Causes of Visual Impairment and Blindness in the 2006 and 2014 Nine-Province Surveys in Rural China

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• PURPOSE: To investigate the primary causes of visual impairment and blindness in rural China.

• DESIGN: Population-based, cross-sectional study.

• METHODS: Geographic cluster sampling was used in randomly selecting residents from a rural county/district within 9 provinces in the East Coast, Inland Middle, and West regions of mainland China. Persons aged 50 years or older were enumerated through household visits and invited to examination sites for visual acuity testing and ocular examination. Causes of vision impairment and blindness in 2014 were compared with data from an earlier 2006 survey.

• RESULTS: Mild visual impairment (20.4% prevalence) was caused by uncorrected refractive error in two thirds of cases and by cataract in nearly another one fourth; moderate-to-severe visual impairment (10.3% prevalence) was caused by cataract in over onec half of cases and by uncorrected refractive error in another one fifth; blindness (1.66% prevalence) was caused by cataract in approximately one half of cases and in another one fourth by retinal disease. Primary causes of visual impairment and blindness in cataract-operated eyes were uncorrected refractive error, posterior capsule opacity, and retinal disease. From 2006 to 2014, the proportion of visual impairment caused by uncorrected refractive error increased, but rates for unoperated cataract were reduced.

• CONCLUSIONS: Uncorrected refractive error and unoperated cataract are the 2 primary causes of mild, moderate, and severe visual impairment in rural China, with unoperated cataract and retinal diseases primary causes for blindness. An effective public health strategy to increase service delivery for these causes would lead to substantial reduction in vision impairment and blindness. (Am J Ophthalmol 2019;197:80–87. © 2018 Elsevier Inc. All rights reserved.)

UNIVERSAL EYE HEALTH: A GLOBAL ACTION PLAN 2014-2019, developed by the World Health Organization (WHO), set a global target aiming for a 25% reduction in the prevalence of avoidable visual impairment by 2019 from the baseline of 2010 and emphasized the importance of periodic assessments to monitor changes in the magnitude and causes of vision impairment over time.[1]

In assessing progress toward achieving this goal, it is critically important that data collection be undertaken at a national level. The Chinese National Health Commission carried out such national-level data collection with a "China Nine-Province Survey" in 2006 and in 2014.[2–5] The surveys were conducted in 9 rural counties/districts representative of the different levels of socioeconomic development within the 4 municipalities, 22 provinces, and 5 autonomous regions in mainland China and distributed across East Coast, Inland Middle, and West regions. The study sites were the same in the 2 surveys, except the Xinjiang autonomous region, where, because of the social situation potentially disrupting survey logistics successful implementation of a survey in 2014 could not be guaranteed, so the study site was replaced by a county with similar sociodemographic characteristics in the Ningxia autonomous region. The study protocol and measurement methods were the same in both surveys.[6]

The overall prevalence of presenting moderate or severe visual impairment (<20/63 to ≥20/400) and blindness (<20/400) decreased 6.31% and 29.0%, respectively, over the 2006-2014 interval; and by 16.1% and 38.0%, respectively, after age and sex standardization between the surveys.[4] Government programs that increased cataract

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surgery in underserved populations, improved affordability of eye care with the introduction of the Universal Medical Insurance scheme, and increased eye-care service capacity throughout China were influential in this reduction.

Causes of visual impairment generally differ between developed and developing countries: Curable diseases, such as cataract and uncorrected refractive error, are consistently reported as primary causes of visual impairment in developing countries, while incurable diseases, such as age-related macular degeneration and glaucoma, are leading causes in Western countries.[7] With a nearly 4-fold growth in per capita gross domestic product over the 2006-2014 interval, China is moving toward developed-country status with a tremendous increase in economic wellbeing and associated lifestyle changes. Understanding changes in the pattern of primary causes of vision impairment associated with rapid economic development would help health care planners and the public better anticipate the challenges and future needs of eye care in China.

This article presents data on the causes of vision impairment and blindness in the 2006 and 2014 surveys.

METHODS

BOTH SURVEYS WERE POPULATION-BASED CROSS-sectional studies of the prevalence of vision impairment and blindness among adults 50 years of age or older. Human subject research approval of the original study protocol and the scripted consent form for obtaining written informed consent was cleared by the WHO Secretariat Committee on Research Involving Human Subjects. The Peking Union Medical College (PUMC) Hospital Committee on Ethics on Research approved implementation of the 2014 survey.

The surveys were carried out in randomly selected samples of individuals from each study site: 1 municipality (Beijing) and 2 provinces (Jiangsu and Guangdong) in the East Coast region; 3 provinces (Heilongjiang, Hebei, and Jiangxi) in the Inland Middle region; and 1 municipality (Chongqing), 1 province (Yunnan), and 1 autonomous region (Xinjiang in 2006 and Ningxia in 2014) in the West region. In collaboration with local academic personnel responsible for prevention of blindness efforts along with community health authorities, 1 county/district socioeconomically representative of rural areas within the province was selected as the study site for the 2006 survey. Geographically defined clusters, each with a population of approximately 1000 individuals (all ages), were used as the study sampling frame—with the central commercial area within the county/district excluded. Depending on the percentage of population ≥ 50 years of age within each sampling frame, 14-21 clusters were randomly selected (with equal probability) as the study population. All households within the selected study clusters were visited to enumerate those ≥ 50 years of age by age, sex, and education.

New study clusters were randomly selected for the 2014 survey, except in Beijing, Jiangxi, and Yunnan, where clusters selected for the 2006 survey were resurveyed. A new cluster sampling frame was prepared for Ningxia, which replaced the 2006 Xinjiang study site. The resurveying of previously selected clusters in Beijing, Jiangxi, and Yunnan involved an entirely new house-to-house enumeration of eligible subjects followed by examinations that included some of those examined previously in 2006.

Both surveys were implemented by local study site teams. Oversight and technical supervision for the 2006 survey was provided by a Chinese Ophthalmological Society (COS) committee of study directors from each of the 9 study sites and chaired by the then COS president (J.Z.). Administrative oversight for the 2014 survey was by the National Institute of Hospital Administration and with technical expertise provided by the PUMC Hospital (J.Z.).

Presenting distance visual acuity (PVA), with corrective spectacles if the participant brought them to the examination, was measured using a retroilluminated logarithm of the minimum angle of resolution (logMAR) tumbling E chart (Precision Vision, Villa Park, Illinois, USA). Participants with PVA 20/40 or worse in either eye were refracted with subjective refraction to achieve best-corrected visual acuity (BCVA). Ophthalmic examination of the eyelid, globe, pupillary reflex, and lens was carried out by the study ophthalmologists. Pupils of eyes with BCVA 20/40 or worse were dilated for direct ophthalmoscopy and slit-lamp examination.

A *principal* cause for eyes with blindness or vision impairment (PVA 20/40 or worse) was determined by the examining ophthalmologist using an itemized list: uncorrected refractive error, amblyopia, cataract, posterior capsule opacification, corneal opacity or scar, phthisical or disorganized or absent globe, glaucoma, other optic atrophy, macular degeneration (age-related macular degeneration, high myopia, or other), diabetic retinopathy, retinal detachment, other retinal or choroidal changes, other cause, undetermined cause. (Glaucoma as a cause of vision impairment was likely underestimated because the visual field test was not included in the examination.) When multiple causes seemed to be involved, the examiner generally favored the most treatable cause. Uncorrected refractive error was assigned as the cause for eyes with PVA 20/40 or worse that improved to 20/32 or better with refractive correction. Examining ophthalmologists, who required at least completing specialist residency program, were selected by study site principal investigators and were convened for a training session before the study began.

• **DATA MANAGEMENT AND ANALYSIS:** Computerized data entry was carried out using standardized programs. Original forms and data files were transferred to the

TABLE 1. The 2006 and 2014 Study Populations by Age, Sex, Education Level, and Study Site

Study Variable	Number Examined (%)		
	2006 Survey	2014 Survey	Both Surveys
Age (y)			
50-59	21 670 (47.4)	18 224 (35.5)	39 894 (41.1)
60-69	13 345 (29.2)	19 435 (37.9)	32 780 (33.8)
70-79	8351 (18.3)	10 218 (19.9)	18 569 (19.1)
80+	2381 (5.20)	3433 (6.69)	5814 (5.99)
Sex			
Male	20 947 (45.8)	22 245 (43.4)	43 192 (44.5)
Female	24 800 (54.2)	29 065 (56.7)	53 865 (55.5)
Education level			
None	13 824 (30.2)	17 423 (34.0)	31 247 (32.2)
Less than Primary	7322 (16.0)	9838 (19.2)	17 160 (17.7)
Primary	16 267 (35.6)	12 586 (24.5)	28 853 (29.7)
Secondary or More	8334 (18.2)	11 463 (22.3)	19 797 (20.4)
Study site			
Beijing	5118 (11.2)	5310 (10.4)	10 428 (10.7)
Jiangsu	5141 (11.2)	5823 (11.4)	10 964 (11.3)
Guangdong	4589 (10.0)	5638 (11.0)	10 227 (10.5)
Heilongjiang	5047 (11.0)	5381 (10.5)	10 428 (10.7)
Jiangxi	5010 (11.0)	5511 (10.7)	10 521 (10.8)
Hebei	5051 (11.0)	6282 (12.2)	11 333 (11.7)
Xinjiang	5250 (11.8)	—	5250 (5.41)
Ningxia	—	4982 (9.71)	4982 (5.13)
Chongqing	5390 (11.8)	6791 (13.2)	12 181 (12.6)
Yunnan	5151 (11.3)	5592 (10.9)	10 743 (11.1)
Totals	45 747 (100.0)	51 310 (100.0)	97 057 (100.0)

PUMC Hospital, where measurement data ranges, frequency distributions, and consistency among related measurements were checked with data-cleaning programs.

Vision impairment was categorized as mild vision impairment (20/40 to 20/63), moderate-to-severe vision impairment (<20/63 to 20/400), and blindness (<20/400). Cause-specific prevalence rates were calculated with regard to the resulting level of vision impairment based on visual acuity in the better-seeing eye (ie, a prevalence rate was calculated for each cause paired with a specific level of vision impairment). The proportionate distribution of causes was tabulated within each of the 3 levels of vision impairment.

Multiple logistic regression was used to investigate the association of age, sex, education, and study site with the primary causes of vision impairment (uncorrected refractive error, cataract, and retinal disease). The significance of the survey year as an independent factor in affecting the cause-specific prevalence of vision impairment was investigated with combined 2006 and 2014 datasets and with survey year included as a covariate in multiple logistic regression modeling.

Prevalence rates were also analyzed based on the causes of vision impairment in both eyes, including causes of vision impairment in cataract-operated eyes.

Statistical analyses were performed using Stata/SE Data Analysis and Statistical Software: Release 12.0 (StataCorp, College Station, Texas, USA). Confidence intervals (CI) and *P* values (significant at the $P \leq .05$ level) were calculated with adjustment for clustering effects associated with the sampling design.

RESULTS

• **2006 AND 2014 STUDY DATA AND DEMOGRAPHY:** Study data were obtained from randomly selected adults 50 years of age or older living in rural China. A total of 50 395 eligible persons were enumerated in the 2006 survey, with 45 747 (90.8%) of these examined; 56 630 were enumerated in the 2014 survey, with 51 310 (90.6%) examined. The distribution of the participants by age, sex, education, and study site are shown in Table 1. The 2014 population was older ($P < .001$, test on equality of means) and had more female subjects ($P < .001$, test on equality of proportions) than the 2006 population.

• **CAUSES OF VISION IMPAIRMENT IN THE BETTER-SEEING EYE:** Prevalence of the causes of presenting vision

TABLE 2. The Prevalence of Causes With the Resulting Level of Presenting Vision Impairment in the Better-Seeing Eye in the 2006 and 2014 Surveys

	Mild Vision Impairment		Moderate-to-Severe Vision Impairment		Blindness		All Vision Impairment and Blindness	
Principal Cause	2006	2014	2006	2014	2006	2014	2006	2014
Refractive error	11.2 (60.2)	13.8 (67.7)	1.94 (18.1)	1.99 (19.3)	0.02 (0.67)	0.01 (0.24)	13.2 (41.6)	15.8 (48.9)
Cataract	5.65 (30.4)	4.71 (23.1)	6.53 (60.7)	5.77 (56.0)	1.46 (63.6)	0.87 (52.6)	13.6 (43.1)	11.4 (35.0)
Retinal disease	0.74 (3.97)	0.93 (4.56)	1.17 (10.9)	1.47 (14.2)	0.34 (14.9)	0.41 (24.8)	2.25 (7.10)	2.81 (8.67)
Posterior capsule opacity	0.13 (0.72)	0.26 (1.26)	0.12 (1.08)	0.27 (2.66)	0.03 (1.43)	0.03 (1.53)	0.28 (0.89)	0.56 (1.72)
Corneal opacity	0.06 (0.32)	0.05 (0.24)	0.19 (1.75)	0.14 (1.40)	0.13 (5.73)	0.11 (6.35)	0.38 (1.19)	0.30 (0.92)
Amblyopia	0.30 (1.60)	0.11 (0.52)	0.27 (2.54)	0.16 (1.59)	0.02 (1.05)	0.01 (0.35)	0.59 (1.88)	0.28 (0.85)
Glaucoma	0.07 (0.38)	0.06 (0.31)	0.16 (1.52)	0.06 (0.57)	0.10 (4.20)	0.08 (5.05)	0.33 (1.04)	0.21 (0.64)
Globe disorder	0.00 (0.00)	0.00 (0.00)	0.01 (0.02)	0.00 (0.00)	0.07 (3.15)	0.05 (2.94)	0.07 (0.23)	0.05 (0.15)
Other causes	0.17 (0.93)	0.16 (0.79)	0.22 (2.01)	0.19 (1.89)	0.07 (3.05)	0.06 (3.88)	0.46 (1.45)	0.42 (1.30)
Undetermined cause	0.29 (1.55)	0.31 (1.52)	0.16 (1.44)	0.25 (2.44)	0.05 (2.29)	0.04 (2.23)	0.50 (1.57)	0.60 (1.85)
All causes	18.6 (100.0)	20.4 (100.0)	10.8 (100.0)	10.3 (100.0)	2.29 (100.0)	1.66 (100.0)	31.7 (100.0)	32.4 (100.0)

Data are given as prevalence percentage, with the percentage distribution of causes within vision impairment levels in parentheses.

impairment and blindness in the better-seeing eye with the resulting level of vision impairment are shown in Table 2. The overall prevalence of vision impairment and blindness across all causes was 31.7% (95% CI: 30.8%–32.5%) in 2006 and 32.4% (95% CI: 31.6%–33.2%) in 2014. Vision impairment was mostly at a mild level, increasing from 18.6% (95% CI: 18.0%–19.3%) in 2006 to 20.4% (95% CI: 19.8%–21.1%) in 2014. The prevalence of moderate-to-severe vision impairment was similar in the 2 surveys, 10.8% (95% CI: 10.3%–11.2%) in 2006 and 10.3% (95% CI: 9.88%–10.7%) in 2014, with the prevalence of blindness decreasing from 2.29% (95% CI: 2.08%–2.50%) to 1.66% (95% CI: 1.49%–1.82%) over the 8-year interval. (Vision impairment has been addressed in greater detail in previous articles.[2,4])

Uncorrected refractive error was the primary cause of presenting vision impairment in the 2014 survey, with a prevalence of 15.8% (95% CI: 15.2%–16.4%), increased from 13.2% (95% CI: 12.7%–13.7%) in 2006. Cataract was the most prevalent cause of vision impairment in the 2006 survey, with a prevalence of 13.6% (95% CI: 13.1%–14.2%), which decreased to 11.4% (95% CI: 10.8%–11.9%) in 2014. This decrease in the prevalence of cataract as a cause of vision impairment is consistent with the increase in cataract surgical coverage over the 2006-2014 interval.[5] Retinal disease was the third most prevalent cause of vision impairment, with a prevalence of 2.81% (95% CI: 2.58%–3.04%) in 2014, increased from 2.25% (95% CI: 2.04%–2.46%) in 2006.

Prevalence rates for specific retinal causes are shown in Table 3. Age-related macular degeneration, generally with mild or moderate-to-severe vision impairment, was a relatively frequent retinal cause, as was myopic retinopathy, generally with moderate-to-severe vision impairment. Diabetic retinopathy was the third most prevalent retinal cause.

• **REFRACTIVE ERROR, CATARACT, AND RETINAL DISEASES:** As shown in Table 4, presenting vision impairment caused by (primarily mild) refractive error, unoperated cataract, and retinal disease was associated with older age (except for the reduction in refractive error among those 80+ years of age) and female sex. Refractive error was also associated with the lack of education, cataract with decreasing levels of education, and retinal disease with education at the primary level. Survey year was statistically significant for all 3 causes of vision impairment: uncorrected refractive error and retinal disease were more prevalent in 2014 compared to 2006, and cataract was less prevalent in 2014 compared to 2006.

The importance of environmental factors, such as the site-specific eye-care delivery setting, was investigated using 2014 data with multiple logistic regression modeling (adjusted for age, sex, and education) and study site as a covariate. Uncorrected refractive error was found to be significantly less prevalent compared to that in Beijing (the regression reference) in all sites except Hebei. Unoperated cataract had a significantly higher prevalence in Guangdong and Heilongjiang compared to Beijing, and a significantly lower prevalence in Ningxia. Retinal disease was significantly more prevalent compared to Beijing in Jiangsu and Heilongjiang, but significantly less prevalent in Guangdong, Hebei, and Chongqing (data not shown).

The proportionate distributions of causes of vision impairment in the fellow eye for vision impairment in the better-seeing eye caused by refractive error, cataract, or retinal disease are shown in Table 5 with 2014 data. Overall, 14.7% (67.6% × [100.0%–78.2%]) of participants had vision impairment in only the fellow eye, with uncorrected refractive error the most prevalent cause; another 32.4% (100.0%–67.6%) of participants had bilateral vision impairment, with the cause in the fellow eye generally the same as in the better-seeing eye.

TABLE 3. The Prevalence of Retinal Causes With the Resulting Level of Presenting Vision Impairment in the Better-Seeing Eye in the 2006 and 2014 Surveys

	Mild Vision Impairment		Moderate-to-Severe Vision Impairment		Blindness		All Vision Impairment and Blindness	
Principal Retinal Cause	2006	2014	2006	2014	2006	2014	2006	2014
Age-related macular degeneration	0.47	0.49	0.40	0.40	0.07	0.03	0.93	0.91
Myopic retinopathy	0.06	0.07	0.42	0.58	0.15	0.22	0.64	0.87
Other retinal or choroidal disease	0.09	0.10	0.16	0.21	0.05	0.06	0.30	0.38
Diabetic retinopathy	0.09	0.15	0.14	0.14	0.02	0.03	0.25	0.32
Retinal detachment	0.00	<0.01	0.00	<0.01	0.01	<0.01	0.01	<0.01
Other optic atrophy	0.03	0.04	0.05	0.07	0.05	0.05	0.13	0.16
Other maculopathy	0.00	0.08	0.00	0.07	0.00	0.02	0.00	0.16
All retinal disease	0.74	0.93	1.17	1.47	0.34	0.41	2.25	2.81

Data are given as prevalence percentage.

TABLE 4. Multiple Logistic Regression Odds of Presenting Vision Impairment or Blindness in the Better-Seeing Eye Caused by Uncorrected Refractive Error, Cataract, or Retinal Disease in the Combined 2006 and 2014 Surveys

	Principal Cause of Vision Impairment		
Study Variable	Uncorrected Refractive Error	Unoperated Cataract	Retinal Disease
Age (years)			
50-59	0.55 (<.001)	0.20 (<.001)	0.59 (<.001)
60-69	Reference	Reference	Reference
70-79	1.13 (<.001)	4.85 (<.001)	1.72 (<.001)
80+	0.64 (<.001)	15.7 (<.001)	2.24 (<.001)
Sex			
Male	Reference	Reference	Reference
Female	1.23 (<.001)	1.48 (<.001)	1.41 (<.001)
Education level			
None	1.08 (.038)	1.36 (<.001)	0.85 (.017)
Less than primary	1.02 (.640)	1.54 (<.001)	0.84 (.068)
Primary	Reference	Reference	Reference
Secondary or more	0.96 (.260)	0.68 (<.001)	0.62 (<.001)
Survey year			
2006	Reference	Reference	Reference
2014	1.16 (<.001)	0.61 (<.001)	1.19 (.034)

Data are given as odds ratios (*P* values).

• **CAUSES OF VISION IMPAIRMENT IN CATARACT-OPERATED EYES:** The prevalence of causes with the resulting severity of presenting vision impairment among all 102 608 examined eyes (including cataract-operated eyes), along with the prevalence of causes in the 2877 cataract-operated eyes, are shown in Table 6 with 2014 data. The overall prevalence of vision impairment and blindness across all causes was 39.8% (95% CI: 38.9%%-40.6%), with a significantly higher 67.6% (95% CI: 65.1%–70.2%) prevalence in cataract-operated eyes: cataract-operated eyes had double the prevalence of vision impairment at the moderate-to-severe level and triple the prevalence for blindness. (Vision impairment in cataract-operated eyes has been addressed in greater detail in previous articles.[3,5])

Uncorrected refractive error, posterior capsule opacity, and retinal disease accounted for over 80% of the vision impairment and blindness in cataract-operated eyes. Most prevalent was refractive error, 22.3% (95% CI: 20.5%–24.1%), with the overwhelming majority having only mild impairment. Posterior capsule opacity was the second most prevalent cause with a prevalence of 18.6% (95% CI: 16.8%–20.4%), two thirds of which was moderate vision impairment or worse. Retinal disease, the third most

TABLE 5. Proportional Distribution of Causes of Vision Impairment in the Fellow Eye for Vision Impairment Caused by Refractive Error, Cataract, Retinal Disease, or Other Causes in the Better-Seeing Eye in the 2014 Survey

Better-Seeing Eye		Causes of Vision Impairment in Fellow Eye					
Principal Cause	Prevalence	No Impairment	Refractive Error	Unoperated Cataract	Retinal Disease	Other Causes	All Causes
No impairment	67.6	78.2	13.3	4.01	1.83	2.64	100.0
Refractive error	15.8	—	74.6	15.6	4.10	5.72	100.0
Cataract	11.4	—	4.38	84.1	4.09	7.48	100.0
Retinal disease	2.81	—	3.89	9.58	78.1	8.40	100.0
Other causes	2.41	—	4.70	21.5	5.18	68.5	100.0

Data are given as prevalence percentage and distribution percentages.

TABLE 6. The Prevalence of Causes With the Resulting Level of Presenting Vision Impairment in All Examined Eyes and in Cataract-Operated Eyes in the 2014 Survey

	Mild Vision Impairment		Moderate-to-Severe Vision Impairment		Blindness		All Vision Impairment and Blindness	
Principal Cause	All Eyes	Cataract-Operated Eyes	All Eyes	Cataract-Operated Eyes	All Eyes	Cataract-Operated Eyes	All Eyes	Cataract-Operated Eyes
Refractive error	15.4	18.0	3.29	4.00	0.03	0.35	18.7	22.3
Cataract	4.26	—	7.12	—	2.05	—	13.4	—
Retinal disease	0.87	2.75	1.83	6.57	1.04	5.18	3.74	14.5
Corneal opacity	0.05	0.10	0.23	0.52	0.38	1.22	0.66	1.84
Amblyopia	0.11	0.24	0.36	0.56	0.10	0.00	0.57	0.80
Posterior capsule opacity	0.19	6.60	0.27	9.56	0.07	2.47	0.52	18.6
Glaucoma	0.06	0.24	0.09	0.35	0.16	0.56	0.31	1.15
Globe	0.00	0.00	0.00	0.00	0.25	0.35	0.25	0.35
Other causes	0.18	0.90	0.35	1.63	0.32	2.78	0.85	5.32
Undetermined cause	0.32	1.04	0.30	1.08	0.12	0.63	0.74	2.75
All causes	21.4	29.9	13.8	24.3	4.52	13.5	39.8	67.6

Data are given as prevalence percentage.

prevalent cause, had a prevalence of 14.5% (95% CI: 12.7%–16.3%), almost evenly split between moderate-to-severe vision impairment and blindness.

DISCUSSION

THE STRENGTHS OF THE 2006 AND 2014 SURVEYS WERE THEIR large, randomly selected, population-based samples; use of the same study protocol and examination methods at each study site; and high examination response rates. Standardized measurement methods and definitions allowed for direct comparisons between study sites and the 2 survey years, while categorization of vision impairment into 3 levels of severity provided for qualitative comparisons of cause-specific prevalence rates.

Because few of the study participants were with corrective spectacles at the examination, the prevalence of uncorrected refractive error was only minimally affected by those with refractive correction. Among those without vision impairment, the percentage presenting with corrective spectacles was 0.43% in 2006 and 1.09% in 2014. Assuming that all would have been visually impaired without spectacles, the prevalence of presenting vision impairment caused by uncorrected refractive error would have been 13.5% instead of 13.2% in 2006 and 16.1% instead of 15.8% in 2014.

Although not reported here, prevalence rates for the causes of vision impairment with best-corrected visual acuity would have remained essentially the same. Changes would have occurred only when the better-seeing eye with best-corrected visual acuity was different from that based on presenting visual acuity.

Vision impairment caused by refractive error, cataract, and retinal disease was associated with older age and female sex—consistent with age- and sex-specific prevalence for vision impairment across all causes.[1,3] The comparatively

low prevalence of refractive error as the principal cause of vision impairment among those 80 years of age or older was likely owing to the onset of other ocular disease, particularly the onset of cataract among the elderly. Less education was significant for unoperated cataract, but without any clear association for uncorrected refractive error or retinal disease.

Previous analyses dealing with the 2006 and 2014 survey data have shown that site-specific, environmental factors (including disease incidence) have a significant influence on the prevalence of vision impairment and blindness in rural China.[1,3] Based on separate multiple logistic regression modeling of the 3 primary causes of vision impairment, it is apparent that environmental factors also affect the causes of vision impairment. This was evidenced for uncorrected refractive error, where Beijing had a significantly higher prevalence in comparison to the other sites; for unoperated cataract, where Guangdong and Heilongjiang had a comparatively high prevalence and Ningxia a low prevalence; and for retinal disease, with Jiangsu and Heilongjiang having a comparatively high prevalence but with comparatively low prevalence in Guangdong, Hebei, and Chongqing. This geographic variation may be attributable to service provision capacity and affordability in accessing eye care, as well as geographically associated exposure to possible environmental risk factors. Disparities regarding the causes of vision impairment, particularly cataract and retinal disease, might also be attributable, in part, to judgmental differences in the assignment of the *principal* cause of vision impairment as determined by the study ophthalmologist.

Cataract-operated eyes had a much higher prevalence of presenting vision impairment compared to that for all examined eyes (67.6% vs 38.9%), with double the prevalence of moderate-to-severe vision impairment and triple the prevalence of blindness. The prevalence of vision impairment in cataract-operated eyes was primarily caused by uncorrected refractive error (22.3%), posterior capsule opacity (18.6%), and retinal disease (14.5%). Both uncorrected refractive error and posterior capsule opacity may exist as prevalent causes of vision impairment because patients are not receiving adequate postoperative follow-up. Also, with greater attention given to accurate biometric measurements in the determination of appropriate intraocular lens power, the need for refractive correction would be minimized.

Retinal disease as a cause of vision impairment in cataract-operated eyes (14.5%) was particularly high in comparison with the significantly lower prevalence in all eyes (3.74%). A number of factors contribute to this differential, including the onset of retinal disease in the interval between the time of cataract surgery and the time of the survey examination, as well as the progression of retinal disease coexisting at the time of surgery. The time interval between surgery and the survey examination averaged 4.9 years, ranging from 3.6 years for those experiencing mild vision impairment caused by retinal disease to 5.9 years for those with blindness.

Refractive error, cataract, and posterior capsule opacity represent readily treatable causes of vision impairment. If uncorrected refractive error were to be entirely eliminated with corrective spectacles, the overall prevalence of presenting vision impairment and blindness would be reduced from 32.4% to 16.6% in 2014, with almost all of the reduction coming from those with mild vision impairment. Although refractive error is easily correctable with refractive spectacles, it is not realistic to expect this amount of reduction for several reasons, including a perception that sharp vision is not needed and the cost of refraction and prescription spectacles. Unoperated cataract represents another opportunity for substantial reduction in the prevalence of vision impairment and blindness, hypothetically to as low as 21.1%, with moderate-to-severe vision impairment and blindness reduced by more than 50%. Although surgical coverage among those with severe vision impairment or blindness can exceed 80%, the uptake of cataract surgery among those with mild or moderate vision impairment is much less.[4] Further, coexisting disease may preclude full restoration of vision among those in whom cataract is the principal, but not the sole, cause of impairment.

In summary, the 2014 survey confirmed that uncorrected refractive error and unoperated cataract were 2 major causes for mild, moderate, and severe visual impairment in this study population, composed predominately of people living in rural China. Unoperated cataract and retinal diseases were primary causes for blindness. From 2006 to 2014, the proportion of vision impairment caused by uncorrected refractive error increased, but rates for unoperated cataract were reduced. An effective public health strategy to increase the service delivery for these 2 diseases would lead to substantial reduction in vision impairment and blindness.

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