Sunlight and Other Risk Factors for Cataracts: An Epidemiologic Study

GWEN W. COLLMAN, PHD, DAVID L. SHORE, PHD, CARL M. SHY, MD, DRPH, HARVEY CHECKOWAY, PHD, AND ALAN S. LURIA, MD

Abstract: A case control study was conducted in North Carolina to explore the relation between individual exposure to sunlight and the risk of cataracts. One hundred thirteen cases and 161 controls aged 40–69 at diagnosis were studied. Sunlight exposure was inferred from interview data on residency and time spent in the sun, combined with solar radiation data from the National Climatic Data Center. Sunlight exposure was very slightly related to all types of opacities combined. Although the numbers of cases with each type of opacity was small, the risk of cataracts was slightly increased in medium and high exposure categories for persons having cortical or posterior subcapsular opacities only, but not nuclear sclerotic changes. Persons with dark brown or hazel eyes are at increased risk. An unexpected finding was that persons who reported using tranquilizers for six months were at increased risk. (*Am J Public Health* 1988; 78: 1459–1462).

Introduction

Throughout the world, cataracts are most prevalent in areas where the amount of annual and daily sunlight is high[1–3] ambient temperatures are warm,[4] and the latitude is low.[3] These areas receive more solar radiation, which includes ultraviolet and infrared radiation and visible light.

Environmental measures of solar radiation exposure have been used in previous studies as surrogates for individual levels of sunlight exposure. In addition, these studies have relied on a single estimate of exposure, based either on current[2,4] or usual residence.[5] Such measures cannot correctly estimate the amount of sun exposure an individual receives, since lifestyle factors influence the amount of time spent in the sun within a geographic area, and since sun exposures change over the subject's lifetime.

To investigate this question further, we conducted a case-control study in North Carolina which utilized a detailed estimate of sunlight exposure for each study subject.

Methods

Study Population

All study subjects were selected from the patients of a private ophthalmology practice in Asheboro, North Carolina. During their first visit to the practice, each patient received a full ocular examination including both external and internal examination of the eye. Direct visualization of the lens using a Zeiss slit lamp was performed after pupil dilation (using 2 1/2 per cent Neosynephrine and 1 per cent Mydracil). All were examined by a single ophthalmologist (ASL).

Cases and controls were chosen by reviewing medical records of all patients aged 40–69 years old at their first examination (1980–83) (n = 864). Ineligible patients included those who were blind (before detection of an opacity), deceased, or did not have a working telephone number listed in their medical record. Cases who had cataracts removed by another physician were excluded because characteristics of the lens were not available. Controls were excluded if they had photokeratitis (a corneal burn due to high solar exposure).

Patients were considered to be cases if their chart indicated the presence of cortical, posterior subcapsular or nuclear sclerotic changes of the lens in either one or both eyes. Ophthalmic information abstracted from the cases' records included: type of cataract, severity of the opacity, number of opacities, eyes involved, surgery, visual acuity and comorbid ocular conditions. Cases were included regardless of visual acuity; and diagnoses were not validated in any other way. There were 133 cases identified in the population, 15.4 per cent of persons aged 40–69 years. Cataract type was classified separately for subjects with one type of opacity and multiple types of opacities. Patients with either one opacity in one eye or the same type of opacity in both eyes were classified in the single opacity type group. Multiple opacities either in one or both eyes were classified according to the combination.

Controls were selected from the remaining patients in the targeted age group. Their records showed no indication of opacification of the lens of either eye during the time of the study. Two controls similar to the cases with respect to current age (± two years) and sex were chosen, when available, otherwise one control was selected. One hundred and ninety-three controls were enrolled into the study.

Eighty-seven per cent (n = 283) of eligible subjects responded to the telephone interview, which gathered historical information on exposure to natural sunlight, demographic characteristics, ophthalmic factors, use of selected medications with photosensitizing properties, medical conditions, selected occupations, smoking, alcohol use, and caffeine intake. Few study subjects were Black (n = 9), so the analysis was restricted to the 113 White cases and 161 White controls.

Sun Exposure Measures

The variable for sun exposure was derived from various sources of questionnaire information. A complete residential history, from place of birth to current residence, was obtained for each study subject. For all residences of one year or more, the subject was asked the state and number of years of residency. The respondent was also asked to estimate the amount of time spent in the sun during those years. Subjects were given a choice of three responses (much time in the sun, a moderate amount, or a little time in the sun). Up to eight residences were recorded for each participant.

Mean total solar radiation values for each state were obtained from the National Climatic Data Center[6] which has

Address reprint requests to Gwen W. Collman, PhD, Epidemiology Branch, National Institute of Environmental Health Sciences, P.O. Box 12233, Research Triangle Park, NC 22709. Dr. Shore is also with that Branch at NIEHS; Dr. Shy is with the Department of Epidemiology, UNC School of Public Health; Dr. Checkoway was with the UNCSPH, Department of Epidemiology but is currently with the Department of Environmental Health, School of Public Health, University of Washington, Seattle; Dr. Luria is with Asheboro Ophthalmology Associates, Inc., Asheboro, NC. This paper, submitted to the Journal July 2, 1987, was revised and accepted for publication April 21, 1988.

TABLE 1—Characteristics of the Population

Characteristics	Cases Number (%)	Controls Number (%)
Sex		
Male	45 (40)	69 (43)
Female	68 (60)	92 (57)
Age*		
40–49	10 (9)	18 (11)
50–59	26 (23)	48 (30)
60 +	77 (68)	95 (59)
Education		
Less than High School	50 (44)	65 (40)
High School Graduate	46 (41)	57 (35)
More than High School	17 (15)	39 (24)
Diabetes		
Yes	18 (16)	21 (13)
No	95 (84)	140 (87)
Lifelong Residents of NC		
Yes	74 (65)	107 (66)
No	39 (35)	54 (34)

*Age (years) in 1983.

routinely measured daily direct and diffuse solar radiation on a horizontal surface at weather reporting stations in each state over a 47-year period (1915–62), although not all weather stations had been in operation for the full 47 years. An average solar value was calculated for states with more than one reporting station. Intensity of the solar radiation is measured in Langley units which equal one gram calorie per square centimeter.

An individual's average annual sun exposure was a weighted average of lifetime sun exposure. The radiation intensity of each state was multiplied by the duration of time spent in that state times the reported amount of time spent in the sun (assigned a proportionate value of 80 per cent for much time in the sun, 50 per cent for a moderate amount of time, 20 per cent for a little time in the sun). This product was summed over the various states of residence and divided by the respondent's age.

Statistical Methods

Unconditional logistic regression models were fitted with lens disease as the dependent variable and with the matching factors (age and sex) included in all models. The exposure variable, annual sunlight exposure, was included in various models as a continuous variable, dichotomized at the median value of the distribution or grouped into three categories (low, medium, and high). Screening procedures were used to identify potential confounders. Odds ratios and 95% confidence intervals were estimated from the logistic models. Separate models were fitted for each type of lens opacity with enough cases.

Results

As shown in Table 1, approximately 60 per cent of the study population was female. The majority of the cases and controls were elderly, non-diabetic lifelong residents of North Carolina.

Seventy-four per cent of all cataract cases had a single opacity type, as seen in Table 2. Nuclear sclerotic changes and posterior subcapsular changes predominated. Most cataract cases had opacities in both eyes, and few had greatly impaired visual acuity.

The mean annual sun exposure score was 212.40 Langley/year (SE=7.63) for cases and 207.62 Langley/year (SE=5.82) for controls. The average number of hours spent in the sun per day as an adult was 5.0 hours/day for cases and 4.9 hours/day for controls.

TABLE 2—Ophthalmic Characteristics of the Cataract Cases

Characteristics	Number (%)
Cataract type	
Single opacity	
Cortical	9 (8)
Posterior Subcapsular	13 (12)
Nuclear Sclerotic	56 (50)
Other	5 (4)
Multiple opacities	
Cortical & Posterior subcapsular	4 (3)
Cortical & Nuclear Sclerotic	3 (3)
Posterior Subcapsular & Nuclear Sclerotic	22 (20)
Number of Eyes Involved	
Unilateral	29 (26)
Bilateral	84 (74)
Number of Opacities—Right Eye	
0	14 (12)
1	83 (74)
2	16 (14)
Visual Acuity—Worst Eye	
20/25 or better	43 (39)
20/30—20/40	21 (19)
20/50—20/90	23 (21)
20/100 or worse	24 (21)

As presented in Table 3, for all types of opacities combined, the odds ratios were 1.06 for moderate exposure and 1.12 for high exposure compared with low exposure to sunlight. The number of cases with each type of opacity was small and the odds ratios correspondingly unstable. Sunlight exposure appeared to relate to cortical and posterior subcapsular opacity but not to nuclear sclerotic lens changes. These small changes in risk were also apparent when the sun exposure data were treated as continuous or dichotomized at the median.

Additional variables were examined as potential risk factors for cataract, as seen as Table 4. The use of tranquilizers was positively associated with the risk of lens opacities (OR=2.20, 95% CI=1.10, 4.39), with 15 per cent of the total study population reporting having used tranquilizers for at least six months. The type of tranquilizers used and frequency and duration of their use was not ascertained during the interview. Persons with hazel and brown eyes had higher risk than persons with green, blue and grey eyes. Persons who reported a family history of cataracts had a slightly increased

TABLE 3—Odds Ratios and 95% Confidence Intervals for the Relationship between Sunlight Exposure and the Risk of Cataracts

Cataract Type	Low Exposure	Medium Exposure	High Exposure
All Cataract Cases	1.00	1.06 (0.77, 1.45)	1.12 (0.56, 1.98)
Cortical Only	1.00	1.23 (0.51, 2.98)	1.53 (0.21, 7.19)
Posterior Subcapsular Only	1.00	1.23 (0.59, 2.59)	1.52 (0.28, 5.44)
Nuclear Sclerotic Only	1.00	0.87 (0.77, 1.31)	0.79 (0.39, 1.96)
PSC & NS*	1.00	1.16 (0.65, 2.08)	1.36 (0.36, 3.72)

*Posterior subcapsular and nuclear sclerotic opacities
95% CI in parentheses.

TABLE 4—The Relationship between Cataracts and Other Risk Factors

Risk Factors	Cases		Controls		Odds Ratio*	95% CI
	Exposed	Unexposed	Exposed	Unexposed		
Tranquilizers	24	87	17	140	2.20	(1.10, 4.39)
Dark Eyes	51	60	58	102	1.60	(0.96, 2.65)
Diabetes	18	95	21	140	1.20	(0.60, 2.39)
Physical Injury to Eye	14	98	21	140	0.99	(0.47, 2.14)
Family History of Cataracts	35	77	44	117	1.39	(0.80, 2.41)
Sunglasses	48	63	69	92	1.04	(0.65, 1.77)
Smoking	60	52	83	78	1.28	(0.74, 2.22)
Outdoor Work	19	91	33	128	0.86	(0.57, 1.75)

*Odds ratio adjusted for age and sex.

risk of lens disease. Diabetes, sunglass use, eye injury, and current smoking habit had odds ratios close to the null. A history of outdoor work which may involve higher sunlight exposure was not related to an increased risk of lens disease in either men or women.

Discussion

To our knowledge, this is the first case-control study conducted to estimate the risk of lens disease according to exposure to natural sunlight. Cases had a slightly higher mean annual sun exposure score than controls but reported an equal number of hours spent in the sun as adults. Our study showed a very weak increase in the overall risk of opacities as lifetime exposure to the sun increased. An increasing trend was seen for risk of cortical or posterior subcapsular cataracts but not nuclear sclerotic cataracts, as well as cases having a combination of opacity types, but these estimates are imprecise because of the small number of cases of each type. The very modest increase in risk we observed is smaller than previously reported from ecologic studies. Hiller, *et al.* [5] using HANES data, reported a risk ratio of 1.58 for Tucson, Arizona compared with Albany, New York. Studies done in Nepal[4] found a prevalence ratio of 2.6 for villages with 12 hours of sunlight compared with villages with 7–9 hours of sunlight. Similar patterns have been reported within Australia[2,7] and the United States.[3] Another study found more cataracts in Manila than in Tampa, Florida and Rochester, New York.[8] Additional analysis of the HANES data found exposure to ultraviolet-B radiation to be significantly associated with cortical changes (RR=3.6, n=55).[11] A positive association was found for nuclear sclerotic cataracts (RR=1.4, n=104) and a negative one for posterior subcapsular changes (RR=0.3, n=18). One likely reason for lower risk levels in these data is that 65 per cent of the study population were lifelong residents of North Carolina and therefore the range of exposure scores was narrower than in the nationwide sample.

Our risk estimates may also be biased toward the null because of limitations in the characterization of lifetime exposure. Solar radiation measurements for the state of residence were quite accurate, but the duration of residence and amount of time spent in the sun could have been incorrectly remembered or interpreted differently among study participants. No direct validation of this exposure classification scheme was possible, but we did note that the average annual sun exposure scores were higher for persons working outdoors than indoors (270.13 Langley/yr, SE=7.1 versus 194.37 Langley/yr, SE=5.0), and persons reporting greater than the median number of hours in the sun had higher scores than persons spending less time outdoors (245.35 Langley/yr, SE=5.6 versus 168.40 Langley/yr SE=5.6).

Our estimates of the relative risk of each of the individual cataract types require cautious interpretation because of the study size. We restricted our study population to ages 40–69 at age of diagnosis to separate the etiologic effects of solar radiation and aging and to improve recall, but there are fewer lens changes occurring in this younger group. A larger study would lend more confidence to our findings.

If the modest gradient in risk with solar radiation in this study and the marked gradient seen in population studies is real, ultraviolet radiation may be the relevant part of the solar spectrum in the etiology of cataracts. This may be of particular importance for ocular health in light of recent reports of future amounts of ultraviolet radiation in our atmosphere from depletion of the ozone layer. Ultraviolet radiation has been used to create cataractous changes in animal lenses.[16] Both UV-A and UV-B are capable of producing lenticular damage.[17] Cataracts are produced experimentally using either a single high dose of ultraviolet radiation or multiple exposures to lower intensity. One may hypothesize that repeated insults of low intensity radiation over the course of a persons lifetime leads to cataracts. Damage may be done episodically, when sun exposure is of high intensity or long duration, with accumulations of aberrations ultimately leading to opacification. The slow progression of lens disease is consistent with this notion of accumulated damage in the lens.

Other risk factors for cataracts were found in our study. The apparent effect of tranquilizers was an unanticipated finding. Bartholomew and others[8] reported no association between the use of major tranquilizers and cataract. In our data, the tranquilizers used were probably sleeping pills or other barbiturates and minor tranquilizers such as diazepam, rather than "major tranquilizers". More detailed data on tranquilizers used should be included in future studies.

Our finding of increased risk among dark-eyed subjects is consistent with reports of high prevalence rates of cataracts in areas populated with dark-eye persons, e.g., India,[10] Nepal,[4] and Aborigines in Australia.[2] Black race was also reported as a significant risk factor for cataracts in the HANES data, but our study population had too few Blacks to study this factor.[5] While melanin protects against the carcinogenic effects of ultraviolet radiation to the skin, melanin in the iris may absorb solar radiation and provide higher amounts of exposure to the lens of the eye.[12] This finding needs replication in other population studies. Our study did not find factors such as eye injury[13] or diabetes[14,15] to be related to lens changes, although they have been

reported as risk factors in other studies. Smoking was evaluated for the first time and found not to be related to cataract risk. The positive associations between lens changes and eye color and tranquilizer use may stand up since a large number of comparisons were made and our numbers are small.

Other studies of lens disease are needed to confirm our findings and those of previously reported geographic studies. Residential history coupled with objective measurements of sun exposure, as attempted in this study, is necessary. Larger populations of cases and controls with substantial variation in sun exposure are also needed.

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NCHS Report Analyzes Prevalence of Chronic Conditions in US

An analysis of the prevalence of selected chronic conditions in US citizens was recently published by the National Center for Health Statistics, using data from its annual National Health Interview Survey 1983-85.

The report ranks the top 10 chronic conditions for the total population, including breakdowns by age, sex, and race. It also shows the 15 most prevalent chronic conditions and the percentage of persons ever hospitalized due to them; chronic conditions were also ranked according to limitation of activity.

There was little difference between sexes in ranking of the top 10 chronic diseases; nine out of 10 chronic conditions ranked equally high.

- Sinusitis was the most prevalent chronic condition (31.2 million reported conditions annually); arthritis ranked second (30.3 million conditions); high blood pressure was third (28.6 million).
- Heart disease and diabetes were the chronic diseases most likely to require hospitalization (42.6 and 32.7 per cent, respectively).
- Chronic conditions causing highest limitation of activity were mental retardation (85.6 percent), followed by multiple sclerosis (76.8percent) and cancer of the lung and bronchus (68.2 per cent).
- Those under age 18 reported more respiratory conditions (hay fever, bronchitis, sinusitis and asthma) while the 65+ age group reported more cataracts, tinnitus, diabetes and hardening of the arteries.
- Among Blacks, high blood pressure was the most prevalent chronic condition reported (146.3 per 1000).

The top 10 chronic conditions in prevalence were very different from those with high levels of hospitalization and activity limitation. Less than 10 per cent of people with the three most prevalent conditions were hospitalized; sinusitis, the most prevalent chronic condition, caused limitations in less than .005 per cent of those reporting the condition.

Copies of the 14-page report, *Prevalence of Selected Chronic Conditions, United States 1983-85,* Advance Data Report No. 155, are available free from: National Center for Health Statistics, USPHS, DHHS, 3700 East West Highway, Room 1-57, Hyattsville, MD 20782.