*Eye* (1989) **3,** 379–384

# Cataracts and Cigarette Smoking

## THE CITY EYE STUDY

D. E. FLAYE,[1] K. N. SULLIVAN,[2] T. R. CULLINAN,[3] J. H. SILVER,[4]
R. A. F. WHITELOCKE[2]
*London*

**Summary**

**The City Eye Study is a nine year longitudinal prospective epidemiological study. During the first three year phase the study recruited 1029 volunteers, aged between 54 and 65 years, primarily from companies and organisations working in or around the City of London.**

**The analysis of the first cohort data shows a significant association between nuclear lens opacities and moderate to heavy cigarette smoking. The Relative Risk for nuclear lens opacity and cigarette smoking ranges from 1.0 for past light-smokers through 2.6 for past heavy-smokers, to 2.9 for present heavy smokers.**

Most previous studies seeking to identify aetiological factors for cataract and senile macular degeneration have been case control studies on patients presenting at hospitals with these conditions. It may be possible however to identify important risk factors at a stage before the patient would typically present at hospital with decreased visual acuity.

The City Eye Study is so named because it recruited volunteers from a range of companies and commercial enterprises in the city of London. It is a nine year longitudinal study into the most important blinding conditions in an ageing population, immediately before and after the years of retirement. The aims of the study are to identify risk factors for the development of these conditions, to collect data on the natural history of senile cataract and senile macular degeneration and to estimate the incidence of these diseases in the population.

The results presented here are from the initial examination of the volunteers in the years 1982-5. It therefore represents a cross-sectional observation from a longitudinal study.

### Methods

The volunteer population was drawn from a representative range of social and occupational backgrounds in and around London. Several large London corporations were canvassed to recruit the volunteers from staff who were in the suitable age range. This was mostly from pre-retirement groups. The aim of the study is to follow the volunteers through a nine year period with regular examinations at three yearly intervals.

From: [1] Department of Ophthalmology, St. Bartholomew's Hospital, London EC1A 7BE.
[2] Department of Preventive Ophthalmology, Institute of Ophthalmology, 27/29 Cayton Street, London EC1V 9EJ.
[3] St. Bartholomew's Medical College, London EC1A 7BE.
[4] Moorfields Eye Hospital, City Road, London EC1V 2PD.
Correspondence to: D E Flaye, Herts and Essex Hospital, Bishop's Stortford, Essex

One thousand and twenty nine volunteers completed a detailed questionnaire including medical, alcohol, tobacco, occupational, travel and family history. They were characterised by age, sex, social class/occupation, eye colour and ethnic background. In turn the patients were seen by a physician, an optometrist, a field technician, an ophthalmologist and a photographer. All participants were examined in the same eye department, at St Bartholomew's Hospital.

The physician checked each of the questionnaires together with the volunteers and measured the sitting blood pressure. Blood pressure measurement was taken on the right arm with a digital sphygmomanometer. Blood was taken for fasting blood sugar, triglycerides and cholesterol.

The optometrist measured visual acuities at six metres with a Snellen test type, first with the present spectacle correction worn (if any) and then after refraction to obtain the best recorded acuity. Best near vision was also recorded using Faculty-approved test types. If N5 for near vision was not obtained with the suitable plus addition, the magnification level required was then assessed.

With the equivalent of the patient's near correction the visual fields for each eye were assessed with the Friedmann Analyser (Mark II). Three thresholds (at 3, 12 and 20 degrees) for each eye were obtained first and the light intensity increased to 0.4 above the lowest threshold e.g. for a threshold of 2.0 the fields were analysed at a light intensity of 1.6.

Routine ophthalmic examination included examination of the anterior segment, applanation tonometry and gonioscopic examination whenever intraocular pressure was found to be raised above 22 mmHg. All volunteers were examined between 9.30 am and 12 midday and the pupils routinely dilated with Guttae Tropicamide 1% (Guttae Mydriacyl 1%). For black patients and those with diabetes mellitus, Guttae Phenylephrine 10% BPC was used in addition.

Examination of the crystalline lens was carried out using a combination of the slit lamp (direct and retro-illumination) and indirect ophthalmoscopy. Lens opacities were graded as nuclear, cortical or posterior subcapsular and, if present, into mild, moderate or severe as to the degree of opacity. The cortical opacities were further broken down into segmented eighths.[1]

Fundus examination was performed with the indirect ophthalmoscope and a 20D lens. Optic disc colour and cupping in both a vertical and a horizontal meridian were assessed, and if either axis of the cup/disc ratio was thought to be greater than 0.5, the disc was also checked with a direct ophthalmoscope. The macula, retinal vessels and peripheral retina were examined as well and the macular appearance re-checked later by examining the posterior pole photographs. In all cases of visible drusen (50 to 200 microns size or larger), a Hruby non-contact fundal lens was used. In all of these cases smaller drusen (50 microns or less) were also found to be present. The drusen size was estimated by comparison with the width of a second-order retinal arteriole.

At this stage the ophthalmic part of the questionnaire was checked and the patient informed of any medical or eye problem serious or irritating enough to warrant referral. This was done via a letter to the volunteer's general practitioner, followed by a referral to an eye department of his choice.

The final procedure involved fundus photography of the posterior pole including both discs and the maculae with a fundal camera.

On the basis of alcohol intake, the volunteers were placed in four categories:

Those who claimed never to have drunk alcohol or only very occasionally
Light drinkers (1–2 measures per day)
Moderate drinkers (3–8 measures per day)
Heavy drinkers (over 8 measures per day)

The subjects were similarly placed into seven categories according to the history of smoking cigarettes.

| *Smoking history* | *code* | *Description* | *Daily cigarette consumption* |
|---|---|---|---|
| Non-smoker | 0 | | |
| Past smoker | 1 | Light | 1–14 |
| | 2 | Moderate | 15–24 |
| | 3 | Heavy | 25 and over |
| Present smoker | 4 | Light | 1–14 |
| | 5 | Moderate | 15–24 |
| | 6 | Heavy | 25 and over |

In all of our analyses smokers were classified as cigarette smokers or non-smokers. This classification did not take into account

pipe smokers, cigar smokers or tobacco chewers, in whom the numbers within each group were not sufficiently large to warrant further investigation. For the present analysis these were treated as non-smokers.

The association between lens opacities and possible risk factors were evaluated using SPSSPC+. Multi-variate analysis (hierarchical log-linear analysis on SPSSPC+) was carried out to reveal any underlying confounding variables.

## Results

*Characteristics of Study Population*

A total of 1029 volunteers were examined. There were more volunteers recruited in the age groups 54–59 years (72%) than 60–65 years (28%) reflecting an early age of retirement amongst several firms. A few others who were outside this age range were excluded from the present analysis, which was carried out on 1012 sets of data. Seventeen cases were excluded from the anlysis due to their having incomplete data sets with regards to the factors under consideration.

Fifty-seven per cent were males and 43% females. There were few volunteers from ethnic minority groups: the present analysis was therefore performed on all subjects, including those people of Asian, African or West Indian origin.

Ten volunteers had a fasting blood sugar of more than 5.8 mmols per litre. The distribution of fasting blood sugar, serum cholesterol and triglycerides shows the cohort to be normally distributed for these parameters when compared with the UK population. Seven per cent of the cohort had a resting diastolic blood pressure greater than 95 mm of mercury. This is in accordance with other population studies.[2]

**Table I** *Lens opacities by age*

| *Type of opacity* | *Age 54–59* | *Age 60–65* |
|---|---|---|
| None | 457 | 238 |
| % | 73.5 | 65.9 |
| Nuclear | 52 | 42 |
| % | 8.4 | 11.6 |
| Cortical | 61 | 50 |
| % | 9.8 | 13.9 |
| Posterior sub-capsular | 14 | 6 |
| % | 2.2 | 1.7 |
| More than one type | 38 | 25 |
| % | 6.1 | 6.9 |
| Totals | 622 | 361 |

Data was missing from 29 cases.

*Prevalence and Association of Cataracts*

The distribution of different types of lens opacities is given in Table I. The prevalence of all types of lens opacities rose from 26.5% in the age group 54–59 years to 34.1% at 60–65 years. In 75% of cases lens opacities were bilateral and in approximately 6.6% of people the lens opacities were of more than one morphological type.

There was a statistical association between cigarette smoking and nuclear opacities. This was present for moderate present smokers (15–24 cigarettes per day) and both present and past heavy smokers (25+ cigarettes each day). The relative risks of a nuclear opacity in smokers is presented in Tables II and III, in comparison with those who have never smoked. The Relative Risks are approximately 2.5 for present light smokers, 2.7 for present moderate, or past heavy, smokers, 3.0 for present heavy smokers, all compared with non-smokers. These figures, together with their 95% confidence limits are illustrated in Fig. 1. Multivariate analysis revealed no confounding variables for this association. The findings are not explained by a high use amongst heavy smokers of steroids or beta-adrenergic blocking drugs and they do not mask exposure to tropical sun, alcohol consumption, or biochemical abnormalities.

There were no positive or negative associations of any type of lens opacities with alcohol intake, fasting triglycerides, cholesterol level or glucose levels, nor with social class or occupation. Only 12 volunteers regularly use systemic steroid therapy and three (25%) had a nuclear opacity. Beta-adrenergic blocking agents, were used by 78 people and nine of these (11.4%) had a nuclear opacity. There was no association with cataract among the 54 volunteers using tranquillisers or the 44 using diuretics.

The problems of intra-observer bias has been addressed by the re-examination of 48 volunteers by the study's ophthalmologist.

**Table II** *Nuclear opacities and cigarette consumption: relative risk of nuclear opacity in at least one eye*

*RELATIVE RISK CALCULATIONS*
*Nuclear opacities compared with other lens conditions in the non-smoker and present heavy, moderate and light smokers respectively*

| | Non-smokers | Heavy smokers | | Moderate smokers | | Light smokers | |
|---|---|---|---|---|---|---|---|
| | | Smokers | Total | Smokers | Total | Smokers | Total |
| Nuclear opacity | 29 | 8 | 37 | 24 | 53 | 34 | 63 |
| No nuclear opacities | 305 | 24 | 329 | 80 | 385 | 120 | 425 |
| Totals | 334 | 32 | 366 | 104 | 438 | 154 | 488 |
| Opacities % | 8.68 | 25 | 10.11 | 23.08 | 12.1 | 22.08 | 12.91 |
| Prevalence ratio (95% confidence limits) | | 2.88 1.4–5.85 | | 2.66 1.63–4.33 | | 2.54 1.63–3.97 | |

The volunteers were selected at random from those seen within the last three months. They were re-examined by the study's ophthalmologist, without access to the previous findings. The data was then tested using the Kappa statistic. A value of 0.71 was obtained with an 80% agreement.

## Discussion

Extensive animal studies *in vivo* and studies of both animal and human lenses *in vitro,* have suggested a number of possible pathways by which lens' crystallins lose their transparency.[3] Only for cataracts in young diabetics,[4] and possibly photochemically-induced cataracts,[5] have these biochemical mechanisms satisfied epidemiological and clinical observations of cataract occurrence.

Several recent studies have provided estimates for the prevalence of cataracts among late middle aged and elderly populations of Western societies, and the disabilities resulting from them. In the Framingham Eye Study[6] almost 5% of volunteers aged 52–64 years had a sight diminishing cataract (6/9 or less) in at least one eye. Cullinan[7] found that untreated cataracts were the commonest ascribed cause of visual disability in England and Wales while Gibson *et al.*[8] have found a population prevalence of 30% among a cohort aged 76–84 years. The great majority of sufferers are not known to have been exposed to those factors associated with a minority of cataracts (radiation, galactosaemia, classical diabetic cataract etc).[9] Other studies have added considerably to the list of possible risk factors.[10,11] These have included the use of certain drugs (diuretics,[10] phenothiazines,[12] steroids[13]) and higher than expected levels of serum creatinine and urea.[10]

**Table III** *Nuclear opacities and cigarette consumption: relative risk of nuclear opacity in at least one eye*

*RELATIVE RISK CALCULATIONS*
*Nuclear opacities compared with other lens conditions in the non-smoker and past heavy, moderate and light smokers respectively*

| | Non-smokers | Heavy smokers | | Moderate smokers | | Light smokers | |
|---|---|---|---|---|---|---|---|
| | | Smokers | Total | Smokers | Total | Smokers | Total |
| Nuclear opacity | 29 | 11 | 40 | 13 | 42 | 16 | 45 |
| No nuclear opacities | 305 | 37 | 342 | 97 | 402 | 171 | 476 |
| Totals | 334 | 48 | 382 | 110 | 444 | 187 | 521 |
| Opacities % | 8.68 | 22.92 | 10.47 | 11.82 | 9.46 | 8.56 | 8.64 |
| Prevalence ratio (95% confidence limits) | | 2.64 1.4–4.97 | | 1.36 0.73–2.53 | | 0.99 0.55–1.77 | |

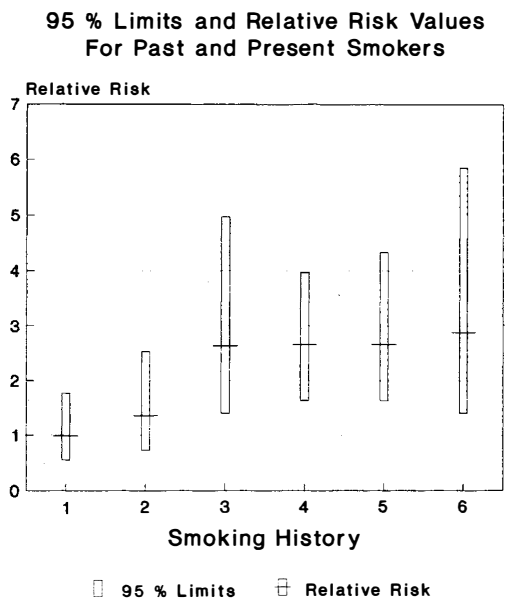


**Fig. 1.** *The x axis refers to smoking history: 1 represents past light smokers, 2 represents past moderate smokers, 3 represents past heavy smokers, 4 represents present light smokers, 5 represents present moderate smokers and 6 represents present heavy smokers.*

Our results confirm a previously noted association between cataracts and cigarette smoking, which were first reported in a case control study of patients presenting to hospital for cataract extraction.[10]

In this study the association between early lens opacities and cigarette consumption has internal strength in that there is a stepwise increase in risk for moderate and heavy cigarette smokers and that the Relative Risks for both age cohorts are similar. The fact that a past exposure to high levels of cigarette smoking also leads to a more than twofold increase in the risk of having an early lens opacity in middle age also lends weight to a causative relationship.

Other risk factors identified in recent case control studies have included diabetes, steroid administration,[13] high alcohol consumption,[10] uraemia,[10] and in India a severe cholera-like diarrhoeal disease and heatstroke.[14]

These associations were found in identified people with well-developed cataract who were presenting for surgery, compared with controls with no sight reducing lens opacities. It is possible that similar associations will show up with the City Eye Study as the volunteers are followed for a longer period. The numbers of people taking systemic steroids who developed lens opacities were too small for meaningful analysis. The distribution of physiological measurements in our results make us confident that although the method of recruiting our population cannot be described as 'random sampling', in any form, it does mean that we have a population which is not strongly biased when compared to the populations of other studies.

In the analysis of confounding variables the SPSS Hierarchical Log-Linear analysis package was used. This allowed us to investigate a number of aspects of possible variable interaction. We found that our results could be accounted for by the presence of one main risk factor. The presence of other possible confounding factors such as alcohol, weight and drugs made no appreciable improvement to the fit of the model.

Most of the volunteers in this study were white caucasian. There is clearly a need for more information on the prevalence of cataract and other blinding conditions in the immigrant non-caucasian populations in Britain.

We would like to thank G J Johnson, D Minassian and A C Bird for their assistance in the preparation of this paper.

The City Eye Study is fully funded by the British Council for the Prevention of Blindness, in conjunction with the Royal National Institute for the Blind and St. Dunstan's. To them our thanks are due—as also to Marks and Spencer Ltd for the provision of equipment.

**References**

[1] West S, Taylor H, Newland H: Evaluation of Photographic Method for Grading Lens Opacities for Epidemiological Research. *ARVO* 1986, **27:** 2: 44.

[2] Hollows F and Graham P: Intra-ocular pressure, glaucoma and glaucoma suspects in a defined population. *Br J Ophthalmol* 1966, **50:** 570–86.

[3] Human cataract formation. CIBA Foundation Symposium 106 1984. Nugent J, Whelan J (eds) Pitman, London.

[4] Ansari NH, Awasthi YC, Strivastava SK: Role of glycosylation in protein disulphide formation and cataractogenesis. *Exp Eye Res* 1980, **31:** 9–19.

[5] Brokman R: Cataracts and photochemical damage

in the lens. CIBA Foundation Symposium 106 1984, 88–109. Nugent J, Whelan J (eds) Pitman, London.

[6] Ederer F in Blindness (1977-78). American Association of workers for the blind inc. *Annual.* Washington DC.

[7] Cullinan T. The epidemiology of visual disability. Health Services Research Unit 1977; report no.28. University of Kent, Canterbury.

[8] Gibson JM, Rosenthal A, Lavery J: A study of the prevalence of eye disease in the elderly in an English community. *Trans Ophthalmol Soc UK* 1984, **104:** 196–203.

[9] Sommer A: Cataracts as an epidemiologic problem. *Am J Ophthalmol* 1977, **83:** 334–40.

[10] Clayton R, Cuthbert J, Duffy J, Seth J, Phillips C, Bartholomew R, Reid J: Epidemiological and other studies in the assessment of factors contributing to cataractogenesis. CIBA Foundation Symposium 1984, **106:** 25–47.

[11] Hockwin O and Koch H: Combined noxious influences In: Cataract and the abnormalities of the Lens (Bellows J, ed) Grune and Stratton, New York, 1975, 243–5.

[12] Hesse R: Anterior lens opacities in prolonged phenothiazine therapy. *Ann Ophthalmol* 1979, **11:** 1212.

[13] Salka H and Prchal J: Effect of corticosteroids on cataract formation. *Arch Ophthalmol* 1980, **98:** 1773.

[14] Minassian DC, Mehra V, Jones BR: Dehydrational crises from severe diarrhoea or heat stroke and risk of cataract. *Lancet* 1984, **i:** 751–3.