EXTENDED REPORT

Risk factors for nuclear, cortical and posterior subcapsular cataracts in the Chinese population of Singapore: the Tanjong Pagar Survey

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Aim: To describe risk factors for nuclear, cortical, and posterior subcapsular (PSC) cataracts in Chinese Singaporeans.

Methods: A population based cross sectional study was carried out on ethnic Chinese men and women aged 40–81 years. A stratified, clustered, disproportionate (more weights to older people), random sampling procedure was used to initially select 2000 Chinese names of those aged 40–79 years from the 1996 electoral register in the Tanjong Pagar district in Singapore. Eligible subjects (n = 1717) were invited for a standardised ocular examination and interview at a centralised clinic, following which an abbreviated examination was conducted for non-respondents in their homes. Cataract was graded clinically using to the Lens Opacity Classification System (LOCS) III system. The main outcome measures were adjusted odds ratio for risk factors for specific cataract types (nuclear, cortical and PSC), any cataract and cataract surgery, examined in multiple logistic regression models.

Results: Out of the 1232 (71.8%) examined, 1206 (70.2%) provided lens data for this analysis. Increasing age was associated with all cataract types, any cataract, and cataract surgery. There was no significant sex difference in presence of any cataract, specific cataract types or cataract surgery. After controlling for age, sex, and other factors, diabetes was associated with cortical cataract (3.1; 95% CI: 1.6 to 6.1), PSC cataract (2.2; 95% CI 1.2 to 4.1), any cataract (2.0; 95% CI: 0.9 to 4.5), and cataract surgery (2.3; 95% CI: 1.3 to 4.1). Lower body mass index was associated with cortical cataract (1.8; 95% CI: 1.1 to 2.9; lowest versus highest quintile) and any cataract (2.3; 95% CI: 1.3 to 4.0). Current cigarette smoking was associated with nuclear cataract (1.7, 95% CI: 1.0 to 2.9; more than 10 cigarettes per day versus none). A non-professional occupation was associated with nuclear cataract (2.9; 95% CI: 1.5 to 5.8; for production or machine operators and 2.6; 95% CI: 1.2 to 5.5; for labourers or agricultural workers, both versus professionals). Lower education was associated with nuclear cataract (2.3; 95% CI: 1.0 to 5.2, none versus tertiary), while lower household income was associated with PSC cataract (4.7, 95% CI: 1.1 to 20.0; income <S$2000 versus >S$4000).

Conclusions: Age related cataracts are associated with a variety of risk factors among Chinese people in Singapore, similar to those reported in European, Indian, and African derived populations. These data support common aetiological mechanisms for age related cataracts, irrespective of ethnic origin.

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Cataract is the principal cause of blindness and visual impairment worldwide, accounting for half of the 45 million people blind.[1] From a public heath perspective, it is desirable to identify risk factors for the development and progression of cataract.[2] This approach is particularly important in countries where delivery of cataract surgery remains suboptimal.[3] However, studies on potential risk factors for cataract have been conducted mainly in white European derived populations in the United States, Australia, and Europe[4–32] Some data are available from the black population in Barbados,[33 34] as well as the Indian population in south Asia,[35–38] but less is known about cataract risk factors in people of east Asian or Chinese origin,[39] even though they account for more than a quarter of the world's population. It is unclear if associations seen in European, Indian, and African derived populations are significant in people of Chinese ethnicity.

The aim of this study was to describe associations for age related nuclear, cortical and posterior subcapsular cataracts and cataract surgery in a defined Chinese population aged 40–81 years residing in Singapore.

METHODS

Study population

This study was approved by the ethics committee of Singapore National Eye Centre and carried out in accordance with the tenets of the World Medical Association's declaration of Helsinki. Informed, written consent was obtained from all subjects. The study was part of a population based survey of ocular disorders among adult Chinese living in Singapore, conducted between 10 October 1997 and 14 August 1998. Detailed population selection and methodology have been previously reported.[40–42] In brief, the 1996 Singapore electoral register in the district of Tanjong Pagar was used as the sampling frame in this study. Tanjong Pagar was chosen because the population demographics of the Chinese residents were representative of the rest of Singapore. The electoral register listed 15 082 Chinese names of people aged 40–79 years residing in the district. Two thousand (13.3%) names were initially selected using a disproportionate (with more weights given to the older age groups), stratified, clustered, random sampling method.

Procedures

The grading of lens opacity was performed by trained ophthalmologists (90% by PJF), according to a written standardised protocol, using the Lens Opacity Classification System (LOCS) III system.[43] After dilatation of pupils with tropicamide 1% and phenylephrine hydrochloride 2.5% eye drops (repeated twice if necessary), the participant was examined at a slit lamp (Model BQ 900, Haag-Streit, Bern, Switzerland),

Table 1 Demographic characteristics of study participants

		Demographic characteristics			
		Men		Women	
		No	%	No	%
Age (years)	40–49	123	22.6	147	22.2
	50–59	113	20.7	185	28.0
	60–69	169	31.0	169	25.6
	70–81	140	25.7	160	24.2
Education*	None	54	10.0	267	40.7
	Primary	273	50.5	215	32.8
	Secondary	168	31.1	137	20.9
	Tertiary	46	8.5	37	5.6
Occupation*	Managers and professionals	95	17.6	50	7.6
	Clerical and sales persons	134	24.8	134	20.3
	Production and machine operators	182	33.7	73	11.1
	Labourers and agricultural workers	79	14.6	97	14.7
	Home makers	5	0.9	279	42.3
	Others	45	8.3	27	4.1
Housing type*	1–2 room flats	117	21.7	113	17.3
	3 room flats	288	53.3	359	54.8
	4–5 room flats and private housing	135	25.0	183	27.9
Individual income†, per month*	Less than $1000	247	45.8	514	79.3
	$1000–2000	136	25.2	56	8.6
	$2000–3000	42	7.8	22	3.4
	More than $3000	31	5.8	20	3.1
	Retired	83	15.4	36	5.6
Household income†, per month*	Less than $2000	373	68.8	474	72.3
	$2000–3000	102	18.8	123	18.8
	More than $3000	67	12.4	59	9.0

*Numbers may not add up to 1206 because of missing data.
†Figures in Singapore dollars.

and the presence and severity of specific lens opacity were compared and documented according to LOCS III standard photographs.

Trained study personnel, masked to cataract status, gathered information on demographic, education, occupation, income, medical history, as well as other variables from a standardised interview. In addition, height (m) was measured without shoes. Weight (kg) without shoes was measured on a single automatic weighing scale. Body mass index (BMI) was derived from the ratio of person's weight divided by the square of his height (US National Institutes of Health cites normal range 18.5–24.9). Systolic and diastolic blood pressures were measured (mm Hg).

For non-responders to the clinic examination an abbreviated examination was conducted in their homes. Cataract was similarly graded using LOCS III standards with a portable slit lamp (Model 904, Clement Clarke, Harlow, Essex, UK), after dilatation of the pupils. Interview data were also similar, but height, weight, and blood pressure measurements were not available for most of these people.

Definitions of cataract

The LOCS III classification system was used for grading lens opacity.[43] This is a method of grading severity of lens opacities according to photographic standards, separated into four major groups: nuclear opalescence (NO), nuclear colour (NC), cortical (C), and posterior subcapsular (P). Because there is a wide spectrum of lens changes and different types of opacities may be present in one or both eyes, three definitions were used for this analysis.

Nuclear, cortical, and posterior subcapsular cataracts

This definition included the presence, in at least one eye, of significant nuclear (NO and NC), cortical, and posterior subcapsular lens cataract. Significant nuclear cataract was the presence, in at least one eye, of a LOCS III score of ⩾4 for NO or ⩾4 for NC. Significant cortical cataract was the presence, in at least one eye, of a LOCS III score of ⩾2 for C. Significant posterior subcapsular cataract (PSC) was the presence, in at least one eye, of a LOCS III score of ⩾2 for P. If a person had unilateral cataract surgery or a non-gradable lens, the LOCS III score of the fellow eye was used. Definitions of cataracts were based on similar criteria published by other groups using the LOCS III system.[9 44]

Any cataract

This was defined as the presence, in at least one eye, of significant nuclear, cortical, or posterior subcapsular cataract, as defined above (that is, LOCS III score of ⩾4 for NO or ⩾4 for NC or ⩾2.0 for C or ⩾2.0 for P).

Any cataract surgery

This was defined as the presence, in at least one eye, of a history of previous cataract surgery (aphakia or pseudophakia).

Definitions of other variables

Age was the age at time of examination. Education was ascertained by the question, "What was your highest education level?" and categorised into four groups: no formal education, primary (6 years or less), secondary (7–10 years), and tertiary (11 years or older, including university education). Occupation was ascertained with the question, "What group of occupations do you feel best categorises your job?" with the response categorised into six groups for this analysis: managerial and professionals; clerical workers and sales people; production workers and machine operators; labourers and agricultural workers; homemakers, and others. Housing type was categorised into three groups for analysis: one or two room government flats, three room government flats, and government flats with four or more rooms; executive government flats; or private housing. Individual and household monthly income were recorded (in Singapore dollars, current exchange rate of 1 = Sing$2.80, $1 = Sing$1.77), with individual income categorised as: S$1000 or less, S$1001–2000, S$2001–3000, and more than S$3000 (retired people were excluded from individual income analysis, n = 119). Household income was

Table 2 Distribution of specific cataract types (nuclear, cortical, and posterior subcapsular cataract), any cataract and cataract surgery in Chinese residents of Singapore, by sociodemographic and medical characteristics

		Number (%) of specific cataract, any cataract, and any cataract surgery				
	No at risk*	Nuclear	Cortical	PSC	Any cataract	Cataract surgery
Age (years)						
40–49	270	5 (1.9)	12 (4.4)	3 (1.1)	19 (7.0)	–
50–59	298	56 (19.0)	75 (25.6)	17 (5.8)	111 (37.5)	7 (2.3)
60–69	338	178 (57.8)	167 (53.9)	43 (14.5)	254 (80.4)	43 (12.7)
70–81	300	211 (84.7)	177 (72.2)	67 (30.3)	237 (93.3)	84 (28.0)
Sex						
Men	545	214 (42.5)	194 (39.0)	58 (12.1)	294 (57.8)	67 (12.3)
Women	661	236 (38.1)	237 (38.2)	72 (11.9)	327 (52.2)	67 (10.1)
Education						
None	321	162 (56.6)	159 (55.0)	48 (17.5)	210 (71.7)	53 (16.5)
Primary	488	202 (44.5)	184 (41.0)	64 (14.8)	272 (59.3)	59 (12.1)
Secondary	305	68 (23.1)	65 (22.3)	12 (4.1)	109 (36.8)	16 (5.2)
Tertiary	83	14 (17.5)	20 (24.7)	5 (6.3)	26 (32.1)	3 (3.6)
Occupation						
Clerical or sales people	268	99 (38.4)	82 (32.4)	31 (12.4)	130 (50.2)	21 (7.8)
Production or machine operators	255	98 (42.2)	96 (41.7)	26 (11.7)	138 (58.5)	35 (13.7)
Labourers or agricultural workers	176	71 (43.3)	77 (46.1)	16 (10.1)	101 (60.1)	20 (11.4)
Home makers	284	128 (48.9)	118 (44.9)	40 (15.9)	166 (62.4)	35 (12.3)
Others	72	21 (32.3)	21 (32.8)	8 (12.7)	33 (50.8)	11 (15.3)
Managers or professionals	145	30 (22.1)	34 (25.0)	9 (6.7)	49 (35.8)	10 (6.9)
Housing type						
1–2 rooms government housing	230	98 (47.3)	81 (38.8)	27 (13.6)	125 (59.0)	31 (13.5)
3 rooms government housing	647	243 (40.4)	244 (40.9)	81 (14.0)	345 (56.7)	76 (11.7)
4–5 rooms and private housing	318	102 (33.6)	102 (33.7)	19 (6.5)	144 (47.2)	25 (7.9)
Individual income, per month						
<$1000	761	325 (46.5)	308 (44.1)	99 (14.7)	438 (61.6)	101 (13.3)
$1000–2000	192	39 (20.6)	43 (23.0)	7 (3.8)	64 (33.9)	7 (3.6)
$2000–3000	64	3 (4.7)	5 (7.8)	2 (3.1)	10 (15.6)	–
>$3000	51	5 (10.0)	6 (11.8)	1 (2.0)	9 (17.6)	–
Household income, per month						
<$2000	847	371 (47.7)	342(44.4)	110 (14.8)	493 (62.6)	115 (13.6)
$2000–4000	225	52 (24.2)	58 (26.9)	16 (7.6)	84 (38.7)	14 (6.2)
>$4000	126	23 (18.7)	28 (22.6)	3 (2.4)	40 (32.3)	3 (2.4)
History of diabetes						
Yes, oral medications and insulin	27	14 (60.9)	11 (50.0	3 (14.3)	16 (69.6)	6 (22.2)
Yes, diet control only	79	39 (56.5)	149 (71.0)	17 (27.4)	56 (80.0)	20 (25.3)
No	1066	377 (37.6)	352 (35.2)	103 (10.6)	525 (51.7)	99 (9.3)
History of "heart attack"						
No	1127	410 (38.8)	399 (37.9)	121 (11.9)	573 (53.6)	116 (10.3)
Yes	75	39 (61.9)	30 (49.2)	9 (15.3)	46 (73.0)	16 (21.3)
History of stroke						
Yes	39	22 (64.7)	22 (64.7)	4 (11.8)	27 (79.4)	7 (17.9)
No	1163	427 (39.4)	407 (37.7)	126 (12.0)	592 (53.9)	125 (10.7)
Hypertension†						
Yes	560	248 (48.2)	238 (46.6)	73 (14.9)	337 (64.7)	74 (13.2)
No	644	202 (33.3)	193 (31.8)	57 (9.7)	284 (46.3)	59 (9.2)
Current smoking						
Yes, > 10 cigarettes per day	163	69 (44.2)	62 (39.7)	18 (12.0)	90 (57.3)	11 (6.7)
Yes, ⩽ 10 cigarettes per day	51	25 (59.5)	20 (48.8)	5 (12.5)	31 (72.1)	13 (25.5)
No	992	356 (38.5)	349 (37.9)	107 (12.0)	500 (53.4)	110 (11.1)
Height (metres)						
1st quintile (1.32–1.51)	221	106 (52.7)	93 (46.7)	32 (16.5)	134 (65.7)	28 (12.7)
2nd quintile (1.52–1.56)	210	78 (39.4)	79 (39.9)	21 (10.9)	106 (52.7)	21 (10.0)
3rd quintile (1.57–1.60)	217	69 (33.7)	74 (36.3)	26 (13.1)	100 (48.3)	18 (8.3)
4th quintile (1.61–1.66)	212	79 (39.7)	67 (34.0)	18 (9.5)	110 (54.7)	24 (11.3)
5th quintile (1.67–1.83)	217	61 (29.2)	62 (29.8)	22 (10.7)	97 (46.0)	12 (5.5)
Body mass index (kg/m^2)						
1st quintile (13.6–20.4)	221	87 (44.4)	82 (42.1)	20 (10.8)	116 (58.3)	28 (13.0)
2nd quintile (20.5–22.5)	210	78 (39.6)	71 (36.4)	22 (11.6)	105 (52.5)	26 (12.1)
3rd quintile (20.6–24.3)	216	88 (43.3)	84 (41.8)	32 (16.2)	118 (57.6)	22 (10.2)
4th quintile (24.4–26.6)	212	64 (30.6)	70 (34.0)	21 (10.2)	102 (48.6)	13 (6.0)
5th quintile (26.4–41.5)	217	76 (36.9)	68 (32.7)	24 (11.9)	106 (50.7)	14 (6.5)

*Numbers at risk based on total people at risk of any cataract or cataract surgery (n=1206), and vary slightly for different cataract types because of ungradeable lens and missing data. Numbers at risk for height and body mass index based on people seen at the study clinic, at risk of any cataract or cataract surgery (n=1077).
†Hypertension: Defined as history of hypertension or systolic blood pressure of =160 mm Hg and/or diastolic blood pressure of =95 mm Hg.
PSC = posterior subcapsular cataract.

categorised as less than S$2000, S$2001–4000, and more than S$4000. Medical history of diabetes, hypertension, heart attack, and stroke were ascertained by asking, "Have you been told by a doctor that you have diabetes (hypertension, heart attack, stroke)?" followed by further questions on treatment and hospitalisation. Hypertension was defined as a self report of hypertension or a systolic blood pressure of ⩾160 mm Hg and/or diastolic blood pressure of ⩾95 mm Hg, if measurements were available. For analysis, hypertension, heart attack, and stroke were categorised as present or absent. For diabetes,

Table 3 Age and sex adjusted associations* of risk factors and specific cataract types (nuclear, cortical, and posterior subcapsular cataract), any cataract, and cataract surgery in Chinese Singaporeans

	Nuclear cataract		Cortical cataract		PSC cataract		Any cataract		Cataract surgery	
	OR (95% CI)	p Value	OR (95% CI)	p Value	OR (95% CI)	p Value	OR (95% CI)	p Value	OR (95% CI)	p Value
Age (per 10 years)	5.6 (4.6 to 6.8)	<0.001	3.4 (2.9 to 3.9)	<0.001	2.9 (2.3 to 3.6)	<0.001	6.1 (5.0 to 7.5)	<0.001	3.9 (2.9 to 5.0)	<0.001
Sex										
Men *v* women	0.9 (0.6 to 1.2)	0.42	1.0 (0.8 to 1.4)	0.79	1.0 (0.7 to 1.5)	0.90	0.8 (0.6 to 1.1)	0.13	0.8 (0.6 to 1.2)	0.33
Education										
None	1.9 (0.8 to 4.5)	0.17	1.1 (0.6 to 2.3)	0.74	1.3 (0.4 to 3.6)	0.67	1.1 (0.5 to 2.3)	0.82	2.2 (0.6 to 8.0)	0.23
Primary	1.8 (0.8 to 4.2)	0.16	0.9 (0.5 to 1.8)	0.12	1.5 (0.5 to 4.1)	0.45	1.0 (0.5 to 2.1)	0.93	2.0 (0.6 to 7.0)	0.28
Secondary	1.5 (0.6 to 3.5)	0.40	0.7 (0.4 to 1.4)	0.34	0.6 (0.2 to 1.9)	0.42	1.0 (0.5 to 2.0)	0.94	1.6 (0.4 to 6.0)	0.52
Tertiary	1	–	1	–	1	–	1	–	1	–
	p=0.14†		p=0.15†		p=0.15†		p=0.68†		p=0.17†	
Occupation										
Production	2.7 (1.4 to 5.2)	0.004	1.7 (1.0 to 3.0)	0.06	1.4 (0.6 to 3.3)	0.41	2.1 (1.1 to 4.0)	0.02	1.7 (0.8 to 3.7)	0.21
Labourers	2.2 (1.1 to 4.3)	0.03	1.6 (0.9 to 2.9)	0.13	1.0 (0.4 to 2.5)	0.97	1.6 (0.8 to 3.1)	0.15	1.1 (0.5 to 2.6)	0.83
Clerks	2.3 (1.2 to 4.4)	0.01	1.0 (0.6 to 1.8)	0.94	1.5 (0.7 to 3.5)	0.31	1.4 (0.7 to 2.6)	0.31	0.9 (0.4 to 2.1)	0.79
Home makers	2.1 (1.0 to 4.4)	0.04	1.1 (0.6 to 2.0)	0.81	1.4 (0.6 to 3.5)	0.46	1.4 (0.7 to 2.7)	0.35	0.9 (0.4 to 2.2)	0.86
Others	1.3 (0.5 to 3.0)	0.61	1.0 (0.5 to 2.1)	0.97	1.6 (0.5 to 4.6)	0.40	1.1 (0.5 to 2.6)	0.74	2.0 (0.7 to 5.2)	0.19
Managers	1	–	1		1	–	1	–	1	–
Housing type										
1–2 rooms	1.5 (0.9 to 2.5)	0.08	0.9 (0.6 to 1.4)	0.61	1.9 (1.0 to 3.7)	0.05	1.1 (0.7 to 1.9)	0.60	1.4 (0.7 to 2.5)	0.31
3 rooms	1.2 to (0.8 to 1.8)	0.33	1.2 (0.9 to 1.7)	0.28	2.2 (1.3 to 3.9)	0.004	1.2 (0.8 to 1.8)	0.29	1.4 (0.9 to 2.4)	0.17
4–5 rooms and private housing	1	–	1	–	1	–	1	–	1	–
	p=0.08†		p=0.73†		p=0.05†		p=0.52†		p=0.31†	
Individual income, per month										
<S$1000	1.4 (0.4 to 4.4)	0.58	1.5 (0.6 to 4.0)	0.40	2.3 (0.3 to 17)	0.43	1.6 (0.6 to 4.1)	0.31	0.6 (0.3 to 1.5)	0.27
S$1000–2000	1.5 (0.5 to 4.9)	0.50	1.6 (0.6 to 4.3)	0.37	1.4 (0.2 to 12)	0.78	1.6 (0.6 to 4.1)	0.35	1.0	–
S$2000–3000	0.8 (0.2 to 4.3)	0.83	0.9 (0.2 to 3.4)	0.88	2.4 (0.2 to 30)	0.50	1.4 (0.4 to 4.4)	0.57	–	–
>S$3000	1	–	1	–	1	–	1	–	–	–
	p=0.54†		p=0.32†		p=0.30†		p=0.35†			
Household income, per month										
<S$2000	1.4 (0.8 to 2.6)	0.23	1.1 (0.6 to 1.8)	0.77	3.1 (0.9 to 10)	0.07	1.3 (0.9 to 2.2)	0.30	2.2 (0.7 to 7.3)	0.20
S$2000–4000	1.4 (0.7 to 2.7)	0.36	1.2 (0.6 to 2.1)	0.63	3.0 (0.8 to 11)	0.09	1.3 (0.7 to 2.4)	0.35	2.2 (0.6 to 8.1)	0.24
>S$4000	1	–	1	–	1	–	1	–	1	–
	p=0.28†		p=0.93†		p=0.11†		p=0.39†		p=0.29†	
History of diabetes										
Yes, oral/insulin	2.8 (0.8 to 9.4)	0.09	3.0 (1.6 to 5.4)	<0.001	2.1 (1.1 to 4.0)	0.02	1.9 (0.9 to 4.1)	0.08	2.3 (1.3 to 4.1)	0.006
Yes, diet only	1.0 (0.5 to 1.9)	0.96	1.6 (0.6 to 4.3)	0.32	1.1 (0.3 to 4.2)	0.86	1.8 (0.6 to 5.4)	0.33	2.2 (0.8 to 6.1)	0.13
No	1	–	1	–	1	–	1	–	1	–
	p=0.68†		p<0.001†		p=0.03†		p=0.05†		p=0.008†	
History of "heart attack"										
Yes *v* no	1.1 (0.6 to 2.1)	0.83	0.7 (0.4 to 1.3)	0.32	0.7 (0.3 to 1.5)	0.35	0.8 (0.4 to 1.5)	0.44	1.1 (0.6 to 2.1)	0.69
History of stroke										
Yes *v* no	1.1 (0.5 to 2.6)	0.80	1.6 (0.7 to 3.5)	0.27	0.5 (0.2 to 1.5)	0.22	1.1 (0.4 to 2.9)	0.91	1.0 (0.4 to 2.4)	0.97
Hypertension‡										
Yes *v* no	0.8 (0.6 to 1.1)	0.13	1.0 (0.8 to 1.4)	0.85	0.9 (0.6 to 1.4)	0.67	0.9 (0.6 to 1.3)	0.52	0.9 (0.6 to 1.3)	0.47
Current smoking										
Yes, >10/day	2.3 (1.4 to 3.7)	0.001	1.5 (0.9 to 2.3)	0.08	1.3 (0.7 to 2.3)	0.42	1.8 (1.1 to 3.0)	0.02	0.7 (0.3 to 1.4)	0.30
Yes, ⩽10/day	1.5 (0.6 to 3.7)	0.36	0.9 (0.4 to 1.9)	0.71	0.6 (0.2 to 1.7)	0.33	1.6 (0.6 to 4.4)	0.36	1.6 (0.8 to 3.4)	0.20
No	1	–	1	–	1	–	1	–	1	–
	p=0.001†		p=0.11†		p=0.60†		p=0.02†		p=0.55†	

*All OR are adjusted for age and sex, except age, adjusted for sex, and sex, adjusted for age only.
†p Value based on test of trend.
‡Hypertension: defined as history of hypertension or systolic blood pressure of =160 mm Hg and/or diastolic blood pressure of =95 mm Hg
PSC = posterior subcapsular cataract.
Occupation: clerks: clerks or sales people, production: production or machine operators, labourers: labourers or agricultural workers, managers: mangers or professionals.

Table 3 Age and sex adjusted associations* of risk factors and specific cataract types (nuclear, cortical, and posterior subcapsular cataract), any cataract, and cataract surgery in Chinese Singaporeans—*continued*

	Nuclear cataract		Cortical cataract		PSC cataract		Any cataract		Cataract surgery	
	OR (95% CI)	p Value	OR (95% CI)	p Value	OR (95% CI)	p Value	OR (95% CI)	p Value	OR (95% CI)	p Value
Height (metres)										
1st quintile	2.0 (0.9 to 4.1)	0.08	1.3 (0.7 to 2.5)	0.48	0.8 (0.3 to 1.9)	0.54	1.3 (0.6 to 2.8)	0.44	1.4 (0.5 to 3.7)	0.50
2nd quintile	1.5 (0.7 to 2.9)	0.29	1.4 (0.7 to 2.5)	0.32	0.7 (0.3 to 2.3)	0.38	1.0 (0.5 to 2.0)	0.97	1.6 (0.6 to 4.0)	0.33
3rd quintile	1.4 (0.7 to 2.6)	0.33	1.4 (0.8 to 2.5)	0.21	1.1 (0.5 to 2.3)	0.86	1.1 (0.6 to 2.1)	0.79	1.5 (0.6 to 3.5)	0.37
4th quintile	1.6 (0.9 to 2.8)	0.09	1.0 (0.6 to 1.6)	0.99	0.6 (0.3 to 1.3)	0.21	1.3 (0.8 to 2.3)	0.33	1.8 (0.9 to 4.0)	0.12
5th quintile	1	–	1	–	1	–	1	–	1	–
	p=0.13†		p=0.45†		p=0.54†		p=0.63†		p=0.71†	
Body mass index										
1st quintile	1.7 (1.0 to 2.9)	0.05	1.7 (1.1 to 2.8)	0.03	0.8 (0.4 to 1.5)	0.47	2.2 (1.2 to 3.8)	0.006	1.6 (0.8 to 3.4)	0.18
2nd quintile	1.3 (0.8 to 2.2)	0.35	1.3 (0.8 to 2.2)	0.25	1.0 (0.5 to 1.9)	0.91	1.3 (0.8 to 2.3)	0.28	1.7 (0.8 to 3.5)	0.16
3rd quintile	1.2 (0.7 to 1.9)	0.59	1.4 (0.9 to 2.3)	0.14	1.2 (0.6 to 2.2)	0.51	1.3 (0.8 to 2.3)	0.28	1.2 (0.6 to 2.5)	0.63
4th quintile	0.9 (0.5 to 1.5)	0.72	1.4 (0.8 to 2.2)	0.20	0.9 (0.5 to 1.8)	0.84	1.3 (0.8 to 2.2)	0.29	1.0 (0.4 to 2.2)	0.97
5th quintile	1	–	1	–	1	–	1	–	1	
	p=0.03†		p=0.05†		p=0.56†		p=0.01†		p=0.06†	

*All OR are adjusted for age and sex, except age, adjusted for sex, and sex, adjusted for age only.
†p Value based on test of trend.
‡Hypertension: defined as history of hypertension or systolic blood pressure of =160 mm Hg and/or diastolic blood pressure of =95 mm Hg
PSC = posterior subcapsular cataract.
Occupation: clerks: clerks or sales people, production: production or machine operators, labourers: labourers or agricultural workers, managers: mangers or professionals.

a separate classification included diabetes on treatment with oral diabetic medications and/or insulin injection, diabetes on diet treatment only, and no diabetes. A history of current cigarette smoking was ascertained by asking, "Do you smoke regularly (at least once a week)?" with a further question on the number of cigarettes smoked per day. Smoking was categorised as smoking more than 10 cigarettes per day, smoking 1–10 cigarettes per day, and non-smoker.

Statistical analysis

The analyses were conducted as follows. The associations between age, sex, socioeconomic variables, medical history, and the presence of specific types of cataract, any cataract, and cataract surgery were evaluated initially by contingency tables and estimated by the odds ratio and its 95% confidence interval (95% CI). Multiple logistic regression models were used to estimate the age and sex adjusted OR, and to assess the influence of the other variables (see Table 2) for each cataract type, any cataract, and cataract surgery. Variables considered for inclusion in the regression models include those that had a p value of <0.10 in the age and sex adjusted models in at least one cataract type. Age and sex were included in all models, in order to adjust for the effect of the disproportionate sampling strategy. Trends in proportions were tested for significance using the Mantel-Haenszel procedure. Statistical analyses of the data were carried out using SPSS (SPSS Inc, Chicago, IL, USA).

RESULTS

Among the 2000 people selected, 46 had died and 235 had moved to addresses outside the district before the study period, and two people were excluded because of severe illness, leaving 1717 subjects considered eligible to participate in this study. These people were invited for a comprehensive eye examination at the study clinic, following which an abbreviated domiciliary examination on non-respondents was conducted. The total number of subjects examined in either setting was 1232 (1090 clinic, 142 at home), an overall response rate of 71.8% (1232/1717). Of these, six people did not undergo pupil dilatation because of narrow angles or angle closure glaucoma, and another 20 were excluded because of bilateral missing lens data (unfit or refused lens examination, or bilateral phthisis bulbi), leaving 1206 people (70.2%) for this analysis.

Of the 1206 people in this study, 103 (8.5%) had a previous cataract operation in the right eye, leaving 1103 potentially gradable lens in the right eye. Likewise, 94 (7.7%) people had cataract operation in their left eyes, leaving 1112 potentially gradable left eyes. The overall number of people with cataract surgery in either eye was 134 (11.1%). There were 621 (54.7%) people with any cataract (nuclear, cortical, or PSC) in either eye. Of these, 450 (40.1%) had nuclear cataract, 431 (38.6%) had cortical cataract, and 130 (12.0%) had PSC cataract (categories not mutually exclusive). Table 1 shows the demographic profile of the study population. Men were more likely to have higher education levels, occupations as managers or professionals, production or machine operators, and higher individual incomes.

Table 2 gives the number people with specific types of cataract, any cataract, and cataract surgery, subdivided according to age, sex, socioeconomic and medical factors. Table 3 summarises the relation between cataract morphology, previous cataract surgery, and various putative risk factors. Increasing age was strongly associated with all types of cataract and cataract surgery ($p<0.001$ for all categories). After adjusting for age and sex, the following associations were noted. For nuclear cataract, significant associations were found for all non-managerial or non-professional occupations (OR between 2.1 to 2.7), current cigarette smoking, and lower BMI. For cigarette smoking and BMI, there was evidence of a dose-response pattern. People who smoked more than 10 cigarettes per day (OR 2.3) had higher odds than those who

Table 4 Results of multiple logistic regressions (final models) for specific cataract types (nuclear, cortical and posterior subcapsular cataract), any cataract and cataract surgery in Chinese Singaporeans

	Nuclear cataract		Cortical cataract		PSC cataract		Any cataract		Cataract surgery	
	OR (95% CI)	p Value	OR (95% CI)	p Value	OR (95% CI)	p Value	OR (95% CI)	p Value	OR (95% CI)	p Value
Age (per 10 years)	5.8 (4.7 to 7.2)	0.001	3.4 (2.9 to 4.0)	0.001	2.8 (2.2 to 3.6)	0.001	6.4 (5.1 to 8.0)	0.001	3.9 (2.9 to 5.0)	0.001
Sex, men	1.0 (0.6 to 1.5)	0.83	1.1 (0.7 to 1.6)	0.71	0.9 (0.6 to 1.4)	0.77	0.8 (0.5 to 1.1)	0.13	0.8 (0.6 to 1.2)	0.33
Diabetes*										
Yes, on treatment	–	–	3.1 (1.6 to 6.1)	0.001	2.2 (1.2 to 4.1)	0.01	2.0 (0.9 to 4.5)	0.08	2.3 (1.3 to 4.1)	0.006
Current smoking										
Yes, >10 cigarettes/day	1.7 (1.0 to 2.9)	0.05	–	–	–	–	–	–	–	–
Body mass index										
1st *v* 5th quintile	–	–	1.8 (1.1 to 2.9)	0.03	–	–	2.3 (1.3 to 4.0)	0.004	–	–
Occupation†										
Production workers	2.9 (1.5 to 5.8)	0.002	1.8 (1.0 to 3.3)	0.04	–	–	2.7 (1.4 to 5.2)	0.002	–	–
Labourers	2.6 (1.2 to 5.5)	0.01	1.5 (0.8 to 2.9)	0.17			2.1 (1.0 to 4.1)	0.04		
Household income										
<$2000 *v* >$4000	–	–	–	–	4.7 (1.1 to 20)	0.03	–	–	–	–

*Diabetes: yes, on oral and/or insulin treatment versus no diabetes.
†Occupation: Production or machine workers, and labourers or agricultural workers, versus managers and professionals.
–No significant association, and not included in the model.

smoked 1–10 cigarettes per day (OR 1.5), compared to those who did not smoke (test of trend, p=0.001). People with the lower quintiles of BMI had higher odds of nuclear cataract (test of trend, p=0.03). Finally, a weak association with living in smaller housing units were found (OR 1.5, p=0.08).

Cortical cataract was associated significantly with diabetes and lower BMI. We could not identify an association with cigarette smoking. People with diabetes using oral medication and/or insulin injection have higher odds (OR 3.0) than those on diet control only (OR 1.6), compared to those with no diabetes (test of trend, p <0.001). There was a shallow dose-response relation for BMI, with the lowest quintile having 1.7 greater risk of cortical opacity than the highest BMI quintile (test for trend, p=0.05). For occupational groups, only production workers or machine operators had higher odds compared to managers and professionals. PSC cataract was similarly associated with diabetes, living in smaller housing units, and lower household income.

The presence of any cataract was significantly associated with diabetes, cigarette smoking, lower BMI, and being a production worker or machine operator. Previous cataract surgery was associated with diabetes, and possibly lower BMI.

Multiple logistic regression models were derived for each cataract type, any cataract, and cataract surgery (final models presented in Table 4). Increasing age was a risk factor for all types of cataract, and for cataract surgery. Nuclear cataract was independently associated with cigarette smoking, and non-managerial or non-professional occupation (production or factory worker and labourer or agricultural worker). Cortical cataract was independently associated with diabetes, lower BMI, and non-managerial or non-professional occupation. PSC cataract was associated with diabetes and lower household income. Cataract of any type was associated with diabetes, lower BMI, and non-managerial or non-professional occupation. For cataract surgery, diabetes was the only independent risk factor.

DISCUSSION

Numerous risk factors for the different types of age related cataracts have been identified in white and black populations.[5–10 33 34] These include environmental factors such as ultraviolet or sunlight exposure,[11–15] systemic diseases such as diabetes,[16–21 34] lifestyle factors such as cigarette smoking,[22–27] indices of nutrition (for example lower body mass index),[28 30] and socioeconomic factors such as lower educational attainment.[10 32] Our study indicates similar factors are associated with age related cataracts in Chinese Singaporeans. As in other studies, we found varying patterns and strengths of association for different cataract types, supporting the hypothesis that distinct causal pathways may exist for nuclear, cortical, and PSC cataracts.[2] Previous studies have identified higher rates of cortical lens opacity in women than in men,[5 9 10 45] although we did not detect any such association.

Studies of risk factors in Asian populations are summarised in Table 5.[2 46–49] In this discussion we have tried to highlight significant differences compared with other populations, and address implications of these findings to the Chinese people.

In European and African derived populations, diabetes has consistently been identified as a risk factor for age related PSC and cortical, but probably not nuclear cataract.[5 6 8 9 9 10 19–21] In contrast, cigarette smoking is associated with nuclear and possibly PSC, but not cortical cataracts.[8–10 25–27] In a population based study of Chinese people in Taiwan, diabetes was associated with PSC cataract (OR: 1.6, 95% CI: 1.1 to 2.3), while cigarette smoking was associated with nuclear cataract (OR: 1.3, 95% CI: 1.0 to 1.7).[39] Our study supports these findings. The consistency of these data in diverse populations therefore suggests these associations are causal in nature. Perhaps more importantly, diabetes and smoking appear to be a growing public health problem in Singapore, Taiwan, and other rapidly

Table 5 Selected epidemiological studies on socio economic and medical risk factors of nuclear, cortical, and posterior subcapsular cataracts in Asia

			Associations with any cataract, specific cataract types and cataract surgery*				
Location, year	Population	Study type	Any/mxed cataract	Nuclear cataract	Cortical cataract	PSC cataract	Cataract surgery
Punjab, India, 1982[35]	1269	Population based survey	Lower weight	–	–	–	–
	Age: 30–80+		Lower weight Lower SES†				
New Delhi, India, 1989[36]	1990 Age 37–62	Case-control study	Lower BMI Lower SES† Higher systolic BP Outdoor lifestyle‡	Lower BMI Higher systolic BP Outdoor lifestyle‡	Lower SES† Outdoor lifestyle‡	Lower SES† Outdoor lifestyle‡	–
Taipei, Taiwan[39]	2038	Population based survey	Diabetes	Smoking	Higher systolic BP	Diabetes	–
	Age: 50–93		Higher diastolic BP		Higher diastolic BP		
Singapore	1206 Chinese	Population based survey	Diabetes		Diabetes,	Diabetes,	Diabetes
	Age: 40–81		Lower BMI Lower SES†	Lower SES† Smoking	Lower BMI, Lower SES†	Lower SES†	

*Associations with age, sex, race, ocular diseases (eg, myopia), nutritional supplements (eg, vitamin use) or drug use (eg, aspirin) not included.
†SES = socioeconomic status, includes a variety of measures, such as education, type of residence (eg, rural) and income.
‡Outdoor lifestyle: intended to be an indirect measure of ultraviolet light. The New Delhi study (36) included outdoor occupation, time spent living at altitude, and estimated exposure to direct sunlight.
BMI = body mass index, PSC = posterior subcapsular.

developing east Asian countries. Alarmingly, the prevalence of diabetes in Singaporeans aged 18–69 years has risen fourfold within three decades, from 2% in 1975, 4.7% in 1984, 8.6% in 1992, to 9.0% in 1998.[50 51] The increasing prevalence of diabetes reflects increasing affluence, an ageing population, a probable trend towards a more sedentary lifestyle, and dietary changes. Similar epidemiological patterns and trends are seen in Taiwan,[52] Hong Kong,[53] and China,[54–57] suggesting that the risk of cataract attributable to diabetes is likely to increase in the future. A related problem is the escalating prevalence of cigarette smoking observed in Singapore[58] and China.[59 60] It has been estimated that up to 20% of cataract in a population is related to cigarette smoking.[2] Thus, an effective antismoking programme in Asia may decrease the burden of cataract blindness, in addition to its potentially beneficial impact on respiratory and cardiovascular health.

The relation between lower BMI and cortical cataract (and possibly nuclear cataract significant after age and sex adjustment, but not after adjustment for other variables) in our study is difficult to explain. There is no overall consensus on either the direction or nature of the relation between BMI and cataract in the literature, partly because it is difficult to infer what BMI represents. A lower BMI has been hypothesised to reflect nutritional deprivation and lower socioeconomic status, particularly in developing countries,[48] but a higher BMI may also be associated with diabetes, hypertension, and other morbidities.[31] Thus, while some studies have found lower BMI to be associated with cataract,[10 31 35 36] others have found that a higher BMI increases cataract risk.[28 30] In our population, lower BMI was correlated with cigarette smoking and lower socioeconomic status (education, income, and housing type). It is possible that the associations we observed were related to some of these factors, although the associations were independent of various socioeconomic indicators. We did consider the possibility of a reverse J-shaped relation between cataract and BMI, although more detailed analysis did not support this hypothesis.

In other populations, people of lower socioeconomic status were consistently more likely to have cataract.[5 8 10 32 33 35 36] In our study, lower education was associated with nuclear cataract, after controlling for smoking, while lower household income was associated with PSC cataract, after controlling for diabetes. Like BMI, the underlying reasons are complex. Lower socioeconomic status and less education are correlated with cigarette smoking, alcohol drinking, lower vitamin supplement intake, and poorer nutrition, all of which may be related to cataract.[61–63] However, other unmeasured factors may also have a role. In the Beaver Dam Eye Study, lower education was associated with nuclear and cortical cataract, while lower income was associated with cortical and PSC cataract, even after controlling for age, sex, diabetes, multivitamin use, alcohol consumption, and cigarette smoking.[32] Some of these (for example, multivitamin use, alcohol consumption) may explain or confound the associations in our study. Another possible reason is that people with lower education or income are less likely to see an eye care provider or have cataract surgery performed. However, we did not find any association between socioeconomic indicators and cataract surgery. Indeed, the crude rate of previous cataract surgery in our cohort was high (12% in men, 10% in women). However, our disproportionate sampling strategy makes crude rates misleading. The age corrected rate of 5.1%[64] is not dissimilar to rates seen in The Blue Mountains Eye Study (6%)[45] and The Beaver Dam Eye Study (3.6%).[65] Irrespective of the underlying reasons, public health efforts should be directed at these high risk groups.

Blue collar workers (production or agricultural workers, machine operators, and labourers) were more likely to have nuclear cataract than the managerial and professional classes, after controlling for age, sex, and smoking. Interpreting these findings in a study such as this is difficult. The differences may reflect socioeconomic (probably nutritional) inequities. Environmental factors such as exposure to ultraviolet radiation may account for some of these observations, although we identified no excess risk in outdoor workers (agricultural workers and labourers), compared with production workers in an indoor environment. A study quantifying individual ultraviolet radiation in different occupational groups would be required to satisfactorily address this question.

Few studies have examined associations with cataract surgery as the end point. In our study, diabetes was the only independent risk factor. In Beaver Dam, people with diabetes were also more likely to have cataract surgery within 5 years compared to those without.[66] In a case-control study in France, diabetes, smoking, and lower socioeconomic status were associated with cataract surgery.[9]

Potential limitations should be noted. Firstly, the reliability of our lens grading is not known. Although we did not have

reproducibility experiments (as in the Lens Opacity Case Control Study[10]), the grading was conducted according to a written standardised protocol, with over 90% by one ophthalmologist, and there were regular feedback meetings to discuss quality control issues. Further, our findings were comparable to other studies in many other respects for different cataract types. A second possibility was that selection bias significantly affected the results, as our overall participation rate was 70%. For example, the association between lower socioeconomic status and cataract could be explained if people with *higher* socioeconomic status and cataract were less likely to participate in our study. However, the reverse may be true.

In summary, we found risk factors for the different morphological types of cataract in Chinese people in Singapore were broadly similar to those identified in people of European and African origin, and those from the Indian subcontinent. Diabetes appears to be an important risk factor for cortical and PSC cataract, but not nuclear cataract. Cigarette smoking appears to be associated with nuclear cataract only, while lower BMI is associated with cortical cataract only. Lower socioeconomic status appears to be related to all cataract types. Our findings therefore support the concept that similar mechanisms are important in the pathogenesis of age related cataract, irrespective of ethnic or racial origin.

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REFERENCES

1 **Taylor HR**. Epidemiology of age-related cataract. *Eye* 1999;**13**:445–8.
2 **West SK**, Valmadrid CT. Epidemiology of risk factors for age-related cataract. *Surv Ophthalmol* 1995;**39**:323–34.
3 **Kupfer C**. Bowman Lecture. The conquest of cataract. The global challenge. *Trans Ophthalmol Soc UK* 1985;**104**:1–10.
4 **Kahn HA**, Leibowitz HM, Ganley JP, *et al*. The Framingham Eye Study. II. Association of ophthalmic pathology with single variables previously measured in the Framingham Heart Study. *Am J Epidemiol* 1977;**106**:33–41.
5 **Hiller R**, Sperduto RD, Ederer F. Epidemiologic associations with nuclear, cortical, and posterior subcapsular cataracts. *Am J Epidemiol* 1986;**124**:916–25.
6 **Miglior S**, Marighi PE, Musicco M, *et al*. Risk factors for cortical, nuclear, posterior subcapsular and mixed cataract: a case-control study. *Ophthalmic Epidemiol* 1994;**1**:93–105.
7 **Hirvela H**, Luukinen H, Laatikainen L. Prevalence and risk factors of lens opacities in the elderly in Finland. A population-based study. *Ophthalmology* 1995;**102**:108–17.
8 **McCarty CA**, Mukesh BN, Fu CL, *et al*. The epidemiology of cataract in Australia. *Am J Ophthalmol* 1999;**128**:446–65.
9 **Delcourt C**, Cristol J-P, Tessier F, *et al*. Risk factors for cortical, nuclear, and posterior subcapsular cataracts: the POLA study. Pathologies Oculaires Liees a l'Age. *Am J Epidemiol* 2000;**151**:497–504.
10 **Leske MC**, Chylack LT, Wu SY. The Lens Opacities Case-Control Study. Risk factors for cataract. *Arch Ophthalmol* 1991;**109**:244–51.
11 **Bochow TW**, West SK, Azar A, *et al*. Ultraviolet light exposure and risk of posterior subcapsular cataracts. *Arch Ophthalmol* 1989;**107**:369–72.
12 **Collman GW**, Shore DL, Shy CM, *et al*. Sunlight and other risk factors for cataracts: an epidemiologic study. *Am J Public Health* 1988;**78**:1459–62.
13 **Taylor HR**, West SK, Rosenthal FS, *et al*. Effect of ultraviolet radiation on cataract formation. *N Engl J Med* 1988;**319**:1429–33.
14 **Cruickshanks KJ**, Klein BE, Klein R. Ultraviolet light exposure and lens opacities: the Beaver Dam Eye Study. *Am J Public Health* 1992;**82**:1658–62.
15 **Delcourt C**, Carriere I, Ponton-Sanchez A, *et al*. Light exposure and the risk of cortical, nuclear, and posterior subcapsular cataracts: the Pathologies Oculaires Liees a l'Age (POLA) study. *Arch Ophthalmol* 2000;**118**:385–92.
16 **Klein BE**, Klein R, Moss SE. Prevalence of cataracts in a population-based study of persons with diabetes mellitus. *Ophthalmology* 1985;**92**:1191–6.
17 **Harding JJ**, Harding RS, Egerton M. Risk factors for cataract in Oxfordshire: diabetes, peripheral neuropathy, myopia, glaucoma and diarrhoea. *Acta Ophthalmol (Copenh)* 1989;**67**:510–17.
18 **Harding JJ**, Egerton M, van Heyningen R, *et al*. Diabetes, glaucoma, sex, and cataract: analysis of combined data from two case control studies. *Br J Ophthalmol* 1993;**77**:2–6.
19 **Klein BE**, Klein R, Wang Q, *et al*. Older-onset diabetes and lens opacities. The Beaver Dam Eye Study. *Ophthalmic Epidemiol*. 1995;**2**:49–55.
20 **Rowe NG**, Mitchell PG, Cumming RG, *et al*. Diabetes, fasting blood glucose and age-related cataract: the Blue Mountains Eye Study. *Ophthalmic Epidemiol* 2000;**7**:103–14.
21 **Klein BE**, Klein R, Lee KE. Diabetes, cardiovascular disease, selected cardiovascular disease risk factors, and the 5-year incidence of age-related cataract and progression of lens opacities: the Beaver Dam Eye Study. *Am J Ophthalmol* 1998;**126**:782–90.
22 **Christen WG**, Manson JE, Seddon JM, *et al*. A prospective study of cigarette smoking and risk of cataract in men. *JAMA* 1992;**268**:989–93.
23 **Klein BE**, Klein R, Linton KL, *et al*. Cigarette smoking and lens opacities: the Beaver Dam Eye Study. *Am J Prev Med* 1993;**9**:27–30.
24 **Cumming RG**, Mitchell P. Alcohol, smoking, and cataracts: the Blue Mountains Eye Study. *Arch Ophthalmol* 1997;**115**:1296–303.
25 **Klein BE**, Klein RE, Lee KE. Incident cataract after a five-year interval and lifestyle factors: the Beaver Dam Eye Study. *Ophthalmic Epidemiol* 1999;**6**:247–55.
26 **West S**, Munoz B, Emmett EA, *et al*. Cigarette smoking and risk of nuclear cataracts. *Arch Ophthalmol* 1989;**107**:1166–9.
27 **West S**, Munoz B, Schein OD, *et al*. Cigarette smoking and risk for progression of nuclear opacities. *Arch Ophthalmol* 1995;**113**:1377–80.
28 **Glynn RJ**, Christen WG, Manson JE, *et al*. Body mass index. An independent predictor of cataract. *Arch Ophthalmol* 1995;**113**:1131–7.
29 **Tavani A**, Negri E, La Vecchia C. Food and nutrient intake and risk of cataract. *Ann Epidemiol* 1996;**6**:41–6.
30 **Hiller R**, Podgor MJ, Sperduto RD, *et al*. A longitudinal study of body mass index and lens opacities. The Framingham Studies. *Ophthalmology* 1998;**105**:1244–50.
31 **Caulfield LE**, West SK, Barron Y, *et al*. Anthropometric status and cataract: the Salisbury Eye Evaluation project. *Am J Clin Nutr* 1999;**69**:237–42.
32 **Klein R**, Klein BE, Jensen SC, *et al*. The relation of socioeconomic factors to age-related cataract, maculopathy, and impaired vision. The Beaver Dam Eye Study. *Ophthalmology* 1994;**101**:1969–79.
33 **Leske MC**, Wu SY, Connell AM, *et al*. Lens opacities, demographic factors and nutritional supplements in the Barbados Eye Study. *Int J Epidemiol* 1997;**26**:1314–22.
34 **Leske MC**, Wu SY, Hennis A, *et al*. Diabetes, hypertension, and central obesity as cataract risk factors in a black population. The Barbados Eye Study. *Ophthalmology* 1999;**106**:35–41.
35 **Chatterjee A**, Milton RC, Thyle S. Prevalence and aetiology of cataract in Punjab. *Br J Ophthalmol* 1982;**66**:35–42.
36 **Mohan M**, Sperduto RD, Angra SK, *et al*. India-US case-control study of age-related cataracts. India-US Case-Control Study Group. *Arch Ophthalmol* 1989;**107**:670–6.
37 **Ughade SN**, Zodpey SP, Khanolkar VA. Risk factors for cataract: a case control study. *Indian J Ophthalmol* 1998;**46**:221–7.
38 **Sreenivas V**, Prabhakar AK, Badrinath SS, *et al*. A rural population based case-control study of senile cataract in India. *J Epidemiol* 1999;**9**:327–36.
39 **Cheng CY**, Liu JH, Chen SJ, *et al*. Population-based study on prevalence and risk factors of age-related cataracts in Peitou, Taiwan. *Zhonghua Yi Xue Za Zhi (Taipei)* 2000;**63**:641–8.
40 **Foster PJ**, Oen FT, Machin D, *et al*. The prevalence of glaucoma in Chinese residents of Singapore: a cross-sectional population survey of the Tanjong Pagar district. *Arch Ophthalmol* 2000;**118**:1105–11.
41 **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**:2486–94.
42 **Wong TY**, Foster PJ, Johnson GJ, *et al*. The prevalence and risk factors for pterygium in an adult Chinese population in Singapore: the Tanjong Pagar survey. *Am J Ophthalmol* 2001;**131**:176–83.
43 **Chylack LT Jr**, Wolfe JK, Singer DM, *et al*. The Lens Opacities Classification System III. The Longitudinal Study of Cataract Study Group. *Arch Ophthalmol* 1993;**111**:831–6.
44 **Leske MC**, Chylack LT Jr, He Q, *et al*. Incidence and progression of cortical and posterior subcapsular opacities: the Longitudinal Study of Cataract. The LSC Group. *Ophthalmology* 1997;**104**:1987–93.
45 **Mitchell P**, Cumming RG, Attebo K, *et al*. Prevalence of cataract in Australia: the Blue Mountains eye study. *Ophthalmology* 1997;**104**:581–8.

46 **Hodge WG**, Whitcher JP, Satariano W. Risk factors for age-related cataracts. *Epidemiol Rev* 1995;**17**:336–46.
47 **Livingston PM**, Carson CA, Taylor HR. The epidemiology of cataract: a review of the literature. *Ophthalmic Epidemiol* 1995;**2**:151–64.
48 **Schoenfeld ER**, Leske MC, Wu SY. Recent epidemiologic studies on nutrition and cataract in India, Italy and the United States. *J Am Coll Nutr* 1993;**12**:521–6.
49 **Harding JJ**. Recent studies of risk factors and protective factors for cataract. *Curr Opin Ophthalmol* 1997;**8**:46–9.
50 **Tan CE**, Emmanuel SC, Tan BY, *et al*. Prevalence of diabetes and ethnic differences in cardiovascular risk factors. The 1992 Singapore National Health Survey. *Diabetes Care* 1999;**22**:241–7.
51 **Lee WR**. The changing demography of diabetes mellitus in Singapore. *Diabetes Res Clin Pract* 2000;**50(Suppl 2)**:S35-S39.
52 **Chang C**, Lu F, Yang YC, *et al*. Epidemiologic study of type 2 diabetes in Taiwan. *Diabetes Res Clin Pract* 2000;**50(Suppl 2)**:S49–59.
53 **Ko GT**, Wu MM, Wai HP, *et al*. Rapid increase in the prevalence of undiagnosed diabetes and impaired fasting glucose in asymptomatic Hong Kong Chinese. *Diabetes Care* 1999;**22**:1751–2.
54 **Cockram CS**. Diabetes mellitus: perspective from the Asia-Pacific region. *Diabetes Res Clin Pract* 2000;**50(Suppl 2)**:S3–7.
55 **Gao M**, Ikeda K, Hattori H, *et al*. Cardiovascular risk factors emerging in Chinese populations undergoing urbanization. *Hypertens Res* 1999;**22**:209–15.
56 **Yu Z**, Nissinen A, Vartiainen E, *et al*. Changes in cardiovascular risk factors in different socioeconomic groups: seven year trends in a Chinese urban population. *J Epidemiol Commun Health* 2000;**54**:692–6.
57 **Hong Y**, Bots ML, Pan X, *et al*. Physical activity and cardiovascular risk factors in rural Shanghai, China. *Int J Epidemiol* 1994;**23**:1154–8.
58 **Emmanuel SC**, Chen AJ, Phe A. Cigarette smoking in Singapore. *Singapore Med J* 1988;**29**:119–24.
59 **Lam TH**, He Y, Li LS, *et al*. Mortality attributable to cigarette smoking in China. *JAMA* 1997;**278**:1505–8.
60 **Chen ZM**, Xu Z, Collins R, *et al*. Early health effects of the emerging tobacco epidemic in China. A 16-year prospective study. *JAMA* 1997;**278**:1500–4.
61 **Syme SL**, Berkman LF. Social class, susceptibility and sickness. *Am J Epidemiol* 1976;**104**:1–8.
62 **Marmot MG**, Kogevinas M, Elston MA. Social/economic status and disease. *Annu Rev Public Health* 1987;**8**:111–35.
63 **Pincus T**, Callahan LF, Burkhauser RV. Most chronic diseases are reported more frequently by individuals with fewer than 12 years of formal education in the age 18–64 United States population. *J Chronic Dis* 1987;**40**:865–74.
64 **Seah SK**, Wong TY, Foster PJ, *et al*. Prevalence of lens opacity in Chinese residents of Singapore: the Tanjong Pagar survey. *Ophthalmology* 2002;**109**:2058–64.
65 **Klein BE**, Klein R, Linton KL. Prevalence of age-related lens opacities in a population. The Beaver Dam Eye Study. *Ophthalmology* 1992;**99**:546–52.
66 **Klein BE**, Klein R, Moss SE. Incident cataract surgery: the Beaver Dam Eye Study. *Ophthalmology* 1997;**104**:573–80.

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P J Foster, T Y Wong, D Machin, et al.

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