual impairment < 20/63 to 20/200 in the better eye was 29.3% (95% confidence interval [CI]: 27.5–31.2) and 13.5% (95% CI: 12.0–14.9) with best correction. The prevalence of presenting bilateral blindness (< 20/200) was 6.9% (95% CI: 5.7–8.1), and 3.1% (95% CI: 2.5–3.7) with best correction. Presenting and best-corrected blindness were both associated with older age and illiteracy; gender and rural/urban residence were not significant.

Cataract in one or both eyes was the main cause of bilateral blindness (82.6%), followed by retinal disorders (8.9%). Cataract (50.3%) and refractive error (35.4%) were the main causes in eyes with vision acuity < 20/63 to 20/200, and refractive error (86.6%) in eyes with acuity < 20/32 to 20/63.

Conclusions—Visual impairment and blindness is a significant problem among the elderly in Gujarat. Despite a reportedly high CSR, cataract remains the predominant cause of blindness.

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Declaration of Interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

Keywords

Blindness; Cataract; India; Refractive error; Visual impairment

INTRODUCTION

The World Health Organization (WHO) estimates that there are 161 million visually impaired in the world, including 37 million blind—a significant proportion of whom reside in the less developed countries.¹ Due to the size of the population and a high prevalence of blindness, every fifth blind person lives in India resulting in an economic burden that a decade ago was estimated at \$4.4 billion United States dollars (USD) annually.² The magnitude of the global burden of visual impairment and blindness has prompted the launching of VISION 2020 – The Right to Sight, for the elimination of avoidable blindness with special emphasis on six blinding conditions, foremost among which is cataract.^{3,4}

Recent studies have documented the high prevalence of lens opacities among elderly populations in India. Cataract (including already operated cases) was observed in 61% of those >40 years of age in South India and in 75.3% among those >50 years in North India.^{5,6} It has been postulated that the age adjusted prevalence of cataract in India is three times that of the United States.⁷

Cataract is responsible for 60–80% of all blindness in India in the older populations,^{8–15} and 44% among populations of all ages,¹⁶ prompting innovative approaches to tackle the burden. With World Bank assistance of USD 117.8 million, a Cataract Blindness Control Project was initiated in 1994.¹⁷ This extensive project covered two-thirds of the country's population. The project transformed the attitudes, surgical skills and practices in the country, in large measure due to increased awareness among the ophthalmic fraternity. In a country where relatively few patients received an intra ocular lens (IOL) implant in the early nineties, 77% of all cataract surgery was with an IOL implant in 2002.^{18,19}

From an estimated 0.5 million cataract surgeries per year in 1982, the output of cataract surgery increased to 4.8 million by 2006.²⁰ The cataract surgical rate (CSR) in the country increased from 1,200 (1981) to, in some states, more than 4,000 per million population per year by 2002.¹⁹ It has previously been stated by some researchers that surgeons in India would need to perform around 8,000 cataract surgeries for every million population in India, every year.²¹ This would help in eliminating avoidable blindness due to cataract provided the blind have adequate access to surgical services and most surgeries are done on those already blind. Available information on CSR in India does not provide any evidence on the age of those operated nor on the case-mix for surgery (first eye versus second eye; visual acuity of those operated etc.). The Government at the national level computes the CSR based on reports received from district blindness program officers who in turn collate figures obtained from individual eye practices.

An area where a revolution in cataract surgery occurred, both quantitatively and qualitatively, was in the western Indian state of Gujarat. Government sources reported that the CSR for the state was above 8,000 by 2003, increasing to an astounding 11,500 per

million per year in 2007.²² Accordingly, Gujarat afforded an excellent opportunity to assess the impact of a high CSR on the prevalence of visual impairment and blindness, specifically cataract blindness.

Navsari district with an area of 2,211 km² and a 2001 census population of 1,229,463 was identified as the study area.²³ Adults 50 years of age represent 15.2% of the population, while 72.6% of the population lives in rural areas. The CSR for Navsari district was 10,310 per million population in 2006,²⁴ and most of those operated on were expected to reside within the district itself, rather than coming from outside the district. Twenty-three ophthalmologists have practices in the district (6 in the public sector and 17 in the private sector).

MATERIAL AND METHODS

The methodology adopted for enumeration of the target population and subsequent clinical examination of participants was similar to that used in eight earlier population-based surveys conducted in India,^{11–13} Nepal,²⁵ China,^{26–28} and Brazil.²⁹ The use of a standardized protocol allowed for direct inter- and intra-country comparison of findings with those from the previous surveys, particularly the three conducted in the Tirunelveli, Sivaganga, and Bharatpur districts of India.^{11–13}

The study population was selected using randomized cluster sampling, with clusters defined geographically on the basis of census information. The annualized growth rate for the state of Gujarat during the period 1991–2001 was used in projecting the 2006 population from 2001 census data.²³ The sampling frame contained a total of 1,380 clusters, each with an estimated 100 to 150 adults 50 years of age (650 to 1,000 for all ages).

Sample size was calculated on the basis of estimating a blindness prevalence of 8% with an error bound (precision) of 15% with 95% confidence. Assuming an examination response rate of 85%, and a design effect of 2.0 to account for the cluster sampling design, a sample size of 4514 persons 50 years of age is required. Accordingly, 35 clusters were randomly selected, with equal probability, from the 1,380 sampling units (26 were rural and 9 urban).

The training of field teams included a pre-pilot exercise in two rural villages outside of the study area. This was followed by a full-scale pilot exercise in two non-study clusters within the district. Inter-observer reproducibility of visual acuity testing by ophthalmic assistants and of the assignment of a principal cause of visual impairment by the examining ophthalmologist was assessed with independent test-retest evaluations during the pilot exercises. Inter-observer reproducibility of visual acuity testing was also monitored during the full study in seven temporally spaced clusters.

Survey fieldwork was carried out over four months immediately following the field training, beginning in March 2007. After mapping the location of households within each selected cluster, house-to-house visits to enumerate eligible adults were carried out by two teams, each with four enumerators and two field supervisors. Basic demographic data (age, gender, education level, occupation, and spectacle use) were collected on those 50 years of age. Adults of eligible age living in the household for at least six months were included in the

enumeration, as were those temporarily absent from the area. Nonresidents and visitors were not included.

Study subjects were invited to a temporary (makeshift) examination site within the cluster, generally at a primary health center or school, at a mutually agreed upon time within two days of the household visit. Written informed consent was obtained at the time of the enumeration and again at the clinical examination site, in the presence of a local witness. Each of the two clinical teams consisted of one ophthalmologist, four ophthalmic assistants and two field assistants. Study ophthalmologists had a minimum of five years clinical experience and ophthalmic assistants a minimum of three years experience. Most of the team members had worked in previous surveys.

Presenting distance visual acuity was measured, separately for each eye, using a retro-illuminated Log-MAR chart at 4 meters, and at 1 meter for those unable to read optotypes at 4 meters. Those unable to read the top line at a distance of 1 meter were tested for counting fingers, hand movement and light perception. For those wearing glasses, distance visual acuity was measured both with and without spectacles. Near vision was tested using a near vision LogMAR chart at a distance of 40 centimeters. Both distance and near visual acuity were recorded as the smallest line read with one or no errors.

Participants with presenting visual acuity $< 20/32$ in one or both eyes, and all cataract operated participants irrespective of presenting vision, were refracted by an ophthalmic assistant to achieve best corrected visual acuity.

Ophthalmic examination of the eyelid, globe, pupillary reflex and lens was carried out by an ophthalmologist. Intraocular pressure (IOP) was measured using a Tonopen tonometer (Reichert Inc, Depew, New York, USA). For aphakic/pseudophakic participants, the surgical history (date and place of surgery) was obtained along with clinical examination pertaining to the type of surgery and signs of surgical complications. Those with best-corrected distance vision $< 20/32$ had their pupils dilated for indirect ophthalmoscopy and slit lamp examination. Participants suspected of having open angle glaucoma, or retinal or disc abnormalities, regardless of their visual status, were also dilated as determined by the examining ophthalmologist.

Eyes with presenting visual acuity of $< 20/32$ were assigned a principal cause of visual impairment/blindness by the ophthalmologist using a 15-item list. Refractive error was assigned as the cause for those eyes where distance visual acuity improved to $\geq 20/32$ with refractive correction. Cataract was assigned as the cause when lens opacity was commensurate with the presenting visual acuity. Glaucoma was assigned as the cause when glaucomatous disc changes were present, generally accompanied by elevated IOP. For eyes with no apparent explanation for the reduction in vision, the cause was recorded as undetermined.

Treatment of minor eye ailments was provided by the examination team at no cost to the participant, as were spectacles for the cataract operated as required. Those needing cataract surgery were referred to a cooperating NGO (SPELL OUT) or government district hospital.

Respondents who would not come to the examination site despite repeated contacts or those who were physically challenged or ill were offered an examination at their home. In such individuals visual acuity was measured with a LogMAR chart in daylight. A basic eye examination was also carried out, but refraction was not done.

The study adhered to the tenets of the Declaration of Helsinki. Informed consent was obtained from all participants after the nature of the study and the examination procedures were explained to them in the local dialect. The study was approved by the Ethics Committee of the All India Institute of Medical Sciences and by the Institutional Review Board of SEWA-Rural. Human subject research approval for the original protocol was cleared by the WHO Secretariat Committee on Research Involving Human Subjects.

Data Management and Analysis

Household enumeration and clinical examination data forms were checked in the field for accuracy and consistency before being transported to the SEWA-Rural base hospital in Bharuch. A senior coordinator once again checked all forms for accuracy and completeness before having them couriered to the Community Ophthalmology Unit at the Dr. R. P. Centre for Ophthalmic Sciences for computer data entry. Measurement data ranges, frequency distributions and consistency among related measurements were checked with computerized cleaning programs.

For analysis purposes, visual acuity was categorized as follows. normal vision: 20/32 ($< 6/9.5$); near-normal vision (mild visual impairment): $< 20/32$ to $20/63$ ($< 6/9.5$ to $6/18$); moderate visual impairment: $< 20/63$ to $20/200$ ($< 6/18$ to $6/60$); moderate blindness (corresponds to WHO definition of severe visual impairment): $< 20/200$ to $20/400$ ($< 6/60$ to $3/60$); severe blindness (corresponds to WHO definition of blindness): $< 20/400$ ($< 3/60$).

Prevalence of visual impairment/blindness was calculated using presenting and best-corrected visual acuity. Multiple logistic regression was used to investigate the association of age (using 10 year age categories), gender, education, and rural/urban residence with both presenting and best corrected blindness.

The principal cause of visual impairment/blindness was tabulated with respect to both persons and eyes. Because those with visual impairment/blindness in both eyes could represent two different causes of reduced vision, both causes are represented when person level data are tabulated.

Statistical analyses were performed using Stata Statistical Software Release 8.0 (Stata Corporation, College Station, Texas, USA). Confidence intervals (CI) and P values (significant at $P < 0.05$ levels) were calculated with adjustment for clustering effects associated with the sampling design. Cluster design effects are represented by a ratio (termed, deff) that compares the estimate of variance actually obtained with the generally smaller variance that would have been obtained were simple random sampling used. Pair-wise interactions between regression model variables were assessed simultaneously using a Wald F test considered significant at the $P < 0.10$ level.

RESULTS

Across the 35 clusters, 8,163 houses were identified and enumeration interviews were possible in 8,130. A total of 4,783 households were without eligible study subjects; 5,158 were enumerated in the remaining 3,347 households. One eligible person was found in 1,685 households, two in 1,540 households, and three or more in 103 households. The largest household had six eligible persons.

Table 1 shows the age, gender, education level, and rural/urban residence for the enumerated population. The mean age was 60.5 years for males and 60.1 years for females, with a median of 58 years for both males and females. Almost half were without schooling/illiterate.

Common responses regarding occupation were housework (39.6%), manual labor (11.1%), and landowner (10.9%). Nearly one-fourth (23.0%) of the respondents said they were unemployed, retired, or old to work.

Because of the concerted efforts of the two enumeration teams, 4,738 (91.9%) of the enumerated subjects were examined (Table 1). Across the 35 clusters, examination response rates ranged between 87.1% and 96.2%. Mean age was 60.5 years for males and 60.0 for females, with a median of 58 years for both. Of the 4,738 participants, 62 (1.31%) were examined in their homes, rather than at the clinical station within the cluster.

Inter observer agreement was assessed for the assignment of a principal cause of impairment by the study ophthalmologists during the pilot exercise and for visual acuity measurement by ophthalmic assistants during both the pilot and the main survey. During the main survey seven clusters were randomly chosen for quality assurance testing with temporal distribution across the time span of the survey. The agreement for both ophthalmologists and ophthalmic assistants was very good with consistency for visual acuity measurements maintained throughout the survey (Table 2).

In logistic regression modelling with age (categorized), gender, literacy, and rural/urban residence as covariates, higher examination response was associated with female gender (Odds Ratio [OR], 1.46; 95% confidence interval [CI] 1.18–1.80) and literacy (OR 1.24; 95% CI: 1.00–1.53). Compared to the 50–59 year age group, response rates in the 60–69 and 70 age groups were not significant ($P = 0.468$ and $P = 0.622$, respectively). Rural/urban residence was also not significant ($P = 0.101$).

Presenting and best corrected visual acuity for the better- and worse-seeing eye, are shown in Table 3. Presenting visual acuity represents vision with spectacles if they were wearing them at the time of the examination. (A total of 817 [17.2%] examinees were wearing glasses for distance vision, 642 [78.6%] had bifocals.)

Normal/near-normal presenting vision in both eyes (NN) was observed in 53.2% (95% CI: 50.4–55.9; deff=3.51) of participants. Visual impairment in one or both eyes (VI) was present in 29.3% (95% CI: 27.5–31.2; deff=1.90), and unilateral blindness (UL) in 10.6% (95% CI: 9.5–11.7; deff=1.55). Bilateral blindness was present in 6.9% (95% CI: 5.7–8.1;

deff=2.44): moderate blindness (MB) in 2.6% (95% CI: 1.8–3.4; deff=3.06) and severe blindness (SB) in 4.3% (95% CI: 3.5–5.1; deff=1.70).

With best correction, normal/near-normal vision (NN) increased to 75.6% (95% CI: 73.4–77.8; deff=2.99) and visual impairment (VI) decreased to 13.5% (95% CI: 12.0–14.9; deff=2.07). Unilateral blindness (UL) was 7.8% (95% CI: 6.9–8.7; deff=1.35). Bilateral blindness with best correction was 3.1% (95% CI: 2.5–3.7; deff=1.32) of which moderate blindness (MB) was 0.5% (95% CI: 0.2–0.7; deff=1.63) and severe blindness (SB) 2.7% (95% CI: 2.1–3.3; deff=1.59).

Age, gender, literacy and residence were used in multiple logistic regression to predict the risk of presenting and best corrected blindness (Table 4). Blindness was associated with older age with both presenting and best-corrected visual acuity. With best-corrected vision, the 70 year age category had a 10-fold higher risk of blindness compared to the 50–59 year age group. Lack of education (illiteracy) was also significant with both presenting and best-corrected vision. Gender and rural/urban residence were not significant.

As shown in Table 5, cataract (in one or both eyes) was the predominant cause of bilateral blindness (82.6%), followed by macular degeneration, retinal detachment, diabetic retinopathy, and other retinal disorders (8.9%). Because the cause of blindness is not always the same in the two eyes of bilaterally blind persons, the cause-specific total (382) is greater than the number bilaterally blind (327). Other causes (5.8%) were those not assignable to a specific cause category; except in two persons, the other causes were all complications of cataract surgery, such as pupillary capture, retained lens matter, vitreous in the anterior chamber and iris prolapse.

For unilateral blindness, cataract was responsible for more than half of the cases (57.4%), followed by retinal disorders (7.0%). The other causes category (9.8%) was attributable to cataract surgery complications in three-fourths of cases, including posterior capsule rupture, dislocated lens, bullous keratopathy, vitreous in the anterior chamber, iris prolapse, corneal decompensation, and chroidal macular edema.

The prevalence of bilateral blindness caused by cataract (in one or both eyes) in the examined population was 5.7%. The prevalence of blindness caused by retinal disorders (macular degeneration, diabetic retinopathy, retinal detachment, and other retinal disorders) was 0.61%. (As with the number of blind, the total across the cause-specific prevalences [8.0%] exceeds the prevalence of bilateral blindness [6.9%.])

As shown in Table 6, cataract (68.3%) was the main cause of blind eyes, accounting for nearly three out of every four (73.9%) blind eyes in the younger age group. Blind eyes in the literate were less likely to be caused by cataract (63.2%) than blind eyes in the illiterate (70.5%). Cataract as the cause of blindness was followed by retinal disorders (6.8%). As already noted, the other category consisted primarily of cataract surgical complications with trauma, visually impairing pterygium and high myopia the other important causes.

For eyes presenting with moderate visual impairment, < 20/63 to 20/200, cataract was the main cause (50.3%) with refractive errors (35.4%) also common (Table 7). For the younger

age group, refractive error (52.7%) was more common than cataract (37.7%) as a cause; as it was in the literate (43.6% versus 41.1%).

Table 8 shows causes for mild visual impairment < 20/32 to 20/63. Refractive errors (86.8%) were the predominant cause, particularly among those in the younger age group (94.2%). Cataract was the second most common cause, notably in the older age group (15.1%).

DISCUSSION

This population-based study, with methodology similar to that in earlier population-based surveys in India and elsewhere,^{11–13, 25–29} is unique in the sense that it was conducted in an area with a reportedly high CSR over a number of years (2003–2006). Strengths of the study were a sample of over 5000 randomly selected study subjects with an examination response rate exceeding 90%. Confidence intervals and *P* values were calculated with adjustment for clustering effects associated with the sampling design. However, further adjustment for clustering at the household level was not done, and thus, the confidence intervals may be overly small.

Mild visual impairment was categorized separately because refractive errors are common in this group and many of them would therefore need appropriate refractive services. Providing refractive services to these people would also help sustainability of eye care services as they could cross-subsidize cataract surgical services for those who cannot afford the same.

Except for the South Indian survey in Sivaganga,¹² the prevalence of blindness in the older age cohorts was lower than what has been reported in other parts of India over the past few years,^{8–11, 13–15} but similar to that reported a decade ago in Ahmedabad, the capital of Gujarat.³⁰ Residents of metropolitan Ahmedabad might be expected to have better access to eye care compared to those living in a predominantly rural district such as Navsari. Thus, the efforts of government, private and NGO service providers in Navsari are laudable in providing a comparatively similar level of eye care.

Blindness in Navsari district was associated with older age (as expected) and illiteracy. Compared to the 50–59 year age group, those 70 years of age had an adjusted odds ratio of 5.9 for presenting blindness, and a 10.3 odds ratio for blindness with best corrected vision. The 5.9 odds ratio for presenting blindness in the elderly was comparable to the similarly calculated odds ratios for this same age group in both Tirunelveli and Sivaganga (4.5 and 5.6, respectively), but considerably less than that in Bharatpur (12.8).^{11–13} Compared to those with at least some level of formal education, illiterates in Navsari were at a 4.5 times higher risk of blindness (1.0 divided by 0.22). The odds ratios for illiteracy in Tirunelveli, Sivaganga and Bharatpur were 2.2, 2.6, and 2.8, respectively. Neither presenting nor best-corrected blindness was associated with gender, which is in contrast to the greater risk among females in both Tirunelveli and Bharatpur. (The finding of higher rates of blindness in females in Navsari is explained by older age and illiteracy.) Rural residency was also not statistically significant, although it was significant in Bharatpur.

Cataract was predominant as the principal cause of both bilateral and unilateral blindness. Retinal disorders (including macular degeneration, diabetic retinopathy, retinal detachment,

and other retinal causes) were the second leading cause among those bilaterally blind. For the unilateral blind, however, retinal disorders were the third most common cause, after absent/disorganized globe.

Refractive error was an infrequent cause of blindness, in part because of the definitional requirement that refractive error could not be assigned as the principal cause of visual impairment/blindness unless acuity improved to 20/32 with best correction. This strict criterion was introduced to ensure that refractive error would not be assigned as the principal cause in eyes where other pathology was also responsible for the reduction in vision. This refractive error definition contrasts with what was used in most other studies, including the earlier ones in India,^{11–13} Nepal²⁵ and China,^{26–28} where improvement to 20/63 was sufficient in assigning refractive error as the principal cause of visual impairment/blindness. If we were to relax the definition and reassign refractive error as the cause in all eyes correcting to 20/63, the percentage of persons bilaterally blind because of refractive error would increase from 1.2% (Table 4) to 12.8%. Similarly, the percentage of unilateral blindness attributed to refractive error would increase from 1.6% to 9.2%.

Glaucoma was observed to be responsible for 3.1% of bilateral blindness and severe visual impairment. The diagnosis of glaucoma was principally based on optic disc characteristics, generally combined with raised IOP. Overall 41 blind persons had optic disc changes in one or both eyes suggestive of glaucoma, but some also had lens changes suggestive of cataract or improved to 20/32 after refraction; therefore, considering the most preventable/treatable cause in assigning a principal cause of blindness, glaucoma was not assigned as the principal cause. If multiple causes of blindness were recorded for each eye, and the aim was to estimate the prevalence of glaucoma-related blindness, irrespective of other pathology, the prevalence of glaucoma would be higher. This overlap of possible causes when more than one diagnosis is implicated is a limitation of our study protocol. It is also important to recognize that glaucoma was likely to have been under diagnosed as a cause of visual loss because visual field testing was not carried out.

For eyes with visual impairment < 20/63 to 20/200, refractive error was the principal cause in more than a third of cases. With mild visual impairment < 20/32 to 20/63, refractive error was assigned as the cause in 86.7% of eyes, with less than 10% having cataract as the principal cause.

This study shows that the prevalence of blindness among those 50 years of age in Navsari district is lower than what has been reported for most other areas of India. Nonetheless, it is clear that cataract must continue to be the focus of attention if the elimination of avoidable blindness is to become a reality in the foreseeable future. Despite the high CSR, cataract blindness continues to be the predominant cause of blindness in Narsari district, and likely throughout the entire state of Gujarat. This raises the question of what CSR level India should aim for in attempting to eliminate avoidable cataract blindness. We believe that with the rapidly expanding and greying population in India,³¹ the CSR may need to increase dramatically in the near future. Even a high CSR per se would be inadequate in elimination of avoidable blindness due to cataract unless a significant proportion of the blind have access to surgery. It is likely that many of those being operated in areas with a high CSR may

actually not be blind. Further, it must be remembered that CSRs in India are computed based on passive reporting from the district level to the state and national levels based on performance reported from individual ophthalmologists in the district. There is no mechanism in the country to verify the accuracy of these reports, which could lead to over-reporting or under-reporting from some of the districts.

It is also imperative that the quality of surgery is given due consideration as acceptance of surgery is dependent on good visual outcomes after surgery. Previous population based studies in India have revealed poor visual outcomes after surgery with 26–40% remaining blind after surgery.^{21,32}

India is facing a demographic transition that will dramatically increase the number of elderly, and in areas where access to cataract services is poor, current levels of cataract blindness control efforts are unlikely to produce an adequate response. Prevention of blindness efforts will need to be scaled up far beyond what is currently envisioned. Additionally, the importance of uncorrected refractive error as a major cause of visual impairment among older adults has been overlooked. Because refractive error can be easily corrected with low-cost spectacles, innovative strategies to eliminate this cause of visual impairment are warranted.

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TABLE 1

Enumerated and examined population by age, gender, education and residence

	Enumerated		Examined		Percent Examined
	N	%	N	%	
Age (yrs)					
50–59	2828	54.8	2595	54.8	91.8
60–69	1520	29.5	1406	29.7	92.5
> 70	810	15.7	737	15.6	91.0
Gender					
Male	2376	46.1	2153	45.4	90.6
Female	2782	53.9	2585	54.6	92.9
Education					
None (illiterate)	2424	47.0	2220	46.9	91.6
< Grade 5	1630	31.6	1515	32.0	92.9
Grade 6–10	737	14.3	671	14.2	91.0
> Grade 11	367	7.1	332	7.0	90.5
Residence					
Rural	3846	74.6	3539	74.7	92.0
Urban	1312	25.4	1199	25.3	91.4
All	5158	100.0	4738	100.0	91.9

TABLE 2

Inter observer agreement in the pilot exercise and in seven randomly selected clusters during the survey

Ophthalmic Assistants				
	<u>Presenting Vision</u>		<u>Best Corrected Vision</u>	
	Kappa	SE	Kappa	SE
Pilot Exercise				
Right Eye	0.8862	0.07	0.8398	0.08
Left Eye	0.7732	0.07	0.6741	0.08
Main Study				
Right Eye	0.8519	0.02	0.7987	0.02
Left Eye	0.8354	0.02	0.7639	0.02
Ophthalmologists				
	<u>Right Eye</u>		<u>Left Eye</u>	
	Kappa	SE	Kappa	SE
Principal	0.8496	0.24	0.8550	0.23
Diagnosis				

SE = Standard error.

TABLE 3

Distribution of presenting and best corrected visual acuity (VA) *

Worse Eye VA	Better Eye VA					All
	> 20/32	< 20/32–20/63	< 20/63–20/200	< 20/200–20/400	< 20/400	
— Normal/Near-Normal Vision (NN) —						
>20/32	1346 (28.4)					1346 (28.4; 25.6–31.2)
	2879 (60.8)					2879 (60.8; 58.2–63.3)
< 20/32–20/63	204 (4.3)	970 (20.5)				1174 (24.8; 22.5–27.0)
	281 (5.9)	422 (8.9)				703 (14.8; 13.6–16.1)
— Unilateral or Bilateral Visual Impairment (VI) —						
< 20/63–20/200	78 (1.6)	456 (9.6)	855 (18.0)			1,389 (29.3; 27.5–31.2)
	134 (2.8)	214 (4.5)	291 (6.1)			639 (13.5; 12.0–14.9)
— Unilateral Blindness (UL) —						
				Moderate Blindness		
< 20/200–20/400	9 (0.2)	25 (0.5)	96 (2.0)	71 (1.5)		201 (4.2; 3.0–5.5)
	15 (0.3)	8 (0.2)	18 (0.4)	10 (0.2)		51 (1.1; 0.6–1.5)
— Severe Blindness —						
< 20/400	50 (1.0)	106 (2.2)	216 (4.6)	51 (1.1)	205 (4.3)	628 (13.3; 11.8–14.7)
	129 (2.7)	84 (1.8)	115 (2.4)	12 (0.2)	126 (2.7)	466 (9.8; 8.7–11.0)
All	1687 (35.6; 32.5–38.7)	1557 (32.9; 30.9–34.8)	1167 (24.6; 22.6–26.7)	122 (2.6; 1.8–3.4)	205 (4.3; 3.5–5.1)	4738 (100.0)
	3438 (72.6; 69.9–75.2)	728 (15.4; 13.8–16.9)	424 (8.9; 7.6–10.3)	22 (0.5; 0.2–0.7)	126 (2.7; 2.1–3.3)	4738 (100.0)

* Data are given as number of persons (prevalence percentage; 95% confidence interval). For each pair of numbers presenting visual acuity is on the top and best corrected visual acuity on the bottom. VA: Visual Acuity.

TABLE 4
Prevalence of bilateral blindness (< 20/200) in persons by age, gender, education, and residence

	Number Examined	Presenting Blindness			Best Corrected Blindness		
		Number Blind	Prevalence (%)	Adjusted OR(95% CI)	Number Blind	Prevalence (%)	Adjusted OR(95% CI)
Age (years)							
50–59	2595	86	(3.3)	Reference	27	(1.0)	Reference
60–69	1406	120	(8.5)	2.7 (2.0–3.6)*	50	(3.6)	3.5 (2.1–5.6)*
> 70	737	121	(16.4)	5.9 (4.2–8.3)*	71	(9.6)	10.3 (6.6–15.9)*
Gender							
Male	2153	124	(5.8)	Reference	48	(2.2)	Reference
Female	2585	203	(7.9)	0.92 (0.68–1.23)	100	(3.9)	1.12 (0.69–1.81)
Education							
Illiterate	2220	257	(11.6)	Reference	124	(5.6)	Reference
< Grade 5	1515	56	(3.7)	0.22 (0.16–0.31)**	18	(1.2)	0.18 (0.11–0.28)**
Grade 6–10	671	13	(1.9)		6	(0.89)	
> Grade 11	332	1	(0.30)		0	(0.00)	
Residence							
Rural	3539	276	(7.8)	Reference	124	(3.5)	Reference
Urban	1199	51	(4.3)	0.70 (0.41–1.2)	24	(2.0)	0.75 (0.49–1.16)
All	4738	327	(6.9)		148	(3.1)	

CI, confidence interval; OR, odds ratio.

* $P < 0.001$

Represents the odds ratio for any level of education (ie, literacy).

TABLE 5

Principal causes and prevalence of presenting blindness (< 20/200)

Principal Cause	Unilateral Blindness			Bilaterally Blindness		
	Persons		% Prevalence	Persons*		% Prevalence*
	No.	(%)		No.	(%)	
Cataract	288	(57.4)	6.1	270	(82.6)	5.7
Macular degeneration	8	(1.6)	0.17	15	(4.6)	0.32
Posterior capsule opacification	15	(3.0)	0.32	13	(4.0)	0.27
Absent/disorganized globe	32	(6.4)	0.67	13	(4.0)	0.27
Corneal opacity/scar	12	(2.4)	0.25	12	(3.7)	0.25
Glaucoma	27	(5.4)	0.57	10	(3.1)	0.21
Other retinal disorders	21	(4.2)	0.44	9	(2.7)	0.19
Other optic atrophy	19	(3.8)	0.40	7	(2.1)	0.15
Refractive error ^φ	8	(1.6)	0.17	4	(1.2)	0.08
Retinal detachment	2	(0.40)	0.04	3	(0.92)	0.06
Diabetic retinopathy	4	(0.80)	0.08	2	(0.61)	0.04
Amblyopia	10	(2.0)	0.21	2	(0.61)	0.04
Other causes	49	(9.8)	1.0	19	(5.8)	0.40
Undetermined	7	(1.4)	0.15	3	(0.92)	0.06
All (any cause)	502	(100.0)	10.6	327	(100.0)	6.9

* Totals for the cause specific prevalence exceed the All (any cause) prevalence because a person can have more than one cause of blindness.

^φ Includes only eyes improving to > 20/32 with subjective refraction.

TABLE 6

Principal causes of blindness (< 20/200) in eyes by age, gender and literacy

Principal Cause	Age				Gender				Literacy				All	
	50-59 years		60 years		Male		Female		Illiterate		Literate		All	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Cataract	244	73.9	546	66.1	311	65.5	479	70.3	572	70.5	218	63.2	790	68.3
Absent/disorganized globe	14	4.2	34	4.1	22	4.6	26	3.8	34	4.2	14	4.1	48	4.1
Glaucoma	4	1.2	38	4.6	20	4.2	22	3.2	26	3.2	16	4.6	42	3.6
Other retinal disorders	18	5.4	18	2.2	18	3.8	18	2.6	20	2.5	16	4.6	36	3.1
Posterior capsular opacification	4	1.2	28	3.4	11	2.3	21	3.1	18	2.2	14	4.1	32	2.8
Macular degeneration	1	0.30	30	3.6	6	1.3	25	3.7	26	3.2	5	1.4	31	2.7
Other optic atrophy	6	1.8	25	3.0	17	3.6	14	2.0	19	2.3	12	3.5	31	2.7
Corneal opacity/scar	8	2.4	20	2.4	16	3.4	12	1.8	18	2.2	10	2.9	28	2.4
Refractive error *	5	1.5	8	0.97	10	2.1	3	0.44	7	0.86	6	1.7	13	1.1
Amblyopia	3	0.91	9	1.1	8	1.7	4	0.59	4	0.49	8	2.3	12	1.0
Diabetic retinopathy	2	0.61	5	0.61	2	0.42	5	0.73	5	0.62	2	0.58	7	0.61
Retinal detachment	1	0.30	4	0.48	4	0.84	1	0.15	1	0.12	4	1.2	5	0.43
Other causes	20	6.1	50	6.0	26	5.5	44	6.5	52	6.4	18	5.2	70	6.0
Undetermined	0	0.0	11	1.3	4	0.84	7	1.0	9	1.1	2	0.58	11	0.95
Total	330	100.0	826	100.0	475	100.0	681	100.0	811	100.0	345	100.0	1156	100.0

* Includes only eyes improving to > 20/32 with subjective refraction.

TABLE 7

Principal causes of visual impairment < 20/63 to 20/200 in eyes by age, gender and literacy

Principal Cause	Age				Gender				Literacy			
	50-59 years		60 years		Male		Female		Illiterate		Literate	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Cataract	389	37.7	896	58.8	549	50.1	736	50.4	832	57.2	453	41.1
Refractive error *	544	52.7	361	23.7	381	34.8	524	35.9	425	29.2	480	43.6
Posterior capsular opacification	21	2.0	89	5.8	48	4.4	62	4.2	56	3.8	54	4.9
Macular degeneration	26	2.5	62	4.1	39	3.6	49	3.3	45	3.1	43	3.9
Glaucoma	2	0.19	24	1.6	13	1.2	13	0.89	14	0.96	12	1.1
Other retinal disorders	9	0.87	12	0.79	10	0.91	11	0.75	13	0.89	8	0.73
Diabetic retinopathy	7	0.68	7	0.46	3	0.27	11	0.75	10	0.69	4	0.36
Amblyopia	9	0.87	5	0.33	10	0.91	4	0.27	6	0.41	8	0.73
Corneal opacity/scar	5	0.48	7	0.46	7	0.64	5	0.34	5	0.34	7	0.64
Other optic atrophy	0	0.0	11	0.72	7	0.64	4	0.27	5	0.34	6	0.54
Retinal detachment	0	0.0	1	0.07	1	0.09	0	0.0	0	0.0	1	0.09
Phthisis/disorganized globe	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Other causes	18	1.7	35	2.3	21	1.9	32	2.2	34	2.3	19	1.7
Undetermined	3	0.29	13	0.85	6	0.55	10	0.68	10	0.69	6	0.54
Total	1033	100.0	1523	100.0	1095	100.0	1461	100.0	1455	100.0	1101	100.0

* Includes only eyes improving to > 20/32 with subjective refraction.

TABLE 8

Principal causes of visual impairment < 20/32 to 20/63 in eyes by age, gender and literacy

Principal Cause	Age				Gender				Literacy				All	
	50-59 years		60 years		Male		Female		Illiterate		Literate		No.	%
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%		
Refractive error*	1462	94.2	904	76.7	962	84.9	1404	87.9	1002	86.6	1364	86.7	2366	86.6
Cataract	57	3.7	178	15.1	110	9.7	125	7.8	102	8.8	133	8.4	235	8.6
Macular degeneration	6	0.39	37	3.1	19	1.7	26	1.6	21	1.8	24	1.5	45	1.6
Posterior capsular opacification	3	0.19	29	2.5	13	1.1	19	1.2	15	1.3	17	1.1	32	1.2
Amblyopia	4	0.26	2	0.25	5	0.44	3	0.19	1	0.09	7	0.44	8	0.29
Other retinal disorders	4	0.26	3	0.25	3	0.26	4	0.25	5	0.43	2	0.13	7	0.26
Glaucoma	0	0.0	5	0.4	4	0.35	1	0.06	0	0.0	5	0.32	5	0.18
Corneal opacity/scar	2	0.13	2	0.17	1	0.09	3	0.19	1	0.09	3	0.19	4	0.15
Diabetic retinopathy	1	0.06	0	0.0	1	0.09	0	0.0	0	0.0	1	0.06	1	0.04
Other optic atrophy	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Retinal detachment	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Phthisis/disorganized globe	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Other causes	8	0.52	13	1.1	13	1.1	8	0.50	7	0.61	14	0.89	21	0.77
Undetermined	1	0.06	6	0.51	2	0.18	5	0.31	3	0.26	4	0.25	7	0.26
Total	1552	100.0	1179	100.0	1133	100.0	1598	100.0	1157	100.0	1574	100.0	2731	100.0

* Includes only eyes improving to > 20/32 with subjective refraction.