Prevalence and aetiology of cataract in Punjab

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SUMMARY Three districts in the Punjab plains were surveyed in 1976-7 for senile cataract and potential risk factors. The prevalence of senile cataract was 15.3% among 1269 persons examined who were aged 30 and older, and 4.3% for all ages. These figures confirmed previous reports of high prevalence. The prevalence was 1% for ages 30-49 and increased markedly in the sixth and seventh decades to 67% for ages 70 and older. Univariate age-adjusted analyses of selected socioeconomic, demographic, dietary, and other variables suggested that a higher prevalence was associated with being widowed, low education, use of rock salt in cooking, infrequent consumption of various protein foods (beans and lentils, milk, eggs, and curd), short height, and low weight. Multivariate analysis further suggested low total protein consumption as a risk factor that may account for as much as 40% of the excess prevalence of Punjab cataract over that in a US population study.

Cataract is a major cause of blindness worldwide, especially in the tropical belt, where most of the densely populated developing countries are located.¹ In India 40% of all blindness may be due to cataract²; 27 million persons are blind from cataract in one or both eyes,¹ and the prevalence of cataract is about 7%.³ Most of these cataracts are unassociated with other eye diseases, and the resultant blindness is curable. Though hundreds of 'eye camps' and mobile eye clinics^{4,5} are organised each year to serve the largely rural population, present levels of effort can restore vision to only a fraction of those blind and visually handicapped by cataract.

Surveys in different climatic zones in northern India have found cataract prevalence of 4-10%, with senile cataract appearing and steadily increasing after age 30 and with prevalence 13-36% among persons aged 30 and older.⁶⁻¹⁰ Variations in prevalence may be related to different environmental factors, but differences in cataract definition and field survey methodology are likely to account for much of the variation. Nevertheless, the reported high prevalence significantly exceeds that reported in the United States¹¹ and other countries.

The aetiology of senile cataract remains obscure even though it is a common disease. In this study we verify a high prevalence area and attempt to identify factors related to the risk of developing senile

cataract. In addition to general socioeconomic and demographic variables we also include nutrition,^{12,13} fluoride¹⁴ and other minerals in drinking water, genetics, and others, following suggestions in an earlier report.⁹

Subjects and methods

Census information was used to select 3 geographically identifiable districts in the green belt of the Punjab plains, of about 1500 population each, of which one-third were expected to be aged 30 or older; a section of Ludhiana city slums (fieldganj); a nearby village (Narangwal); and a more distant village in the region known for high fluoride content of household water (Bajakhana) (Fig. 1). Each district was mapped and its households and regular occupants enumerated and checked against the census lists.

Field work was done in 1976-7. Under the supervision of the principal investigator (AC) an ophthalmologist (ST) and an ophthalmic assistant visited each household during daylight hours and clement weather, and examined each member aged 30 or older who was present and willing to be examined. Absent members were examined when possible on repeated visits. Of 4762 persons enumerated 1529 (32%) were aged 30 or older and 83% (1269) of them were examined (Table 1). The response to examination was 76% for men and 91% for women; 52.6% of examinees were women.

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Fig. 1 Study districts in Punjab: Fieldganj (Ludhiana), Narangwal, and Bajakhana.

Examinations were performed according to a written protocol suitable for local field study conditions, and the results recorded on an examination form designed to facilitate coding for subsequent computer analysis. Responses to questionnaire items

Table 1 Study census* and percentage examined, by age and sex

Age (yrs)	Male		Female		Total	
	No. in census	% Examined	No. in census	% Examined	No. in census	% Examined
30-39	272	76	238	89	510	82
40-49	193	72	197	94	390	83
50-59	135	74	153	90	288	83
60-69	121	73	90	90	211	80
70-79	51	100	33	85	84	94
80+	24	83	22	95	46	89
Total	796	76	733	91	1529	83

*Number enumerated under age 30: 3233.

(Table 2) were recoded in appropriately defined categories. Visual acuity was tested with a Snellen illiterate E chart, held in the shade of a building so that it was not directly illuminated by sunlight, at a distance marked by a 6 metre rope. Acuity was recorded separately for each eye, the examinee occluding the other eye and taking care not to press on the eye. Acuity was tested with spectacles when available, and in all eyes with acuity less than 6/6 was further checked with plus and minus spherical lenses of power 1, 2, 3, and 4. Pinhole acuity was also tested for eyes with acuity less than 6/6. The best vision thus obtained was recorded.

Lens examination was done in a dimly illuminated room in the examinee's house both with a unocular loupe with oblique focal illumination and with distant direct ophthalmoscopy through an undilated pupil. Lens opacity location, form, and type were recorded according to the examination protocol. Opacities not of diabetic, traumatic, congenital, mixed, or other

Table 2 Questionnaire items

Age
Caste
Marital status
Economic status
Education
Usual occupation in last 10 years
Occupation location (indoors or out)
Cigarette smoking
Alcohol intoxication
'Usually urinate at night?'
'Sugar disease?'
Diet history: corn bread, wheat bread, beans and lentils, rice, meat, milk, eggs, curd, vegetables
Type of curd eaten
Use, type of salt
Water source
Weight
Height

type were designated senile type and further graded as to maturity.

Samples of drinking water were collected at random locations in each of the 3 districts and analysed for fluoride (F) by the colorimetric or visual comparison method at Patiala Medical College; for sodium (Na) and potassium (K) by flame photometry and calcium (Ca) by atomic absorption spectrophotometry, at the Department of Biochemistry, Christian Medical College Hospital, Ludhiana; and for magnesium (Mg) by the versenate titration method at Punjab Agricultural University.

For prevalence and analysis of associations we used as a 'case' a person with aphakia not attributable by history or examination to specific causes, or an opacity of senile type accompanied by best visual acuity 6/18 or worse, in at least one eye. Prevalence is based on persons actually examined, with no adjustment for unexamined eligible persons. Association of single polychotomous variables with cataract was assessed by direct adjustment of prevalence to 10-year age groups of the total study population, and by the Mantel-Haenszel¹⁵ significance test of 'average' relative odds comparing different levels of a variable. Note that the adjusted rates are valid for comparisons only within this study or in populations with similar age distribution.

The multiple logistic function,^{16,17} $p = (1 + e^{-Y})^{-1}$ where $Y = a + \sum b_i X_i$, was used to examine multivariate association with senile cataract or aphakia. In this model p is the probability or risk of senile cataract or aphakia, the X_i s are values of individual risk factors or variables (either discrete or continuous), and the b_i s are coefficients to be estimated from the data. Positive coefficients indicate factors that increase risk. Maximum likelihood estimates of the coefficients were obtained by iteratively reweighted

least squares.¹⁷ Variables were selected for inclusion in the model from among those showing the strongest univariate associations, and were retained in the model if their contribution to association was significant and if they were not highly correlated with other variables in the model.

Results

Lens examination findings are summarised by location and type of opacity and gradation of senile cataract in Table 3. Opacities were found in 14% of the eyes of persons age 30 and older. Aphakia was unilateral in 30 persons and bilateral in 26 persons. Three-quarters of the senile cataracts were early immature (iris shadow present and some fundal detail visible by direct ophthalmoscopy).

Table 4 shows the prevalence of senile cataract accompanied by best visual acuity 6/18 or worse, or aphakia, by age and sex. Overall prevalence was 15.3% for ages 30 and older, and 4.3% for all ages assuming negligible occurrence under age 30. Bilateral senile cataract or aphakia occurred in 73%

Table 3 Lens examination of persons age 30 and older

	Number of eyes	%
Lens opacity location:		
No opacity, or aphakia	2161	85.1
Anterior cortex	5	0.2
Nucleus	151	6.0
Posterior cortex	52	2.1
Posterior subcapsular	8	0.3
Mixed	73	2.9
Other	67	2.6
Not done*	21	0.8
Total	2538	100.0
Lens opacity type:		
No opacity	2078	81.9
Aphakia†	83	3.3
Diabetic type	0	—
Traumatic	1	0.0
Congenital	11	0.4
Complicated cataract	4	0.2
Mixed	2	0.1
Unknown	3	0.1
Not done*	21	0.8
Other (including senile)	335	13.2
Total	2538	100.0
Senile cataract or aphakia:		
Aphakia (bilateral, 26 persons)	82	19.9
Senile cataract		
Early immature	248	60.0
Advanced immature	47	11.4
Mature	30	7.3
Hyperimmune	6	1.4
Total	413	100.0

*Includes 1 enucleation, 16 phthisis, 2 corneal leucoma, 2 'blind eyes.'

†Includes one aphakia due to trauma.

Table 4 Prevalence of senile cataract* or aphakia, by age and sex

Age (yr)	Sex	No. examined	Number with senile cataract or aphakia		%
			One eye	Two eyes	One or two eyes
30-39	M	205	0	0	0
	F	214	0	1	1
	Total	419	0	1	1
40-49	M	138	1	2	3
	F	185	3	1	4
	Total	323	4	3	7
50-59	M	100	6	5	11
	F	138	14	10	24
	Total	238	20	15	35
60-69	M	87	8	24	32
	F	82	9	30	39
	Total	169	17	54	71
70-79	M	51	3	24	27
	F	28	3	14	17
	Total	79	6	38	44
80+	M	20	2	16	18
	F	21	3	15	18
	Total	41	5	31	36
Total	M	601	20	71	91
	F	668	32	71	103
	Total	1269	52	142	194

*With best visual acuity 6/18 or worse.

Table 5 Distribution of frequency of use of food, according to response to interview, in percent

Food	Number of times used per month			
	0	1-5	8-20*	30-90†
Corn bread	57.4	9.7	3.2	29.7
Wheat bread	0.0	0.0	0.1	99.9
Beans and lentils	0.2	1.2	11.8	87.0
Rice	76.9	17.1	4.7	1.3
Meat	79.0	16.1	4.0	0.9
Milk	55.6	1.3	2.3	40.8
Eggs	82.9	7.4	6.3	3.4
Curd	54.8	5.0	9.2	31.0
Vegetables	12.8	0.0	0.7	86.5

*Two to 5 times per week.

†One to 3 times per day.

of the 194 cases. Prevalence increased steadily with age, with marked increases seen in the sixth and seventh decade. Age-adjusted prevalence was 13.7% for men and 16.9% for women aged 30 and older. This difference is of marginal significance ($p=0.07$) and size of effect (combined relative odds=1.5). The lower rate of response to examination by men, together with the possibility that men away from home and working have less cataract than those at home, suggests the likelihood of a more definite sex difference in prevalence. Nevertheless, adjustment for sex was not done in subsequent analyses of

association with single variables. Aphakia accounted for 24% of all eyes with cataract or aphakia in Table 4.

Table 5 shows the distribution of frequency of use of foods according to questionnaire response. Wheat bread, beans and lentils, and vegetables were each reported as eaten at least once a day by over 85% of the study population. Rice, eggs, and meat were each reported as never eaten by over 75% of the respondents. Analysis of association of food use with senile cataract was based on approximate tertiles of frequency of use.

Age-adjusted percentage cataract or aphakia is given in Table 6 for each level of selected questionnaire items, along with results of continuity-corrected Mantel-Haenszel significance tests of differences between levels. Age-adjusted prevalence for urban Fieldganj (18.5%) was higher than for either rural district, 13.8% and 13.6% ($p<0.04$). Khatri and Arora caste members showed significantly higher prevalence than for the Jath caste ($p<0.03$). Adjusted prevalence for widowed persons was higher than for married persons ($p=0.001$). Prevalence decreased as economic status improved, and was significantly lower for high school graduates than for illiterates ($p<0.03$). Usual occupation, location of occupation, cigarette smoking, and alcohol intoxication were applicable to men only, with no significant findings but with the suggestion of higher prevalence for indoor occupations, nonsmokers, and nondrinkers.

Affirmative response to 'Usually urinate at night?' and 'Sugar disease?', possibly indicative of diabetes, had higher prevalence of cataract or aphakia (although not significantly so) than negative response.

Among the dietary variables higher prevalence was associated with infrequent consumption of beans and lentils ($p<0.005$), meat ($p<0.06$), milk ($p<0.04$), eggs ($p<0.03$), and curd (or yoghurt) ($p<0.02$). For curd made from buffalo milk, prevalence was higher for skim milk curd than for whole milk curd ($p=0.05$); use of curd from cow's milk was rare. Prevalence was higher among persons using rock salt in cooking than among persons never using rock salt ($p<0.01$).

Higher prevalence of cataract or aphakia was associated with short height ($p<0.05$), with low weight ($p<0.02$), and with low weight/height ratio ($p<0.03$).

Analysis of mineral content of drinking water showed no differences among districts in mean calcium, potassium, and magnesium. The 2 rural districts have over 3 times (12 mEq/l) the sodium found in Fieldganj water. Average fluoride in Bajakhana (0.33 mEq/l, or 6.2 ppm) is markedly elevated as expected, 10 or more times that of either of the other districts.

Preliminary multivariate analyses, which included most of the variables showing significant or consistent

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Table 6 Age-adjusted percentage senile cataract or aphakia, by levels of single study variables

	n†	%		n	%		n	%
District:			Usually urinate at night:			Type of buffalo milk curd:		
Fieldganj	423	18.5	Yes	36	32.7	No curd eaten	697	16.1
Narangwal	427	13.8	No	1233	14.9	Home-made	505	13.0
Bajakhana	419	13.6	Sugar disease:			Fortified	67	21.2
*Fieldganj>Narangwal, Bajakhana			Yes	9	21.6	*Fortified>Home-made p=0.05		
p<0.04 RO=1.78			No	1255	15.2	RO=2.26		
Caste:			Corn bread, frequency per month:			Vegetables, frequency per month:		
Khatri	80	19.9	None	728	15.9	None	162	17.7
Arora	296	18.3	1-20	164	16.6	1-30	833	13.7
Bania	52	16.8	21-90	377	14.2	31-120	274	18.8
Harijan	344	14.5	Wheat bread, frequency per month:			*31-120>1-30 p=0.01 RO=1.81		
Ramagharia	61	14.1	8-30	22	11.3	Use of salt in cooking:		
Jath	393	13.1	31-60	648	14.6	Little	21	11.7
Brahmin	21	8.3	61-90	599	15.9	Average	1238	15.6
Rajput	19	3.9	Beans and lentils, frequency per month:			Much	10	0.0
*Khatri, Arora>Jath		p<0.03	0-20	165	21.1	Use of rock salt:		
RO=2.99, 1.86			21-30	1055	14.3	Never used	934	13.8
Marital status:			31-90	49	16.5	Some use	335	18.9
Single	29	25.2	*0-20>21-30 p<0.005 RO=2.29			*Some use>Never used p<0.01		
Widowed	138	22.2	Rice, frequency per month:			RO=1.80		
Married	1099	13.9	None	976	15.1	Height, in cm:		
*Widowed>Married p=0.001			1	112	17.0	101-152	344	18.4
RO=2.21			2-30	181	14.3	153-160	359	15.7
Economic status:			Meat, frequency per month:			161-166	259	11.4
Poor	488	16.8	None	1002	15.6	167-185	307	13.7
Low middle	667	14.9	1-2	136	16.7	—		
Upper middle	114	11.8	3-30	131	9.3	101-160	703	17.3
Education:			*None>3-30 p<0.06 RO=2.13			161-185	566	12.6
Illiterate	908	16.2	Milk, frequency per month:			*101-152>161-166, 167-185 p<0.05		
Can read	276	13.7	None	706	16.7	RO=2.39, 1.87		
Highschool grad	85	4.2	1-20	46	19.2	*101-160>161-185 p<0.01		
*Illiterate>High school grad p<0.03			21-90	517	13.1	RO=1.81		
RO=7.46			—			Weight, in kg:		
Usual occupation (men):			1+	563	13.6	23-45	401	18.7
Other	156	17.3	*None>21-90 p<0.04 RO=1.57			46-52	293	15.2
Farmer	102	15.6	*None>1+ p<0.07 RO=1.48			53-60	269	12.4
Artisan	26	15.0	Eggs, frequency per month:			61-99	306	11.7
Business	124	11.0	None	1052	15.7	—		
Laborer	148	9.2	1-5	94	15.0	23-52	694	17.2
Professional	44	3.7	6-60	123	7.9	53-99	575	12.1
Occupation location (men):			*None>6-60 p<0.03 RO=2.39			*23-45>53-60, 61-99 p<0.02		
Indoor	288	17.1	Curd, frequency per month:			RO=2.01, 2.50		
Outdoor	267	12.5	None	696	16.1	*23-52>53-99 p<0.005 RO=1.88		
Mixed	46	11.5	1-20	180	18.0	(Weight/Height)×1000:		
Cigarettes per day (men):			21-90	393	12.1	163-283	330	17.1
None	533	15.2	—			284-323	317	16.9
<10	28	9.2	0-20	876	16.1	324-369	305	14.0
10-19	23	5.5	*None, 1-20>21-90 p<0.04			370-615	317	12.7
20+	17	10.4	RO=1.71, 2.07			—		
—			*0-20>21-90 p<0.02 RO=1.81			163-323	647	16.9
1+	68	11.4				324-615	622	13.1
Alcohol intoxication (men):						*163-283, 284-323>370-615 p<0.07		
Do not drink	262	17.2				RO=1.79, 1.84		
Never/rarely	235	13.2				*163-323>324-615 p<0.03		
1/month	48	11.9				RO=1.61		
1/week	56	12.4						
—								
Any drinking	339	12.9						

*Significant differences; RO is relative odds by Mantel-Haenszel method.

†Number of persons at this level of the variable.

Table 7 Multivariate risk function analysis, with risk factor coefficients ranked by *t* values

Risk factor	Coeff. B	Std. coeff.†	<i>t</i>
Model 1:			
Age	0.1366	1.549	13.58
'Nutrition'	-0.0114	-0.341	-2.88
Married*	-0.7050	-0.228	-2.88
Weight	-0.0250	-0.283	-2.56
'Urinate at night'	1.1305	0.185	2.31
High school graduate*	-1.5461	-0.385	-1.70
Constant	-7.9571		-9.25
Model 2:			
Age	0.1411	1.600	15.06
Constant	-9.4648		-16.68

*Yes=1, No=0.

†Standardised coefficient for variable $X = B \times SD(X)$, the contribution to change in $\log(p/(1-p))$ for one standard deviation change in x .

univariate associations in Table 6, were used to select a subset of variables likely to contribute meaningfully to multivariate association with senile cataract or aphakia. A general nutrition variable was created as the total frequency of use of protein foods: beans, meat, milk, eggs, and curd. Table 7 shows the results of multiple logistic regression analysis of association of risk of senile cataract or aphakia with age, education (high school graduate), 'Frequently urinate at night?', weight, marital status (married), and 'nutrition' as defined above (model 1), and also with

age alone (model 2). The number of expected and observed cases of senile cataract or aphakia is given by decile of risk in Table 8, indicating the adequacy of fit of the multiple logistic model to the data.

Age alone was seen to be a good predictor of risk, with sensitivity 43%, and 72% for the upper decile and quintile of risk, respectively. The 6-variable model improves slightly the prediction ability, but with statistically significant contributions from all variables except possibly high school graduate, yielding corresponding sensitivities 47% and 76%. Risk decreases with increased 'nutrition', increased weight, for married persons, and for high school graduates. Risk increases with increasing age and for persons who frequently urinate at night. The relative odds (or relative 'risk') for one unit change in X_i , with the other X s fixed, is e^{b_i} . One unit (year) increase in age is equivalent in relative risk to a decrease of 12 units in frequency of use of the foods in 'nutrition' and to 5.5 kg decrease in weight. The state of being married has relative risk equal to that of a decrease of 5 years of age. High school graduate status has relative risk equal to a decrease of 11 years of age. Similarly, frequent urination at night has relative risk equal to an increase of 8 years of age. Relative risk associated with an increase in age of 1, 5, 10, 20 years is 1.15, 1.98, 3.92, and 15.4, respectively.

Discussion

Prevalence of senile cataract in this study confirms the previously reported high rates for northern India. The age-adjusted prevalence comparable to the Framingham Eye Study is 43.3%, almost 3 times higher than observed in Framingham (Table 9). This difference is conservative, since our acuity criterion was more stringent, our method of examination (in field conditions, with loupe and ophthalmoscope through undilated pupils) might be expected to yield some false negatives, and lesser opacities detectable by slit-lamp were included in the Framingham study. The Punjab prevalence is consistent with Framingham prevalence about 14 years later in age. Average life expectancy in Punjab (about 65 years) is one of the highest in India and only 6 years less than in Framingham. The mortality rate for all ages is 7.9/1000 in Framingham and about 11.1/1000 in our rural-urban Punjab population. Age-specific mortality for Punjab and Framingham do not differ greatly for ages 40 and older (Table 10). These similarities, together with lack of reason or evidence for lower mortality with cataract in Punjab, suggests that the markedly higher prevalence in Punjab is due to factors other than differences in aging. There is at present no basis for assessing whether genetic difference is an important factor.

Table 8 Distribution of senile cataract or aphakia by decile of risk from multivariate risk function

Predicted decile of risk of senile cataract or aphakia	Model 1 (6 variables)			Model 2 (age alone)		
	No. expected	No. observed	Maximum risk	No. expected	No. observed	Maximum risk
1	0.3	1	0.004	0.7	0	0.007
2	0.8	0	0.007	1.0	0	0.011
3	1.2	0	0.011	1.5	1	0.016
4	1.9	1	0.019	2.5	1	0.022
5	3.3	0	0.034	4.2	1	0.043
6	5.9	2	0.060	6.8	7	0.083
7	11.3	12	0.126	12.4	14	0.154
8	23.9	31	0.259	25.2	31	0.270
9	47.9	56	0.534	46.6	55	0.498
10	97.6	91	0.998	93.1	84	0.989
Sensitivity* Specificity* Sensitivity Specificity						
Upper decile of risk	0.47	0.97	0.43	0.43	0.96	
Upper quintile of risk	0.76	0.90	0.72	0.89		

*Sensitivity = $a/(a+c)$, specificity = $d/(b+d)$:

		Cataract		Noncataract	
Risk Function	Top 10% Bottom 90%	a	b	c	d
		Total		Total	
		a+c		b+d	

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Table 9 Prevalence of senile cataract or aphakia for Punjab and Framingham, by sex and Framingham age groups*

Age (yr)	Sex	Punjab %	Framingham %
52-64	M	26.2	4.3
	F	32.7	4.7
	Total	29.4	4.5
65-74	M	35.7	16.0
	F	52.6	19.3
	Total	43.3	18.0
75-85	M	79.3	40.9
	F	84.6	48.9
	Total	81.8	45.9
Total	M	36.2	13.2
	F	45.4	17.1
	Total	40.5	15.5
Total, age-sex adjusted to Framingham Eye Study population			

*Senile cataract definition includes best visual acuity 6/18 or worse (Punjab), 6/9 or worse (Framingham).

When making many statistical comparisons at a given significance level (such as $p=0.05$), as was done for univariate risk factors, one is likely to find about one in 20 comparisons 'significant' even when in fact there are no real associations. We find about 25 significant associations at that level out of over 130, suggesting that some of them are likely to be real. Independent studies are required to verify these associations.

Univariate association of senile cataract or aphakia with caste is not readily distinguishable from association with Fieldganj district, since 95% of Arora and Khatri castes and 1% of Jath caste were in Fieldganj. Similarly, all users of skim milk curd and rock salt were in Fieldganj. Thus, the elevated prevalence in Fieldganj may reflect the effect of rock salt in cooking,

Table 10 Age-specific annual mortality rates (per 1000) for Punjab and Framingham

Age (yr)	Punjab*	Framingham†
40-44	5.3	1.2
45-49	5.2	3.3
50-54	10.8	6.9
55-59	11.3	11.2
60-64	20.9	19.7
65-69	24.5	25.7
70+	96.8	82.2
All ages	11.1	7.9

*Sample Registration System, Punjab, 1976 (combined in proportion to study population: 2/3 rural, 1/3 urban).

†Massachusetts Department of Public Health, 1976.

membership of the Khatri or Arora castes, lack of membership of the Jath caste, use of skim milk curd, use of water low in sodium, or some combination of these factors.

Eight of the 9 positive responses to 'Sugar disease?' were in Fieldganj, and only one of the positive responses to 'Frequently urinate at night?' was in Bajakhana. Although these categories, especially the latter, are not definitively indicative of diabetes, the elevated prevalence for both categories is consistent with the known relationship between cataract and diabetes. Estimated prevalence of diabetes in this study for persons age 30 and older, based on positive response to these two questions, is 3% and is consistent with other reports on India.

Body weight, height, weight/height ratio, and frequency of use of protein foods, possible indicators of adequate nutrition, showed inverse association with cataract.

Multivariate analyses suggested that sex, economic status, use of rock salt, and Fieldganj district were unimportant in the prediction of risk of cataract when considered together with the factors in Table 7. Although age is, as expected, a strong predictor of risk, other factors also made statistically significant contributions. 'Nutrition' and weight are both significant, suggesting they singly are different or incomplete descriptions of nutritional status.

We find an association between low frequency of present use of protein foods and concurrent diagnosis of cataract. Although similar findings supported by data from nonexperimental studies in man are rare, anecdotal evidence such as given by Cass¹⁸ implicates protein and other nutritional factors. If the present nutritional level of a study individual consistently reflects the relative level over the years, so that, for example, persons nutritionally lower than average today were lower than average 10 and 20 years ago, then the association may suggest a causal relationship.

This study suggests rather broadly that low protein intake (or possibly calorie intake) is related to early development of cataract. The design does not readily permit a finer breakdown of nutrition in terms of vitamins or aminoacids. Data available on Indian and US food and protein consumption are not fully comparable owing to differences in survey intent, detail, and methodology. Nevertheless, a rough nutritional comparison of Punjab and Framingham populations suggests that an increase in Punjab consumption of protein foods to the level of US consumption would, under the multiple logistic risk function model, reduce the expected Punjab prevalence of senile cataract for ages 30+ and 52-85 to 9.6% and 27.1%, respectively, a 37% reduction from the observed rates. Thus perhaps 40% of the excess of Punjab cataract prevalence over Framingham shown in Table

9 may be explained by current nutritional differences. The plausibility of a nutritional effect of this magnitude is enhanced by evidence that these 2 populations were even more nutritionally separated 10 to 20 years ago when a potential risk factor would logically have more causal impact on cataracts observed today. Still, the association of low protein consumption with increased development of cataract in man suggested here requires verification in more carefully designed studies. Especially helpful would be prospective studies or studies with stronger dietary components.

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References

- 1 Liu HS, McGannon WJ, Tolentino FI, Schepens CL. Massive cataract relief in eye camps. *Ann Ophthalmol* 1977; **9**: 503–8.
- 2 Specter A. Report on National Eye Institute cataract workshop. *Invest Ophthalmol Visual Sci* 1974; **13**: 325–32.
- 3 Venkataswamy G. Massive eye relief project in India. *Am J Ophthalmol* 1975; **79**: 135–40.
- 4 Chatterjee A. Mobile eye hospitals and cataract surgery in India. *Israel J Med Sci* 1972; **8**: 1239–43.
- 5 Franken S. The function of a mobile eye clinic. *Israel J Med Sci* 1972; **8**: 1243–5.
- 6 Franken S, Mehta KR. *A Survey to Determine the Ophthalmic Morbidity in the Population Living in the Dry Belt in the Southern Punjab and Haryana*. Ludhiana, Punjab: Christian Medical College, 1968.
- 7 Jain IS. *Blindness and Ocular Morbidity in Two Rural Blocks of Punjab and Haryana*. Chandigarh: Post Graduate Institute of Medical Education and Research, 1970.
- 8 Dhir SP, Gupta SB, Agarwal LP. Eye diseases in rural India. *Orient Arch Ophthalmol* 1969; **7**: 85–92.
- 9 Chatterjee A. Cataract in Punjab. In: *The Human Lens – in Relation to Cataract*. Ciba Foundation Symposium 19 (new series). Amsterdam: Associated Scientific Publishers, 1973: 265–79.
- 10 Mehrotra SK, Maheshwari BB. Prevalence of ocular lesions in a rural community. *Indian J Ophthalmol* 1976; **23**: 17–20.
- 11 Kahn HA, Leibowitz HM, Ganley JP, Kini MM, Colton T, Nickerson RJ, Dawber TR. The Framingham Eye Study. I. Outline and major prevalence findings. *Am J Epidemiol* 1977; **106**: 17–32.
- 12 Richter CP, Duke JR. Cataracts produced in rats by yoghurt. *Science* 1970; **168**: 1372–4.
- 13 Hall Bowles LL, Sydenstricker VP, Schmidt HL Jr. Cataracts due to deficiency of phenylalanine, histidine and tryptophan in diets of rats. *J Nutr* 1948; **36**: 277–95.
- 14 Jolly SS, Singh BM, Mather OC. Endemic fluorosis in Punjab (India). *Am J Med* 1969; **47**: 553–63.
- 15 Mantel N, Haenszel W. Statistical aspects of the analysis of data from retrospective studies of disease. *J Natl Cancer Inst* 1959; **22**: 719–48.
- 16 Truett J, Cornfield J, Kannel W. A multivariate analysis of the risk of coronary heart disease in Framingham. *J Chron Dis* 1967; **20**: 511–24.
- 17 Walker SH, Duncan DB. Estimation of the probability of an event as a function of several independent variables. *Biometrika* 1967; **54**: 167–79.
- 18 Cass E. A decade of northern ophthalmology. *Can J Ophthalmol* 1973; **8**: 210–7.