Prevalence and Associations of Cataract in a Rural Chinese Adult Population: The Handan Eye Study

Running head: Prevalence of cataract in rural China

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Abstract

Background: Cataract remains the leading cause of blindness and visual impairment in the world and in China. However, data on the prevalence of cataract based on standardized lens grading protocols from mainland China are limited. This paper estimated the age- and gender-specific prevalence and risk factor for cataract

Methods: In a population-based Chinese sample, participants underwent a comprehensive ophthalmic examination including assessment of cortical, nuclear, posterior subcapsular (PSC) and mixed lens opacities from slit lamp grading using the Lens Opacities Classification System III.

Results: Of the 7,557 eligible subjects, 6,830 took part in the study (90.4% response rate), and 6,544 participants (95.8%, mean age 52.0 ± 11.8 years) had lens data for analyses. The prevalence of any cataract surgery in at least one eye was 0.8% (95% confidence interval [CI], 0.62, 1.06), with similar rates between men and women. The overall prevalence of any cataract or cataract surgery was 20.8% (95% CI, 19.8, 21.8), higher in women than in men after adjusting for age (23.6% vs. 17.6%; OR: 1.78; 95% CI: 1.54-2.07). When distinct lens opacity was categorized in each eye as cortical, nuclear, PSC or mixed, based on one randomly selected eye, cortical cataract was the most common distinct subtype (12.3%), followed by mixed (3.2%), nuclear (1.7%), and PSC (0.2%) cataract. The prevalence of all lens opacities increased with age (P < 0.001). After excluding other causes for visual impairment, the

proportion of people with best corrected visual acuity <20/60 was 21% among those with PSC and 12% among those with mixed opacities in the better seeing eye. In multivariable logistic regression models, myopia was associated with all cataract types, while higher fasting plasma glucose and diabetes were only associated with PSC cataract.

Conclusions: Cataract affects 20% of the population aged 30 years and older living in rural China, with cortical cataract the most common subtype. Risk factors for cataract include myopia and diabetes.

Keywords: cataract, prevalence, risk factor, population-based

Cataract is the most common cause of blindness in the world, with the majority of those affected in Asia. [1-3] In China, cataract remains the leading cause of blindness and visual impairment despite sustained public health efforts to increase cataract surgery rates. [4, 5] Furthermore the prevalence of cataract is expected to further increase with the aging of China's population. [1]

While there have been epidemiological studies on the prevalence of cataract in China, previous data based on standardized grading protocols are limited. [6, 7] Furthermore, almost all research on cataract has been conducted in either urban cities or in economically well-developed regions of China, [6, 8-10] and information on the prevalence of cataract among rural Chinese living in economically underdeveloped regions, who represent 60% (or 800 million) of the total Chinese population, is scarce.

The purpose of this report is therefore to describe in a rural Chinese population, the prevalence of and associated factors for lens opacity, measured and defined based on slit lamp examination using the Lens Opacities Classification System III (LOCS III).

METHODS

Study Population

The Handan Eye Study (HES) was designed to provide population-based prevalence estimates of eye disorders in rural adult Chinese people. Yongnian County, Handan, located in the south part of Hebei province (about 500

kilometers south of Beijing) has demographic characteristics similar to other rural Chinese locations according to the 2000 China National Census. [12, 13] Residents of Yongnian County aged 30+ years were randomly selected using a clustered sampling technique with probabilities proportionate to the size of population in each cluster. Of the 458 villages in the Yongnian County, 13 were randomly selected to achieve a target sample size of 5,105. The sampling frame was a list of persons living in the town obtained from the Household Resident Register Record Office of the local police stations. All residents aged 50+ years in the selected 13 villages were invited to participate. In addition, in order to study individuals aged 30-49 years, we randomly selected six out of the 13 villages with probabilities proportionate to size where all residents aged 30-49 years were also invited.

A total of 8,653 individuals were selected and their permanent residency in the villages was confirmed in a door-to-door census. A person was considered ineligible if he had moved out of the village, had not lived there in the past six months, was deceased or was terminally ill with a life expectancy estimated to be less than 3 months. Of 8,653 individuals, 7557 (87.3%) were considered eligible. The study protocol was approved and monitored by Beijing Tongren Hospital Ethical Committee and written informed consent was obtained from all participants at the time of the examination. For those who were illiterate, we read the consent form to them and asked them to mark the consent form with an inked forefinger. All study procedures adhered to the principles outlined in

the Declaration of Helsinki for research involving human subjects. Details of the study design, sampling plan, and baseline data are reported elsewhere. [13, 14] The study was conducted from October 2006 to October 2007.

Lens Examination Protocol

The grading of lens opacity was performed by two senior ophthalmologists (XRD graded 70% and RZY), who were trained and certified according to a written standardized protocol, using slit lamp-based LOCS III. [15-18] Participants were examined at a slit lamp after maximum dilation of pupils. The presence and severity of lens opacities was compared to LOCS III standard transparency which was next to the slit lamp and visible to the examining physician. Decimal grades were documented separately for cortical opacities (C; ranging from 0.1 to 5.9, using 5 standards), nuclear opalescence (NO; ranging from 0.1 to 6.9, using 6 standards), nuclear color (NC; ranging from 0.1 to 6.9), and posterior subcapsular opacities (P; ranging from 0.1 to 5.9, using 5 standards). If grading was not possible, the reasons for not grading any regions in one or both eyes were also recorded.

Definition of Lens Opacities

Cataract was defined based on the LOCS III grade in four major characteristics: C, NO, NC, and P, [15-18] following similar criteria published by other groups using the LOCS III. [16, 19, 20]

1. **Any cataract in a person**: This definition was used to calculate person-based rates. Any cortical cataract as C ≥ 2, any nuclear cataract

was defined as NO or NC ≥ 4, and any posterior subcapsular cataract (PSC) as P ≥ 2 in either eye. If a person had unilateral cataract surgery or ungradable lens, the LOCS III score of the fellow eye was used. Any cataract or cataract surgery was defined as the presence, in at least one eye, of any cataract (cortical, nuclear, or PSC cataract meeting the criteria above) or a history of previous cataract surgery (pseudophakia or aphakia).

2. **Distinct type of cataract in an eye**: This definition included the presence of a distinct type of cataract in one eye, resulting in four mutually exclusive categories: cortical only, nuclear only, PSC only, and mixed cataract (more than one type in that eye). Prevalence of distinct types of lens opacities was based on eyes with gradable LOCS III findings in all regions (i.e., cortical, nuclear, and posterior subcapsular regions).

The reproducibility of LOCS III grading between 2 examiners was evaluated at the beginning and during the conduct of the study. The intra-grader consistency of one of the examiners (XRD) was also evaluated during the conduct of the study. The assessment consisted of performing an independent replicate grading on 30 participants aged 50+ years.

Examinations and Definitions of Other Variables

A detailed interview was conducted asking ocular and medical histories and assessing various risk factors. Socioeconomic status including job, income, level of education of each participant was obtained from questionnaire. [13]

Visual acuity (VA) for each participant was measured using a log of the minimal angle of resolution (LogMAR) chart at a distance of 4 meters. Automated refraction was performed (Auto Refractometer KR 8800, Topcon Corp., Japan), followed by subjective refraction performed by trained optometrists on subjects with vision worse than 1.0 (< 20/20) in either eye (best corrected VA [BCVA]).

Blood pressure, height, weight, and Perkins applanation intraocular pressure were measured. Fasting plasma glucose, serum cholesterol, high density lipoprotein cholesterol (HDL), low density lipoprotein cholesterol (LDL) and triglyceride were tested in 83.7% participants.

Diabetes mellitus was diagnosed from a self-reported history of medication use and/or fasting plasma glucose greater than or equal to 7.0 mmol/L. Hypertension was defined as having a history of hypertension on medication or elevated blood pressure when measured during the examination (diastolic blood pressure greater than or equal to 90 mmHg or systolic blood pressure greater than or equal to 140 mmHg).

Refractive error was defined by spherical equivalent (SE, sum of spherical power and half of the cylinder power, in diopters). Emmetropia was defined as a SE between -0.50 D to +0.50 D, hyperopia as a SE greater than +0.50 D, myopia as a SE less than -0.50 D. [21] Visual impairment was defined as a BCVA of 20/60 or worse in an eye.

Data Handling and Statistical Analyses

Statistical Analysis System (SAS Institute Inc, Cary, NC, version 9.1.3) was

used for tabulations and statistical analyses. Reproducibility of lens assessment was measured by intraclass correlation coefficient (ICC). Frequency distributions were used to determine the gender- and age-specific prevalence for each opacity type (all lens changes, any lens opacity, and single and mixed opacities). Chi-square analyses were used to determine the association of age- and gender-specific groups (by decade) and opacity type. All analyses were conducted at the 0.05 significance level. Multiple logistic regression was used to investigate the associations of the binary dependent variable 'presence vs absence of cataract' with continuous (e.g., age and biochemical parameters) and dichotomous variables (e.g., hypertension, diabetes, smoking and other indices of systemic disease status). Odds ratios (OR) and 95% confidence intervals (CI) are reported.

RESULTS

Reproducibility analyses showed good inter-grader agreement for all opacity types. At the beginning of the study, ICC for cortical opacities was 0.98 (95% CI= 0.95-0.99); 0.97 (0.93-0.99) for NO, 0.97 (0.93-0.99) for NC and 1.00 (1.00-1.00) for PSC; and during the study, respective ICCs were 0.99 (0.97-0.99), 0.99 (0.98-1.00), 0.97 (0.94-0.99) and 1.00 (1.00-1.00). The respective intra-grader consistency of one examiner (XRD) was: 0.99 (0.97-0.99) for cortical opacities; 0.99 (0.98-0.99) for NO, 0.99 (0.97-0.99) for NC, and 0.99 (0.98-1.00) for PSC.

Of the 7,557 eligible subjects, 6,830 took part in the study (90.4% response rate). Of the 6,830 participants, data on the lens were available for 6,544 subjects (95.8%, 13,008 eyes). The mean age of these participants was 52.0 ± 11.8 years and 3516 (53.7%) were women. Compared with those who were excluded, included persons were significantly younger, had higher serum HDL cholesterol and were more often illiterate. Both groups did not vary significantly in gender, spherical equivalent and other parameters (Table a). For 6,464 subjects, lens data were available from both eyes, while for the remaining 80 subjects, lens data were available from only one eye. Of the 652 eyes excluded from this analysis, 264 eyes (153 participants) did not undergo pupil dilation because of narrow angles or a diagnosis of angle-closure glaucoma and 388 eyes (215 participants) declined a slit-lamp examination or had missing lens data.

Cataract Surgery

Of the 6,544 subjects in this study, 55 (0.8%; 95% CI: 0.62-1.06; 71 of 13,008 eyes, 0.55%; 95% CI: 0.42-0.67) had previous cataract operations, with similar rates (P = 0.22) between men (1.0%; 95% CI: 0.64-1.34) and women (0.7%; 95% CI: 0.43-0.99; OR: 0.72; 95% CI: 0.42-1.23). Rates of cataract surgery in at least one eye increased significantly with age (P for trend < 0.001). In the 5350 subjects aged 40+ years, rate of cataract surgery in at least one eye was 0.9% (95% CI: 0.63-1.13).

Prevalence and Characteristics of Cataracts

After excluding those with cataract surgery in both eyes (n = 20), 6524 persons had lens data on at least one eye for the analysis of lens opacity (6482 right eyes and 6486 left eyes). Overall, the prevalence of any lens change in the population was 20.8% (95% CI: 19.83-21.80, Table b). In participants aged 40+ years, the prevalence of any cataract or cataract surgery was 24.8% (95% CI: 23.66-25.98). The prevalence of any cataract or cataract surgery increased from 4.4% in those 40 to 49 years of age to 78.7% in those 70 years of age and older (P for trend < 0.001). After adjusting for age, women were more likely to have lens changes than men (23.6% vs. 17.6%; OR: 1.78; 95% CI: 1.54-2.07).

The most common distinct type of cataract was cortical only, followed by mixed, nuclear only, and PSC only in one randomly selected eye of each subject (Table c). The prevalence of cortical only, nuclear only and mixed cataract was strongly associated with increasing age (P for trend < 0.001). After adjusting for age, no significant gender differences were found in the prevalence of nuclear only (1.6% vs. 1.7%; OR=0.9; 95% CI: 0.6-1.3) or PSC only cataract (0.2% vs. 0.2%; OR=1.0; 95% CI: 0.4-2.8). However, women were more likely to have cortical only (14.5% vs. 9.6%; OR=1.7; 95% CI: 1.5-2.1) and mixed cataract (4.0% vs. 2.3%; OR=2.0; 95% CI: 1.5-2.8) than men.

Prevalence of Visual Impairment and Cataracts

The presence of visual impairment (BCVA of 20/60 or worse, according to

the WHO criteria) was more common among individuals with PSC only and mixed opacities after excluding cases whose visual impairment was caused by other reasons (e.g., glaucoma, diabetic retinopathy, age related macular degeneration, myopic retinopathy). About 21% of those with PSC only and 12% of those with mixed opacities were visually impaired in the better-seeing eye. Visual impairment in the worse-seeing eye was 26% and 24% respectively in those with PSC only and mixed opacities.

Risk Factor Associations with Cataracts

Based on logistic regression models, after controlling for other factors, myopia was associated with an increased risk for all types of cataracts, whereas hyperopia was inversely associated with PSC only (Table d). Higher fasting plasma glucose and presence of diabetes were associated with PSC only cataracts (OR: 1.25, 95% CI: 1.05-1.49; per mmol/L increase in glucose and OR: 5.03, 95% CI: 1.25-20.25 for presence of diabetes, respectively). Higher serum cholesterol was associated with nuclear opacities, whereas HDL and LDL cholesterol were inversely associated with nuclear opacities. None of the other previously suggested risk factors including body mass index (BMI), smoking and drinking habits (past and current smoking or drinking vs. never smoking or drinking), hypertension (history or examination), time spent outdoors, and level of income and education were significantly associated with any cataract or cataract type in our study (OR: 0.00-2.17, all *P*>0.05, data not shown).

DISCUSSION

In this large rural Chinese population aged 30 years and older, we report an overall prevalence rate of 20.8% for any cataract or cataract surgery. The prevalence increased to 24.7% among participants aged 40 years and older, and to 37.7% among those 50 years and older, after age standardization to the year 2000 China national census.

Direct comparison with other studies is limited by differences in the age distributions of the population examined, methodology of cataract assessment, and lack of universal 'epidemiological definitions' and 'cut-offs' for cataract. For example, the specific cut-off points to define cataract vary from study to study even when using the LOCS III.[16, 23-25] Nonetheless, in comparison with other studies of Chinese adults, our age-adjusted rate was similar to that seen in Yang County Eye Survey conducted in a rural area in Shanxi Province and Shihpai Eye Study in Taiwan (≥60 years, 54.9% vs. 59.2%) [26] who used the same LOCS III system evaluation (Table e). The distribution of cataract types in our study was also similar to the Yang County Eye Survey in which the most common type was cortical only, but different from the Shihpai Eye Study which reported nuclear opacity as the most common type. This difference is likely due to differing definitions of nuclear cataract (the Shihpai Eye Study used NO or NC≥2 to define nuclear cataract, whereas we used NO or NC≥4, similar to the Tanjong Pagar Survey in Singapore and the Meiktila Eye Study in

Myanmer). [16, 25, 26] Compared with other studies in Asian countries which used the LOCS III, our age and gender standardized rate was lower than that observed in India, Singapore and Indonesia, [16, 23, 24] but similar to that in another study in Myanmar [25] (Table f).

Differences between whites and non-white populations in cataract type and prevalence have been elaborated previously. [27-29] Many studies have reported that non-white persons are at increased risk for cortical cataract. [28] For example, the Barbados Eye Study [27] reported significant difference in types of lens opacities with a higher prevalence of any cataract and higher prevalence of cortical opacities in blacks compared to whites. Possible explanations for the type and prevalence difference of cataract have been attributed to genetic background or a higher exposure to cataract risk factors including diabetes and increased ultraviolet light exposure, but the exact underlying reasons, if it indeed exists, remain unclear and further investigations are warranted. [10, 27, 28]

Although cataract remains the leading cause of blindness, the surgical rate in China is low. In our study, only 1.4% of subjects over 50 years of age had previous cataract surgery. This rate was similar to that seen in the Shunyi District Eye Study [8] conducted in the economically well developed suburb of Beijing in 1996 and the Shanxi Eye Survey conducted in a rural area of Shanxi Province in 2003 (Table e), and was similar to the result of a nine-province survey in rural China. [31] Importantly, the cataract surgery rate in China is lower than that seen in most other Asian countries, such as Singapore,

India, and Myanmar [16, 23, 25, 32] after age and gender standardization to the year 2000 world population[33] (Table f). This may reflect the lack of knowledge about cataract and concerns about the quality of healthcare services and cataract surgery in rural China. [34] These findings suggest that increased efforts to inform rural populations that cataract can be treated surgically, and improved training in surgery and postoperative management are needed to increase cataract surgical rates in rural China.

Consistent with other studies, we found that both unilateral and bilateral visual impairment were frequently associated with lens opacities, [27, 35] particularly for PSC cataract. We confirmed that cataract was the most common cause of both blindness (41.9%) and low vision (48.2%) in our study.[5]

With regards to risk factors, age is strongly related to prevalence of cataracts. [16, 25] Also consistent with previous studies, women had a higher prevalence of cataracts and cortical cataracts than men.[23, 26] While hormonal differences in older women have been postulated as a potential explanation for this gender difference, [36] further etiologic studies are needed to clarify the relation between gender and cataract. Myopia was associated with any cataract and each cataract subtype, a finding similar to that from the Melbourne Visual Impairment Project Study [37] The Tanjong Pagar Survey [38] also found that nuclear and PSC cataract was associated with myopia, but not with axial length, suggesting that associations of myopia with cataract is likely

related to the 'myopic shift' with age. [38, 39] The finding between higher fasting plasma glucose, diabetes and PSC cataracts are similar to several population-based and clinical-based studies. [17, 40, 41] In contrast, a possible relationship between serum cholesterol and nuclear opacities needs to be verified since conflicting results have been reported in previous studies. [6, 42] We found no association between cataract and BMI, cigarette smoking and other previously reported risk factors. [17, 24, 26, 37, 43, 44] The failure to identify these associations could be due to different methodology, less precise measurement of some variables (e.g., assessment of hours outside as an indirect proxy to ultraviolet light exposure), less variation in the variables being studied (most were farmers, and spent a lot of time outdoors and most were smokers), or a spurious association being identified in the original studies.

Strengths of our study include its large sample size with high response rate in a population-based sample, and the use of standardized protocols when grading lens opacification. There are a number of limitations of this study. First, no lens photographs were taken. However, photographic documentation of cortical and nuclear opacities has been shown to correlate well with clinical grading at the slit lamp [35, 45] and lens grading was performed strictly adhering to the methodology specified in the LOCS III protocol with standard lens transparency and certification of graders. Second, the exclusion of small numbers of participants who did not undergo pupil dilation because of narrow angles or a diagnosis of angle-closure glaucoma could have resulted in a slight

underestimate of the true cataract prevalence since these people are more likely to have cataract.

In conclusion, we report the prevalence of cataract in a population-based sample of subjects across a wide age range living in rural areas of China, using standardized LOCS III grading. We confirm that cataract is common and is a major cause of blindness and low vision in rural China. Key risk factors for cataract, including myopia and diabetes, are similar reported in our Chinese population. Further strengthening public health interventions in China are needed to tackle this major problem with an aging population.

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TABLE a. Characteristics of Participants Included and Excluded from the

Analysis

	Included (n = 6544)	Excluded (n = 286)	P
Gender (Female, %)	53.7	52.8	0.757
Age (y, Mean ± SD)	52.0 ± 11.8	60.8 ± 15.9	< 0.001**
Spherical Equivalent (D, Mean ± SD)	-0.10 ± 1.80	-0.30 ± 1.80	0.370
Body Mass Index (kg/m^2, Mean ± SD)	24.50 ± 3.75	24.51 ± 4.61	0.975
Serum cholesterol (mmol/l, Mean ± SD)	4.61 ± 0.95	4.61 ± 1.08	0.989
Serum triglyceride (mmol/l, Mean ± SD)	1.51 ± 1.05	1.65 ± 1.05	0.155
Serum HDL cholesterol (mmol/l, Mean ± SD)	1.28 ± 0.29	1.21 ± 0.24	0.009**
Serum LDL cholesterol (mmol/l, Mean ± SD)	2.71 ± 0.65	2.73 ± 0.72	0.733
Diabetic Mellitus (%)	6.8	11.3	0.090
Hypertension (%)	47.6	51.5	0.318
Drinking (%, past and current vs. never)	18.6	18.8	0.980
Smoking (%, past and current vs. never)	27.4	31.5	0.209
Income (%, <3500￥/year)	59.6	50.4	0.055
Level of Education			0.009**
Illiteracy (%)	11.4	17.1	
Partial literacy (%)	54.2	54.9	
Primary school (%)	31.4	26.2	
Middle school or higher (%)	3.0	1.8	
**p<0.01, *p<0.05			

TABLE b. Age- and Gender-specific Prevalence of Any Cataract in the Handan Eye Study

Gender	Age (yrs)	Any Nuclear Cataract			Any Cortical Cataract			Any Posterior Subcapsular Cataract			Any Cataract or Cataract Surgery		
		No. at Risk	n	%	No. at Risk	n	%	No. at Risk	n	%	No. at Risk	n	%
Men	30-39	533	1	0.2	533	9	1.7	532	0	0.0	534	14	2.6
	40-49	590	0	0.0	590	21	3.6	590	0	0.0	590	21	3.6
	50-59	1116	12	1.1	1116	113	10.1	1115	14	1.3	1117	129	11.6
	60-69	532	40	7.5	532	155	29.1	531	8	1.5	536	188	35.1
	≥70	246	80	32.5	247	147	59.5	244	16	6.6	251	181	72.1
	Total	3017	133	4.4	3018	445	14.7	3012	38	1.3	3028	533	17.6
			$P < 0.001$*			$P < 0.001$*			$P < 0.001$*			$P < 0.001$*	
Women	30-39	659	0	0.0	659	16	2.4	659	2	0.3	660	20	3.0
	40-49	715	2	0.3	715	33	4.6	713	1	0.1	715	37	5.2
	50-59	1296	6	0.5	1296	236	18.2	1295	13	1.0	1297	246	19.0
	60-69	525	55	10.5	525	233	44.4	525	17	3.2	527	260	49.3
	≥70	311	138	44.4	311	233	74.9	302	25	8.3	317	266	83.9
	Total	3506	201	5.7	3506	751	21.4	3494	58	1.7	3516	829	23.6
			$P < 0.001$*			$P < 0.001$*			$P < 0.001$*			$P < 0.001$*	
Total	30-39	1192	1	0.1	1192	25	2.1	1191	2	0.2	1194	34	2.9
	40-49	1305	2	0.2	1305	54	4.1	1303	1	0.1	1305	58	4.4
	50-59	2412	18	0.8	2412	349	14.5	2410	27	1.1	2414	375	15.5
	60-69	1057	95	9.0	1057	388	36.7	1056	25	2.4	1063	448	42.1
	≥70	557	218	39.1	558	380	68.1	546	41	7.5	568	447	78.7
	Total	6523	334	5.1	6524	1196	18.3	6506	96	1.5	6544	1362	20.8
			$P < 0.001$*			$P < 0.001$*			$P < 0.001$*			$P < 0.001$*	

* Test of trend for age.

TABLE c. Age- and Gender-specific Prevalence of Distinct Types of Cataract in One Randomly Selected Eye of Each Subject in the Handan Eye Study

Gender	Age (yrs)	No. at Risk	Mixed		Nuclear Only		Cortical Only		Posterior Subcapsular Only	
			n	%	n	%	n	%	n	%
Men	30-39	531	0	0.0	0	0.0	6	1.1	0	0.0
	40-49	590	0	0.0	0	0.0	15	2.5	0	0.0
	50-59	1110	8	0.7	3	0.3	78	7.0	4	0.4
	60-69	522	14	2.7	23	4.4	110	21.1	3	0.6
	≥70	237	47	19.8	26	11.0	79	33.3	0	0.0
	Total	2990	69	2.3	52	1.7	288	9.6	7	0.2
			P < 0.001*		P < 0.001*		P < 0.001*		P = 0.140*	
Women	30-39	657	0	0.0	0	0.0	15	2.3	1	0.2
	40-49	711	0	0.0	1	0.1	27	3.8	1	0.1
	50-59	1285	7	0.5	2	0.2	183	14.2	3	0.2
	60-69	513	33	6.4	23	4.5	170	33.1	2	0.4
	≥70	297	100	33.7	29	9.8	108	36.4	1	0.3
	Total	3463	140	4.0	55	1.6	503	14.5	8	0.2
			P < 0.001*		P < 0.001*		P < 0.001*		P = 0.348*	
Total	30-39	1188	0	0.0	0	0.0	21	1.8	1	0.1
	40-49	1301	0	0.0	1	0.1	42	3.2	1	0.1
	50-59	2395	15	0.6	5	0.2	261	10.9	7	0.3
	60-69	1035	47	4.5	46	4.4	280	27.1	5	0.5
	≥70	534	147	27.5	55	10.3	187	35.0	1	0.2
	Total	6453	209	3.2	107	1.7	791	12.3	15	0.2
			P < 0.001*		P < 0.001*		P < 0.001*		P = 0.091*	

* Test of trend for age. Persons without gradable Lens Opacity Classification System III scores in all regions (i.e., nuclear, cortical, and posterior subcapsular) in their one randomly selected eye were excluded from analysis (n = 71).

TABLE d. Results of Multivariate Analysis of Risk Factors for Any Cataract and Specific Cataract Subtypes in the Handan Eye Study

Characteristics	Any Cataract or Cataract Surgery (OR, 95% CI)	Nuclear Only (OR, 95% CI)	Cortical Only (OR, 95% CI)	Posterior Subcapsular Only (OR, 95% CI)
Myopia	2.37 (1.78, 3.17) **	6.47 (3.14,13.32) **	2.17 (1.60, 2.95) **	6.67 (2.56, 17.36) **
Emmetropia	reference	reference	reference	reference
Hyperopia	0.77 (0.59, 1.01)	0.58 (0.27,1.21)	0.81 (0.61,1.06)	0.16 (0.03,0.85) *
Fasting Glucose (mmol/L)	1.09 (0.99, 1.19)	1.06 (0.82,1.37)	1.05 (0.95,1.15)	1.25 (1.05,1.49) *
Serum cholesterol (mmol/l)	1.54 (0.85, 2.79)	5.42 (1.76,16.70) **	1.47 (0.80, 2.70)	0.56 (0.08, 4.16)
Serum HDL cholesterol (mmol/l)	0.83 (0.40, 1.71)	0.13 (0.02, 0.74) *	0.91 (0.43,1.90)	6.78 (0.56, 82.69)
Serum LDL cholesterol (mmol/l)	0.65 (0.30, 1.39)	0.11 (0.03, 0.44) **	0.69 (0.32, 1.51)	2.19 (0.18, 27.13)
Diabetes	1.19 (0.68, 2.08)	1.42 (0.38, 5.34)	1.16 (0.64, 2.10)	5.03 (1.25, 20.25) *

**p<0.01, *p<0.05

TABLE e. Comparison of the age standardized prevalence of cataract in Handan Eye Study and other population-based eye studies in China using the year 2000 China national census.

Study	Region	Year Conducted	Urban/ Rural	Age Range	Population at Risk	Method of Evaluation	Prevalence (%)	Rate of Cataract Surgery (%)	Age-Standardized Rate (%, 95%CI)	Age-Standardized Cataract Surgery Rate (%, 95%CI)
Tibet Eye Study [10]	Tibet	1987	Suburb	≥20	2660	Slit-lamp evaluation & Visual Acuity < 6/12	5.6	Not available	14.2 (12.9-15.5)	Not available
Shunyi District Eye Study [8]	Beijing	1996	Suburb	≥50	5084	Slit-lamp evaluation & Pinhole Visual Acuity < 0.7	23.3	1.7	22.3 (21.2-23.5)	1.4 (1.3-2.0)
Doumen County Eye Study [9]	Guangdong Province	1997	Rural	≥50	5342	Slit-lamp evaluation & Pinhole Visual Acuity < 0.7	20.9	2.0	14.1 (13.1-15.0)	Not available
Shihpai Eye Study [26]	Taiwan	1999-2000	Community	≥65	1361	Slit-lamp evaluation with LOCS III system	59.2	12.9	Not available	Not available
Beijing Eye Study [6]	Beijing	2001	Urban and rural	≥40	4378	Photographs of lens using a modification of the Age-related Eye Disease Study (AREDS)	53.1	1.3	Not available	Not available
Shanxi Eye Survey [30]	Shanxi Province	2003	Rural	≥50	1762	Slit-lamp evaluation	37.2	1.1	39.5 (37.2-41.8)	1.3 (0.7-1.8)
Yang County Eye Survey [7]	Shanxi Province	2006	Rural	≥50	1536	Slit-lamp evaluation with LOCS III system	29.4	0.5	33.7 (31.4-36.1)	Not available

| Handan Eye Study | Hebei Province | 2006-2007 | Rural | ≥30 | 6544 | Slit-lamp evaluation with | 20.8 | 0.8 | Not available | Not available |
| | | | | ≥50 | 4045 | LOCS III system | 31.4 | 1.1 | 37.7 (36.2-39.2) | 1.4 (1.0-1.8) |

TABLE f. Comparison of the age and gender standardized prevalence of cataract in Handan Eye Study and other population-based eye studies using the year 2000 world population. [33]

Study	Country	Year Conducted	Ethnicity	Age Range	Population at Risk	Method of Evaluation	Prevalence (%)	Rate of Cataract Surgery (%)	Age & Gender-standardized Rate (%, 95%CI)	Age& Gender-standardized Cataract Surgery Rate (%, 95%CI)
Beaver Dam Eye Study [46]	United States of America	1988-1990	non-Hispanic white	43-84	4646	Photographic evaluation with standardized system	46.1	3.6	Not available	Not available
Barbados Eye Study [27]	Barbados	1987-1992	black most	40-84	4631	Slit-lamp evaluation with LOCS II system	41.0	3.0	Not available	Not available
Blue Mountains Eye Study [47]	Australia	1992-1994	non-Hispanic white	≥49	3444	Photographic evaluation with standardized system	54.6	6.0	Not available	Not available
Salisbury Eye Evaluation Study [28]	United States of America	1993-1995	Caucasians	65-84	1772	Photographic evaluation with standardized system	55.1	12.2	Not available	Not available
			African Americans		621		68.0	4.8	Not available	
Aravind Comprehensive Eye Study [23]	India	1995-1997	Indian	≥40	5150	Slit-lamp evaluation with LOCS III system	47.5	9.4	48.5 (47.1-49.8)	10.5 (9.6-11.3)
Tanjong Pagar Survey	Singapore	1997-1998	Chinese	40-81	1206	Slit-lamp evaluation with	34.7	5.1	42.7 (39.9-45.5)	7.3 (5.9-8.8)

Study	Country	Year	Ethnicity	Age	N	Grading method				
						LOCS III system				
Los Angeles Latino Eye Study [35]	United States of America	2000-2003	Latinos	≥40	6090	Slit-lamp evaluation with LOCS II system	19.5	3.9	20.8 (19.8-21.8)	Not available
A Study in Rural Sumatra [24]	Indonesia	2003	Malay	21-86	914	Slit-lamp evaluation with LOCS III system	22.6	0.7	Not available	Not available
				≥40	414		44.9	1.4	40.8 (36.0-45.5)	1.2 (0.2-2.3)
Meiktila Eye Study [25]	Myanmar	2005	Burman	≥40	2044	Slit-lamp evaluation with LOCS III system	40.4	3.3	33.5 (31.5-35.6)	1.9 (1.3-2.5)
Handan Eye Study	China	2006-2007	Chinese	≥30	6544	Slit-lamp evaluation with LOCS III system	20.8	0.8	Not available	Not available
				≥40	5350		24.8	0.9	25.7 (24.6-26.9)	1.0 (0.7-1.2)

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