A Population-Based Assessment of Presbyopia in the State of Andhra Pradesh, South India: The Andhra Pradesh Eye Disease Study

Praveen K. Nirmalan,[1] *Sannapaneni Krishnaiah,*[1,2] *Bindiganavale R. Shamanna,*[1] *Gullapalli N. Rao,*[1] *and Ravi Thomas*[1,3]

Purpose. To determine the prevalence of presbyopia in the state of Andhra Pradesh in south India.

Methods. Comprehensive ocular examinations including logMAR (logarithm of the minimum angle of resolution) distance and near (presenting and best corrected) visual acuity, slit lamp biomicroscopy of the anterior segment, and dilated posterior segment examinations were performed using a standardized protocol for subjects identified through a random cluster-sampling strategy in Andhra Pradesh. Information of difficulty in performing near tasks was collected as part of a visual function questionnaire administered to all subjects. A person was defined as having presbyopia if the person required an addition of at least 1.0 D in either eye for near vision in addition to their best corrected distance correction to improve near vision to at least N8 and if they had graded lens opacities (Lens Opacities Classification System [LOCS III] system).

Results. Examined in the study were 5587 subjects 30 years of age or older (mean age 47.5 ± 13.0 years). The age-, gender-, and area-adjusted prevalence of presbyopia was 55.3% (95% confidence interval [CI]: 54.0–56.6). One third (n = 1173; 30.0%) of the 3907 subjects with presbyopia were currently using spectacles. Of the 2734 subjects with presbyopia and not using spectacles, 528 (19.3%) had moderate to severe difficulty in reading small print, and 2085 (76.3%) had moderate to severe difficulty in recognizing small objects and performing near work, including 1057 (38.6%) subjects who were unable to manage any near work. On multivariate analysis, female sex (OR: 1.4, 95% CI: 1.1–1.8), rural residence (OR: 1.5, 95% CI: 1.2–1.8), alcohol consumption (OR: 0.8, 95% CI: 0.6–0.9), nuclear opacity of the lens greater than grade 2 LOCS III (OR: 4.8, 95% CI: 1.4–16.8), myopia (OR: 1.6, 95% CI: 1.3–2.1), and hyperopia (OR: 3.6, 95% CI: 2.7–5.2) were associated with presbyopia.

Conclusions. The high prevalence of presbyopia and the stated effect on performing activities related to near vision needs to be translated into programs and strategies that specifically target presbyopia. (*Invest Ophthalmol Vis Sci.* 2006;47: 2324–2328) DOI:10.1167/iovs.05-1192

Refractive error is recognized globally as an important cause of treatable vision impairment and is a priority of VISION 2020—The Right to Sight Initiative.[1] Treatment of refractive errors is easier than treating other ocular diseases and can be achieved through an appropriate pair of spectacles or contact lenses. Several population-based studies report on the prevalence of refractive errors in different populations, focusing entirely on disorders of distant vision, especially myopia.[2–13] There are, however, few such reports on presbyopia[13–15] Presbyopia is a chronic disorder involving changes in accommodation of the eye and causes difficulty in near vision. The changes in accommodation maybe related to changes in the ciliary muscles, lens, capsule of the lens, and/or changes in the vitreous, but are age related. Almost all persons older than 50 years are likely to have presbyopia.[16–26] The treatment of presbyopia is relatively easily achieved through appropriate refraction, a procedure that does not necessarily require an ophthalmologist. Although presbyopia affects a large number of people and is easily treated, it has not gained adequate recognition as an major cause of vision impairment, possibly because current definitions of vision impairment do not account for difficulty in near vision.

The Andhra Pradesh Eye Disease Study (APEDS) was a population-based cross-sectional epidemiologic study of 10,000 people that explored the burden, causes, and risk factors for vision impairment and blindness in four representative areas of the south Indian state of Andhra Pradesh.[27] As part of the study, APEDS obtained information on distant and near vision from each participant.[3] In this article, we report the prevalence of presbyopia in a population 30 years of age or older of Andhra Pradesh. To the best of our knowledge, there is no prior report on the population-based prevalence of presbyopia from India.

Methods

Institutional Ethics Board approval was obtained before the conduct of the study, which adhered to the tenets of the Declaration of Helsinki and spanned a 5-year period (1996–2000).[28] The design of APEDS has been published in detail.[3,27,28] Briefly, we used a multistage sampling procedure for random selection of 10,000 persons comprising 5000 persons each younger and older than 30 years, from a sampling frame that included one urban and three rural areas from different parts of Andhra Pradesh (AP) and approximately reflected the urban–rural and socioeconomic distribution of the population of the state. The four areas selected for the study were Hyderabad (urban), West Godavari district (semirural), and Adilabad and Mahabubnagar districts (poor, rural). We randomly chose 24 clusters (including one cluster representing the homeless) using stratified random cluster sampling from Hyderabad to reflect the urban population of the study, and 70 rural clusters to identify the rural population of the study.

From the [1]International Center for Advancement of Rural Eye Care, the [2]Professor Brien Holden Eye Research Center, and the [3]V. S. T. Center for Glaucoma, L. V. Prasad Eye Institute, Hyderabad, India.

Supported by grants from the Christoffel-Blindenmission, Bensheim, Germany, and the Hyderabad Eye Research Foundation, Hyderabad, India.

Submitted for publication September 7, 2005; revised December 27, 2005, and January 29, 2006; accepted March 20, 2006.

Disclosure: **P.K. Nirmalan**, None; **S. Krishnaiah**, None; **B.R. Shamanna**, None; **G.N. Rao**, None; **R. Thomas**, None

The publication costs of this article were defrayed in part by page charge payment. This article must therefore be marked "*advertisement*" in accordance with 18 U.S.C. §1734 solely to indicate this fact.

Corresponding author: Praveen K. Nirmalan, ICARE, L.V. Prasad Eye Institute, Hyderabad 500034, India; npraveen@lvpei.org.

Clinical Examinations

Before performing ocular examinations, we obtained written, informed consent from eligible subjects who were willing to be part of the study. Comprehensive ocular examinations were performed of eligible subjects in a clinic specially set up for this study by two ophthalmologists and optometrists trained for the study.[28] Details of ocular examinations pertinent to this report are presented. Comprehensive ocular examinations included measurement of distance and near visual acuity, both presenting (with current refractive correction if any) and best corrected after refraction, with logarithm of minimum angle of resolution (logMAR) charts used with standard illumination that was tested at repeated intervals with a light meter.[3] The examination included external eye examination, assessment of pupillary reaction, and slit lamp biomicroscopy for anterior segment abnormalities; measurement of intraocular pressures (IOP) with a Goldmann applanation tonometer or Perkins applanation (if a Goldmann applanation tonometer could not be used); gonioscopy for angles of the anterior chamber; dilation; and a detailed examination of the lens, vitreous, and posterior segment, and visual field perimetry. Refraction was attempted on all subjects who presented with a visual acuity (either distance or near) worse than 20/20 in either eye. The study optometrist performed objective refraction with a streak retinoscope and further refined it with subjective refraction. Refraction was repeated by the optometrist after dilation, if the subject was suspected to have manifest hypermetropia or if further refinement of the refraction was deemed necessary. All subjects who had difficulty in reading at least N8 vision were subjected to refraction to check for the presence of hyperopia. Near vision was assessed in all subjects, irrespective of their distance vision, using a near vision chart at working distance for each individual (~33–35 cm) with illumination focused on the chart from behind the subject, after correcting for their distance vision. The ophthalmologist graded the lens clinically at the slit lamp against photographic standards for nuclear opalescence, using the Lens Opacities Classification System (LOCS) III,[29] and for cortical and posterior subcapsular lens opacities, using the Wilmer classification.[30] For the present analysis we considered an eye with nuclear opalescence of LOCS III grade 2.0 or higher to have nuclear changes. Cortical cataract was considered to be present if an eye had a Wilmer grade greater than 1.0. Posterior subcapsular cataract (PSC) was deemed present if an eye had a Wilmer grade PSC greater than 1.0. For this analysis, we defined myopia as a refractive power worse than −0.5 D (n = 1552) and hypermetropia (n = 896) as a refractive power worse than +1.0 D. We defined a person to have presbyopia if the person required an addition of at least 1.0 D in any eye in addition to best corrected distance vision, to improve near vision to at least N8. Each person who could not read with at least N8 vision after best distance correction were checked for improvement by adding increments of 0.25 D (+0.25, +0.50, +0.75 D, and so on).

Demographic and Risk Behavior Information

A personal interview to collect demographic details, personal risk behavior, and utilization of eye care services preceded ocular examinations. We collected, from each subject, information on level of formal education and the ability to read and write and the current occupation and prior occupation if they were currently retired. We collected information on current and prior history of smoking and alcohol consumption from each subject. We defined a person, for this analysis, as a smoker if the person was either a current or past smoker of any tobacco products (cigarettes, cigars or beedis, a local cigarette in India). We considered a subject as consuming alcohol if the person was consuming alcohol currently or gave a prior history of consuming alcohol. We collected information on current and previous use of refractive aids (spectacles or contact lenses), and the source and purpose for which the aids were prescribed. We used two questions to collect information of difficulty in performing near tasks as part of a visual function questionnaire administered to all subjects. The two questions focused on (1) difficulty in reading small print and (2) difficulty in recognizing small objects. Response to these two questions was scored on a five-point scale ranging from "no difficulty" to "cannot manage" with an additional option of "do not know" if the subject was unsure of the response. We also collected information on barriers to access eye care services, by using a 15-item list with an additional option to express any barriers that were not addressed by the list.

A computer was used for all statistical analyses (Stata, ver. 8.0; Stata Corp., College Station, TX). Prevalence estimates and confidence intervals around prevalence estimates were determined by using a binomial approximation of the normal distribution. A t-test was used to compare the means of the two groups. Factors that were found to be significant in the bivariate analysis were introduced in a multivariate logistic regression model for risk factors for subjects of all persons 30 years of age or older. We considered $P < 0.05$ to be significant for these analyses.

Results

We examined 5587 subjects 30 years of age or older as part of the APEDS study. The mean age of participants was 47.5 ± 13.0 years (median, 45.0; range 30–102). Three-fourths of the subjects were residents of rural areas (n = 4188, 75.0%), and 2992 (53.5%) were women. We determined 3907 (69.9%) of the 5587 subjects 30 years of age or older to have presbyopia. The prevalence of presbyopia in the urban area was 64.2% (95% CI: 61.7–66.7) and was 71.8% (95% CI: 70.5–73.2) in the rural areas. The age-, sex-, and area-adjusted prevalence of presbyopia is 55.3% (95% CI: 54.0–56.6). Table 1 shows the demographic characteristics of the 5587 subjects examined by status of presbyopia. Presbyopia showed an increasing trend with increasing age (test score for trend of odds; $P < 0.001$). The mean age of persons with presbyopia among those aged 30 to 39 years was 36.6 ± 1.9 years (median, 37.0).

One third (n = 1173; 30.0%) of the 3907 subjects with presbyopia were currently using spectacles. One hundred thirty-one (11.2%) of the 1173 subjects with presbyopia who were currently using spectacles stated that they had been prescribed spectacles to read and to see near objects clearly, an additional 386 (32.9%) subjects stated they received a spectacle prescription to address their difficulty in seeing near objects, and 309 (26.3%) stated that they had been prescribed spectacles for reading. Four hundred sixty-seven (11.9%) of the 3907 subjects with presbyopia had used spectacles but were not currently using them. Spectacles had been prescribed by an ophthalmologist for 1540 (92.5%) of the 1664 subjects with presbyopia who had ever used spectacles.

Five hundred twenty-eight (19.3%) of the 2734 persons with presbyopia and not currently using spectacles stated they had moderate to severe difficulty in reading small print, and 2085 (76.3%) subjects stated they had moderate to severe difficulty in recognizing small objects and performing near work such as threading a needle, including 1057 (38.6%) subjects who stated they were unable to manage any near work. Table 2 compares the difficulty with near vision tasks between presbyopes using spectacles and presbyopes not using spectacles. Subjects not using presbyopic glasses were more likely to report difficulty with near work than were subjects who were using glasses. Table 3 shows the principal barriers to eye care reported by 2615 (95.6%) of the 2734 persons with presbyopia not currently using any spectacle correction.

A multivariate model (inclusive of all subjects) that included age; sex; area; education; smoking; alcohol consumption; lens status; and interaction between age and lens status, myopia, and hypermetropia showed that female sex (OR: 1.4, 95% CI: 1.1–1.8), rural residence (OR: 1.5, 95% CI: 1.2–1.8), alcohol consumption (OR: 0.8, 95% CI: 0.6–0.9), nuclear opacity of the lens greater than LOCS III grade 2 (OR: 4.8, 95% CI:

TABLE 1. Presbyopia by Demographic Characteristics among 5587 Subjects Aged 30 Years and Older

	Presbyopia		
	Yes *n* (%)	**No *n* (%)**	**Total *n* (%)**
Age (y)			
30–39	427 (22.9)	1436 (77.1)	1863
40–49	1320 (92.7)	104 (7.3)	1424
50–59	1001 (95.6)	46 (4.4)	1047
60–69	847 (94.1)	53 (5.9)	900
70+	312 (88.4)	41 (11.6)	353
Gender			
Male	1787 (68.9)	808 (31.1)	2595
Female	2120 (70.9)	872 (29.1)	2992
Area			
Urban	898 (64.2)	501 (35.8)	1399
Rural	3009 (71.8)	1179 (28.2)	4188
Can read or write*			
Yes	1472 (65.4)	779 (34.6)	2251
No	2292 (72.6)	863 (27.4)	3155
Occupation			
Involves near work	1437 (66.7)	716 (33.3)	2153
Does not involve near work	2470 (71.9)	964 (28.1)	3434

* Data on ability to read or write were not available for 181 subjects.

1.4–16.8), myopia (OR: 1.6, 95% CI: 1.3–2.1), and hyperopia (OR: 3.6, 95% CI: 2.7–5.2) were associated with presbyopia.

DISCUSSION

The results of our study indicate that the age of onset of presbyopia in India may be in the fourth decade. One fifth (n = 364, 19.5%) of subjects aged 30 to 39 years and one third (n = 332, 35.1%) of subjects aged 35 to 39 years in this population had presbyopia. These results are similar to those in studies from Central America and Africa that have reported an age of onset of presbyopia early in the fourth decade rather than in the fifth.[13–15] Previous studies have correlated geographical variations in the age at onset of presbyopia with latitude and ambient temperature. Higher ambient temperatures were associated with earlier onset of presbyopia.[26,31,32]

Similar to a previous report, we found women more likely to have presbyopia.[33] It is possible that hormonal influences play a role in the onset, but our study was not designed to explore this possibility. Age-related cataract is more common among women in this population,[34] and it is possible that factors associated with lens changes and female gender are common for presbyopia in this population. An association of lens changes and presbyopia is supported by several studies.[35–39] There are reports of an increase in the cross-sectional area of the lens in the accommodated form and of a decline of this property with age.[35] A recent study has reported that replacement of a presbyopic lens with a flexible polymer restores the ability to accommodate, suggesting a possible lenticular contribution to presbyopia.[36] Studies have reported that significant changes in the shape of the lens nucleus are necessary to enable transition between accommodative states, and that the extent of change required by the nucleus is far more than that of the cortex.[37,38] Sclerosis of the nucleus that occurs with age will thus possibly decrease the ability of the lens to undergo the changes required for accommodation.[39] It is thus possible that risk factors for sclerosis of the lens nucleus may also influence the onset of presbyopia. We found, from among the factors associated with age-related cataract in this population (APEDS, unpublished data, 1996 to 2000), that female sex, rural residence, and alcohol consumption were associated with presbyopia. Education, occupation, and smoking that were associated with age-related cataract in this population was not associated with presbyopia. We found 81 (6.4%) of subjects 60 years of age or older who did not require an addition of at least 1 D for near vision to be able to see at the

TABLE 2. Comparison of Difficulty with Near-Vision Tasks between Presbyopes Using or Not Using Glasses

Level of Difficulty	**None *n* (%)**	**Slight *n* (%)**	**Moderate/Severe *n* (%)**
Task: reading small print*			
Urban			
Glasses (n = 415)	354 (85.3)	35 (8.4)	26 (6.3)
No glasses (n = 204)	39 (19.1)	38 (18.6)	127 (62.3)
Rural			
Glasses (n = 351)	227 (64.7)	49 (13.9)	75 (21.4)
No glasses (n = 628)	120 (19.1)	107 (17.0)	401 (63.8)
Task: recognizing small objects			
Urban			
Glasses (n = 495)	387 (78.0)	39 (7.9)	69 (13.9)
No glasses (n = 393)	155 (39.4)	69 (17.5)	169 (43.0)
Rural			
Glasses (n = 658)	253 (38.4)	80 (12.2)	325 (49.4)
No glasses (n = 2351)	278 (11.8)	157 (6.7)	1916 (81.5)

* Applicable only to those who could read or write.

TABLE 3. Principal Barriers to Eye Care Expressed by 2615 Subjects Not Currently Using Correction among 2734 Subjects with Presbyopia

	n (%)
Did not have a serious problem	622 (23.8)
Able to see adequately	613 (23.4)
Other obligations prevent eye checkup	534 (20.4)
Do not have money	458 (17.5)
Natural process with old age and hence need not treated	91 (3.5)
No escort	66 (2.5)
Eye checkup not a priority	58 (2.2)
Have to travel far for a checkup	46 (1.8)
Do not know where to go	28 (1.0)
Afraid that vision loss will be revealed	27 (1.0)
Dominant family member does not think a checkup is needed	27 (1.0)
Not comfortable with accessible modern medicine practitioner	15 (0.6)
Not comfortable with accessible indigenous practitioner	15 (0.6)
Not comfortable with accessible alternative medicine practitioner	15 (0.6)

N8 level at least, with best distance correction. These subjects had LOCS III grades for nuclear sclerosis greater than 1.5, with an associated amount of myopia (mean spherical equivalent of 2 D), possibly related to the lens changes (index myopia) that precluded the need for addition for near vision.

The high response rates (>90%) obtained in APEDS, the population-based random sample, and standardized examination procedures are strengths of the study.[28] Although we corrected for distance vision, it is possible that we may have misclassified some persons with low hyperopia as having presbyopia, and may, thus have over estimated the prevalence of presbyopia. Our definition of presbyopia, which includes people with physiologic presbyopia rather than functional presbyopia at presentation, may actually overstate the need for services. If we extrapolate the results of our study to the population 30 years of age or older in India, there may be approximately 260 million people who require correction for presbyopia. Approximately 182 million people with presbyopia are not currently using any spectacle correction, including an estimated 72 million people who are unable to manage near work. Although we are unable to comment on the potential changes on quality of life or productivity in this population due to the difficulty in performing near work (as our study was not designed to explore this question further), these data raise several important issues for consideration by eye care programs in the region. A better understanding of the quality of life and productivity needs associated with difficulty in near vision is required, especially since correction for presbyopia is still often considered necessary only for people who are required to read or write.

A major task will be development of human resources capable of performing good quality refraction. Our study indicates that a major proportion (92.5%) of the prescriptions for spectacles were sourced from ophthalmologists. Extrapolating these statistics, an ophthalmologist in India may have to perform at least 100 refractions each working day (300 working days in a year) to cover the 260 million subjects requiring presbyopic correction. This is a wasteful use of human resources, especially when one considers the high eye disease burden including age-related cataract in India that requires medical and surgical interventions by an ophthalmologist. Currently, there are varied cadres of ophthalmic support personnel in India engaged in performing refraction such as optometrists, ophthalmic assistants or technicians, vision technicians, and various other midlevel ophthalmic personnel. Standards of training and certification, and the curriculum for training vary among these groups and institutions and should be improved.[40]

Another problem that should have priority is the availability and affordability of refractive services, including a system for efficient dispensation of good-quality, affordable spectacles. A significant proportion of subjects in the study cited "other obligations" and "do not have money to pay for eye checkup" as reasons for not seeking care. Addressing these barriers will require innovative hospital- and community-based solutions, to identify people with problems within communities and to provide them with good-quality refraction and low-cost spectacles of good quality. The "vision center" concept promoted by the VISION 2020—the Right to Sight Initiative and partners of the International Agency for Prevention of Blindness (IAPB) where a trained person (vision technician) provides primary eye care services including refraction for a population of 50,000 is a step in the right direction. Further studies are needed to assess the impact of such programs on utilization of refractive services.

Acknowledgments

The authors are grateful to the APEDS team, in particular Lalit and Rakhi Dandona and Catherine McCarthy who designed and conducted the detailed study, and to all the subjects participating in this study.

References

1. World Health Organization. Elimination of avoidable visual disability due to refractive errors. Geneva, Switzerland: WHO/PBL/00.79; 2001:10.
2. Attebo K, Ivers RQ, Mitchell P. Refractive errors in an older population: The Blue Mountains Eye Study. *Ophthalmology.* 1999; 106:1066–1072.
3. Dandona R, Dandona L, Naduvilath TJ, et al. Refractive errors in an urban population in southern India: the Andhra Pradesh Eye Disease Study. *Invest Ophthalmol Vis Sci.* 1999;40:2810–2818.
4. Hyams SW, Pokotilo E, Shkurko G. Prevalence of refractive errors in adults over 40: a survey of 8102 eyes. *Br J Ophthalmol.* 1977; 61:428–432.
5. Johnson GJ, Mathews A, Perkins ES. Survey of ophthalmic conditions in a Labrador community, I. Refractive Errors. *Br J Ophthalmol.* 1979;63:440–448.
6. Katz J, Tielsch JM, Sommer A. Prevalence and risk factors for refractive errors in an adult inner city population. *Invest Ophthalmol Vis Sci.* 1997;38:334–340.
7. Lavery JR, Gibson JM, Shaw DE, Rosenthal AR. Refraction and refractive errors in an elderly population. *Ophthalmic Physiol Opt.* 1988;8:394–396.
8. Lee KE, Klein BE, Klein R. Changes in refractive errors over a 5-year interval in the Beaver Dam Eye Study. *Invest Ophthalmol Vis Sci.* 1999;40:1645–1649.
9. Lewallen S, Lowdon R, Courtright P, Mehl GL. A population-based survey of the prevalence of refractive error in Malawi. *Ophthalmic Epidemiol.* 1995;2:145–149.
10. Wang Q, Klein BE, Klein R, Moss SE. Refractive status in the Beaver Dam Eye Study. *Invest Ophthalmol Vis Sci.* 1994;35:4344–4347.
11. Wensor M, McCarty CA, Taylor HR. Prevalence and risk factors of myopia in Victoria, Australia. *Arch Ophthalmol.* 1999;117:658–663.
12. Wong TY, Foster PJ, Hee J, et al. Prevalence and risk factors for refractive errors in adult Chinese in Singapore. *Invest Ophthalmol Vis Sci.* 2000;41:2486–2494.
13. Wharton KR, Yorton RL. Visual characteristics of rural Central and South Americans. *J Am Optom Assoc.* 1986;57:426–430.
14. Nwosu SN. Ocular problems of young adults in rural Nigeria. *Int Ophthalmol.* 1998;22:259–263.

15. Kamali A, Whitworth JA, Ruberantwari A, et al. Causes and prevalence of non-vision impairing ocular conditions among a rural population in SW Uganda. *Ophthalmic Epidemiol.* 1999;6:41–48.
16. Duane A. Are the current theories of accommodation correct? *Am J Ophthalmol.* 1925;8:196–202.
17. Fincham EF. The mechanism of accommodation. *Br J Ophthalmol.* 1937;8:5–80.
18. Fincham EF, Walton J. The reciprocal actions of accommodation and convergence. *J Physiol.* 1957;137:488–508.
19. Eskridge JB. Review of ciliary muscle effort in presbyopia. *Am J Optom Physiol Opt.* 1984;61:133–138.
20. Hess C. Observations concerning accommodation organs. *Klin Monatsbl Augenheilkd.* 1904;42:309–315.
21. Gullstrand A. Mechanism of accommodation. In: Southall JPC, ed. *Helmholtz's Treatise on Physiological Optics.* Vol 1. Rochester, NY: Optical Society of America; 1924:appendices.
22. Fisher RF. The significance of the shape of the lens and capsular energy changes in accommodation. *J Physiol.* 1969;201:21–47.
23. Fisher RF. The elastic constants of the human lens. *J Physiol.* 1971;212:147–180.
24. Koretz JF, Handelman GH. How the human eye focuses. *Sci Am.* 1988;259:92–99.
25. Coleman DJ. Unified model for accommodative mechanism. *Am J Ophthalmol.* 1970;69:1063–1079.
26. Weale RA. Epidemiology of refractive errors and presbyopia. *Surv Ophthalmol.* 2003;48:515–543.
27. Dandona R, Dandona L, Naduvilath TJ, et al. Design of a population-based study of visual impairment in India: the Andhra Pradesh Eye Disease Study. *Indian J Ophthalmol.* 1997;45:251–257.
28. Dandona L, Dandona R, Srinivas M, et al. Blindness in the Indian State of Andhra Pradesh. *Invest Ophthalmol Vis Sci.* 2001;42:908–916.
29. Chylack LT, Wolfe JK, Singer DM, et al. The lens opacities classification system III. *Arch Ophthalmol.* 1993;111:831–836.
30. Taylor HR, West SK. A simple system for the clinical grading of lens opacities. *Lens Res.* 1988;5:175–181.
31. Miranda MN. The geographic factor in the onset of presbyopia. *Trans Am Ophthalmol Soc.* 1979;77:603–621.
32. Rambo VC. Further notes on the varying ages at which different people develop presbyopia. *Am J Ophthalmol.* 1953;36:709–710.
33. Pointer JS. The presbyopic add, II. Age related trend and a gender difference. *Ophthalmic Physiol Opt.* 1995;15:241–248.
34. Nirmalan PK, Krishnadas R, Ramakrishnan R, et al. Lens opacities in a rural population of Southern India: The Aravind Comprehensive Eye Study. *Invest Ophthalmol Vis Sci.* 2003;44:4639–4643.
35. Strenk SA, Strenk LM, Semmlow JL, DeMarco JK. Magnetic resonance imaging study of the effects of age and accommodation on the human lens cross-sectional area. *Invest Ophthalmol Vis Sci.* 2004;45:539–545.
36. Koopmans SA, Terwee T, Barkhof J, Haitjema HJ, Kooijman AC. Polymer refilling of presbyopic human lenses in vitro restores the ability to undergo accommodative changes. *Invest Ophthalmol Vis Sci.* 2003;44:250–257.
37. Dubbelman M, Van der Heijde GL, Weeber HA, Vrensen GF. Changes in the internal structure of the human crystalline lens with age and accommodation. *Vision Res.* 2003;43:2363–2375.
38. Koretz JF, Cook CA, Kaufman PL. Accommodation and presbyopia in the human eye: changes in the anterior segment and crystalline lens with focus. *Invest Ophthalmol Vis Sci.* 1997;38:569–578.
39. Pau H, Kranz J. The increasing sclerosis of the human lens with age and its relevance to accommodation and presbyopia. *Graefes Arch Clin Exp Ophthalmol.* 1991;229:294–296.
40. Dandona R. Optometry and eye care in India (Letter). *Indian J Ophthalmol.* 1998;46:175.