Light Exposure and the Risk of Cortical, Nuclear, and Posterior Subcapsular Cataracts

The Pathologies Oculaires Liées à l’Age (POLA) Study

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**Background:** Exposure to light may be an important risk factor for the development of cataracts.

**Objective:** To present the relation of ambient solar radiation and professional and leisure exposures to light with the different types of cataracts.

**Methods:** Pathologies Oculaires Liées à l’Age (POLA) is a population-based study on cataract and age-related macular degeneration and their risk factors in 2584 residents of Sète (southern France). Cataract classification was based on lens examination at slitlamp according to Lens Opacities Classification System III. A questionnaire about light exposure was administered.

**Results:** After multivariate adjustment, participants who had higher ambient solar radiation had a 2.5-fold (95% confidence interval [CI], 1.2-5.0), 4.0-fold (95% CI, 2.0-8.0), and 2.9-fold (95% CI, 1.5-5.3) increased risk of cortical and mixed cataract and cataract surgery, respectively. Solar ambient radiation was not significantly associated with posterior subcapsular and nuclear cataracts. By contrast, posterior subcapsular cataracts were significantly associated with professional exposure to sunlight (odds ratio [OR], 1.63; 95% CI, 1.01-2.63) and frequent use of sunglasses (OR, 0.62; 95% CI, 0.43-0.90). Mixed cataract was also associated with professional exposure to artificial light (OR, 3.02; 95% CI, 1.03-8.82).

**Conclusion:** Our study further confirms the role of sunlight exposure in the pathogenesis of cataract, in particular in its cortical localization.


**CATARACT** is the leading cause of blindness, accounting for 50% of blindness worldwide. With the global aging of the populations, in particular in industrialized countries, this condition is expanding rapidly. The only therapy currently available is lens extraction. The growing need for surgical resources is particularly critical in developing countries but also affects the industrialized countries. For instance, cataract surgery has become the most frequent surgical procedure in people 65 years or older in the United States, with an estimated cost to Medicare of $3.4 billion in 1991. An increased understanding of cataract etiology may lead to the development of nonsurgical strategies to delay or prevent cataract. In the United States, the National Eye Institute estimates that a 10-year delay in the onset of cataract would result in a 50% reduction in the prevalence of cataract.

Among other factors that contribute to the development of lens opacities (genetic factors, diabetes, use of corticosteroids, etc), the role of sunlight exposure has been questioned in several epidemiological studies. Ecologic studies have suggested that areas with higher solar radiation had higher prevalence of cataract, using crude estimates of exposure and cataract prevalence. These first results have been further confirmed by several US studies, performed in Maryland and Wisconsin, using estimations of UV-B exposure at the individual level and a standardized lens examination, allowing the study of the different types of cataract (cortical, nuclear, posterior subcapsular [PSC]). These studies have shown an association of ocular exposure to UV-B with cortical cataract, and in only 1 study, with PSC cataract.

The Pathologies Oculaires Liées à l’Age (POLA) study is an epidemiological study taking place in Sète (southern France) that was designed to identify risk factors for cataract and age-related macular degeneration. In particular, a standardized interview on lifetime sunlight exposure (residential history, professional and leisure exposures, use of sunglasses, etc)
SUBJECTS AND METHODS

STUDY POPULATION

The POLA study is a prospective study that takes place in Sète. The objective of this survey is to study age-related eye diseases (cataract and age-related macular degeneration) and their risk factors. Inclusion criteria were (1) residence in the town of Sète and (2) age of 60 years or older on the day of the examination. According to the 1990 population census, there were almost 12,000 eligible residents, from which our objective was to recruit 3000 participants. The population was informed of the study through the local media (television, radio, and newspapers). We also contacted 4343 residents individually by mail and telephone using the electoral roll. Between June 1995 and July 1997, we recruited 2584 participants, including 1133 men and 1451 women, with an average age of 70.4 years. Except for 4 blacks and 1 Asian, the participants were white, mainly of European origin. Even most of the participants who were born in North Africa were of French origin. These countries were French colonies before the 1960s, and participants born in these countries came back to France at the time of independence.

The baseline examination took place in a mobile unit equipped with ophthalmologic devices (a projector of Snellen chart using decimal scale [model L28 IR; Luneau, Chartres, France], an autorefractometer [model RM-A7000; Topcon, Tokyo, Japan], a slitlamp [model SL7F; Topcon], and a retinal camera [model TRC 50 XF; Topcon]). The mobile unit moved from one area to another to be in the proximity of the contacted participants.

Participants gave written consent for participation in the study. The design of this study was approved by the Ethical Committee of Montpellier’s University Hospital, Montpellier, France.

OPHTHALMOLOGIC EXAMINATION

Four ophthalmologists (L.B., J.C., J.L.D., and F.R.) performed the ophthalmologic examinations. This examination included, in particular, a recording of ophthalmologic history (in particular lens extraction and year of the extraction); a measure of best corrected visual acuity in the right and left eyes; after pupil dilation, a quantitative assessment of nuclear, cortical, and PSC lens opacities (N, C, and P, respectively), which is based on standard photographs, provides decimal, nearly continuous grades separately for nuclear opalescence (NO; ranging from 0 to 6.9, using 6 standards), nuclear color (NC; ranging from 0 to 6.9), cortical opacities (C; ranging from 0 to 5.9, using 5 standards), and PSC opacities (P; ranging from 0 to 5.9, using 5 standards).

Cataract Classification

The type and degree of lens opacification were graded at slitlamp following the procedures of the LOCS III.13 This system, which is based on standard photographs, provides decimal, nearly continuous grades separately for nuclear opalescence (NO; ranging from 0 to 6.9, using 6 standards), nuclear color (NC; ranging from 0 to 6.9), cortical opacities (C; ranging from 0 to 5.9, using 5 standards), and PSC opacities (P; ranging from 0 to 5.9, using 5 standards).

Severe Cataract

We chose to classify as severe cataract lens opacifications that led to significant visual impairment in most participants (NO or NC $\geq$ 4 for nuclear cataract, C $\geq$ 4 for cortical cataract, PSC opacities $\geq$ 2 for PSC cataract). Participants were classified as having a single type of cataract (nuclear, cortical, or PSC) when only 1 type of opacity was present. The nuclear group, for instance, consisted of participants with nuclear cataract only in both eyes or nuclear cataract only in 1 eye and none or moderate cataract in the other eye. The mixed cataract group consisted of participants with various combinations of nuclear, cortical, and PSC in 1 or both eyes. In this study, the group of subjects with mixed cataract consisted of 23.8% of subjects with all 3 types of opacities, 11.3% with corticonuclear cataract, 48.3% with nuclear-PSC cataract, and 16.6% with cortical-PSC cataract.

No Cataract

All the remaining subjects were classified as having no cataract. Most of these participants (n = 1726) showed moderate opacities (2 $\leq$ NO $< 4$, 2 $\leq$ NC $< 4$, 2 $\leq$ C $< 4$, 1 $\leq$ P $< 2$). Only relatively few (n = 131) showed no opacities (NO $< 2$, NC $< 2$, C $< 2$, and P $< 1$). Finally, participants who had already had bilateral lens extractions form a separate group (cataract surgery). Participants with unilateral lens extraction (n = 100) were classified according to their other eye.

Lens examination was lacking in both the right and left eyes in 25 participants (1%), in 13 because of lack of dilation (8 refused, and 5 had contraindications) and in 12 because of technical failure. We excluded 1 case of traumatic cataract. Thus, cataract status could be determined in 2558 participants (98.9%) of 2584.

INTERVIEW DATA

Data were collected by trained study personnel, who were unaware of cataract status. A standardized interview was performed to assess, in particular, sociodemographic variables (marital status, educational level, major lifetime occupation, etc), medical history (treated hypertension, cardiovascular diseases, diabetes, knee or hip osteoarthritis, etc), recording of all medications currently used, and smoking history.

The subject was then asked about residential history, professional exposure to sunlight (work on the sea, in particular fishing, work on the beach or oyster farming, driving, agriculture, building industry, and others) or to artificial light (arc welding, photography, show business, and others) and the duration of these professional exposures (years), leisure exposure to sunlight (beach, sailing, fishing, skiing, and others), use of sunglasses, and habits concerning sunbathing. Concerning residential history, in France, locations were divided in 101 geographic areas, corresponding to the 101 administrative departments.

The interviewer then measured height, weight, waist and hip circumferences, and systolic and diastolic blood pressures.

Participants were considered as having high education if they had reached at least the end of high school. History of cardiovascular disease was defined by a history of myocardial infarction, stroke, or angioplasty. Hypertension was defined as known treated hypertension confirmed by current use of antihypertensive drugs and/or systolic blood pressure of 160 mm Hg or greater and/or diastolic blood pressure of 95 mm Hg or greater.
AVERAGE ANNUAL AMBIENT SOLAR RADIATION

To our knowledge, no data are available on the level of ambient UV-B in the different areas of France. Statistics for solar radiation (a measure of solar energy that includes all wavelengths) are available only for a limited number of sites. Ambient solar radiation was, therefore, estimated, taking into account the latitude, the cloud cover, and the seasons.

Indeed, ambient solar radiation depends principally on 2 factors. The first factor is solar radiation at the limit of the atmosphere (extraterrestrial solar radiation), which depends only on the distance from the sun and on the angle of the sun's rays, and, therefore, on the season and latitude. It can be calculated by astronomical equations as follows:

\[
(1) \quad ESR = 0.36 \times 10^3 \times \left[ \frac{(DD \times \sin \phi \times \sin \delta + 24)}{(\pi \times \sin \omega \times \cos \varphi \times \cos \delta) + \cos \omega \times \tan \varphi \times \cot \delta} \right],
\]

where \( ESR \) indicates the extraterrestrial solar radiation in joules per cubic centimeters; \( Io \), the illumination at the limit of the atmosphere (in watts per square meter), which depends only on the distance from the sun (and thus on the day of the year); \( \varphi \), latitude; \( \delta \), declination (depends on the day of the year); \( \omega \), hour angle at sunset; \( \cos \omega \), \( \tan \varphi \times \cot \delta \), and \( \pi \), 3.1416. \( Io \) is obtained by the following formula:

\[
(2) \quad Io = 1370 \times (1 + 2 \times 0.0167 \times \cos [2 \times \pi (J - 2)/365.25]) \quad \text{where J is the day of the year.}
\]

Astronomical duration of the day (DD) depends on the day of the year and on the latitude. It is obtained by the following formula:

\[
(3) \quad DD = \frac{24}{\pi} \times \text{Arc} \cos (\tan \varphi \times \cos \delta).
\]

The second factor is that once the sun's rays penetrate the atmosphere, their attenuation depends principally on the cloud cover (or conversely on the sunshine hours). It is possible to approximate the attenuation of the extraterrestrial solar radiation by the cloud cover using a simple equation:

\[
(4) \quad ASR = ESR \times \sqrt{0.18 + 0.62 \times (SH/DD)}, \quad \text{where ASR is ambient solar radiation; ESR, extraterrestrial solar radiation; SH, sunshine hours per day; and DD, astronomical duration of the day.}
\]

For each location, we first calculated the extraterrestrial solar radiation for each day of the year, according to equation 1. Using the average monthly statistics of sunshine hours obtained from Division Climatologie, Banques de Donnees, we then estimated cumulative ambient solar radiation for each month of the year using equation 4. Finally, for each location, the annual ambient solar radiation was obtained by adding the monthly values.

For each participant, the average annual ambient solar radiation was estimated using the residential history by weighting the annual ambient solar radiation at each location by the time spent at that location. This average was assessed on the first 60 years of life, since the quasi totality of the subjects lived in Sète after the age of 60 years.

For France, statistics of sunshine hours during 30 years are available in 72 departments. Those departments without sunshine data were given the value of the nearest available data. Concerning foreign countries, annual solar radiation was generally estimated for the capital of the country, except when the capital was not centered, in which case a more central location was chosen. Large countries (United States and China) were excluded from this analysis, since an estimation of solar radiation based on a single geographic location is meaningless for them.

For several countries, statistics of sunshine hours were unavailable, impeding the estimation of solar radiation. When, for a given subject, the number of years spent in such countries was 3 years or less, these countries were eliminated from the calculations. For 36 subjects, the average ambient solar radiation was, therefore, calculated on 37, 58, or 59 years instead of 60 years.

Of the 2538 subjects with cataract status, 95 subjects were excluded from the analysis because they had spent more than 3 years in countries where solar radiation could not be estimated and 13 subjects because they had missing data in other variables related to sunlight exposure (leisure and/or professional exposure, and use of sunscreens). Data on sunlight exposure were, therefore, available for 2450 (95.8%) of 2538 subjects.

BIOLGIC MEASUREMENTS

Biologic measurements were made from fasting blood samples performed at home on the morning of the examination. They include measurements in plasma (cholesterol, triglycerides, and vitamins A, E, and C) and in red blood cell (reduced glutathione). Plasma triglyceride and total cholesterol levels were measured by routine enzymatic methods with a reagent purchased from Boehringer Ingelheim, Ingelheim, Germany. Retinol and α-tocopherol were measured by high-performance liquid chromatography according to the method previously described by Catignani and Bieri. In each series, 1 sample was added with the liotrol mixture as internal standard to prevent any shift during the study. Measurement of plasma glutathione peroxidase (GPX) concentration was performed by enzyme-linked immunosassay (Bioxytech pl-GPX-EIA; OXIS International Inc, Portland, Ore). Red blood cell superoxide dismutase activity was measured by a spectrophotometric assay (Bioxytech SOD-325; OXIS International Inc).

STATISTICAL ANALYSIS

For each light exposure variable, age- and sex-adjusted odds ratios (ORs) were obtained using logistic regression with the type of cataract (PSC, cortical, nuclear, or mixed cataract or cataract surgery) as the dependent variable and age, sex, and the light exposure variable as the independent variables. Annual ambient solar radiation was divided in 3 groups (lower quartile, intermediate quartiles, and upper quartile).

For each type of cataract, a multivariate logistic model was then performed with age, sex, and all light exposure variables that were close to significance in the first model (P<.10) and potential confounding factors (educational level, diabetes, and corticosteroids). In all analyses, the reference group was the group of participants without any type of severe cataract.

Subjects with missing data in the confounding factors, used in multivariate analyses, were excluded from all statistical analyses. Of the 2450 subjects with available cataract and sunlight exposure data, we excluded 38 subjects with missing interview data (educational level and medical history) and 48 with missing biologic variables (because of refusal of the blood sampling or of technical failure). The statistical analyses were, therefore, performed for 2364 subjects.

All statistical analyses were performed with SAS software (SAS Institute Inc, Cary, NC).
was performed, allowing the assessment of the association of the different types of cataract with sunlight exposure.

Sète is a town with 40,000 inhabitants located on the French Mediterranean. Its principal economic activities are the harbor and fishing, oyster farming, tourism, and industry. This town, located near our research center, was chosen because of the diversity of sunlight exposures in this population (fisherfolk and oyster farmers with high life-exposure to sunlight, people coming from other South Europe countries, French people who were born in North Africa, people from northern France coming to retire). Most epidemiological studies on this subject were conducted in the United States; our study is among the few such European studies and is the first in France. We present herein the associations of age-related PSC, cortical, nuclear, and mixed cataracts with sunlight exposure.

**RESULTS**

As shown in Table 1, in men, the prevalence of cataract increased from 9.2% between ages 60 and 69 years to 61.8% after age 80 years. Its prevalence was slightly higher in women and increased from 12.3% at younger than 70 years to 73.5% at older than 80 years. Although PSC was the most frequent type of cataract at younger than 70 years (4.4% in men and 5.0% in women), nuclear and mixed cataracts were the most frequent types after 80 years of age (17.4% and 16.5%, respectively, in men, and 13.9% and 20.5% in women).

Table 1. Prevalence of the Different Types of Cataract According to Age and Sex in the Pathologies Oculaires Liées à l’Age (POLA) Study

<table>
<thead>
<tr>
<th>Variable</th>
<th>Age, y</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>60-69 y</td>
<td>70-79 y</td>
</tr>
<tr>
<td>Men, %</td>
<td>(n = 520 for Men and 659 for Women)</td>
<td>(n = 378 for Men and 541 for Women)</td>
</tr>
<tr>
<td>PSC only</td>
<td>4.4</td>
<td>9.5</td>
</tr>
<tr>
<td>Cortical only</td>
<td>1.5</td>
<td>3.4</td>
</tr>
<tr>
<td>Nuclear only</td>
<td>1.4</td>
<td>6.6</td>
</tr>
<tr>
<td>Mixed</td>
<td>1.1</td>
<td>6.1</td>
</tr>
<tr>
<td>Cataract surgery</td>
<td>0.8</td>
<td>5.6</td>
</tr>
<tr>
<td>Total</td>
<td>9.2</td>
<td>31.2</td>
</tr>
<tr>
<td>Women, %</td>
<td>(n = 520 for Men and 659 for Women)</td>
<td>(n = 378 for Men and 541 for Women)</td>
</tr>
<tr>
<td>PSC only</td>
<td>5.0</td>
<td>8.9</td>
</tr>
<tr>
<td>Cortical only</td>
<td>2.9</td>
<td>5.0</td>
</tr>
<tr>
<td>Nuclear only</td>
<td>1.5</td>
<td>9.2</td>
</tr>
<tr>
<td>Mixed</td>
<td>1.4</td>
<td>8.5</td>
</tr>
<tr>
<td>Cataract surgery</td>
<td>1.5</td>
<td>5.2</td>
</tr>
<tr>
<td>Total</td>
<td>12.3</td>
<td>36.8</td>
</tr>
</tbody>
</table>

*PSC indicates posterior subcapsular.

Table 2 presents the distribution of the light exposure variables in the POLA study. The median of the annual ambient solar radiation was 562 kJ/cm², showing an important interindividual variability. This variability was, in particular, due to differences in geographical origins: almost 60% of the participants were born in southern France, about 20% were born elsewhere in France, more than 15% were born in northern Africa (the latter remained there for 33 years in median, which corresponds to independence of these countries in the 1960s), and about 5% were born in southern Europe. Professional exposures to sunlight were frequent in men (33.2%) and rare in women (2.5%). Professional exposures to artificial light were rare in both sexes (4.6% in men and 0.5% in women). Leisure exposures to sunlight were ex-
tremely frequent: three fourths of the participants declared that they performed frequently during their life-
times leisure activities at sea (beach, sailing, and fishing), which is not surprising since most of them lived the ma-
Solar Radiation (midpoint of the
Figure 1.
Figure 1 presents the distribution of annual am-
ambient solar radiation, estimated from residential history. This variable showed an important interindividual vari-
ability, ranging from 357 to 659 kJ/cm². The peak at 570

\[\text{Annual Ambient Solar Radiation, kJ/cm}^2\]

\[
\begin{align*}
\text{Frequency} & \quad \text{Annual Ambient Solar Radiation, kJ/cm}^2 \\
\text{0} & \quad 370, 390, 410, 430, 450, 470, 490, 510, 530, 550, 570, 590, 610, 630, 650
\end{align*}
\]

Table 3. Sex- and Age-Adjusted Odds Ratios (ORs) and 95% Confidence Intervals (CIs) Between Each Light Exposure Variable and the Types of Cataract in the Pathologies Oculaires Liées à l’Age (POLA) Study

<table>
<thead>
<tr>
<th>Variable</th>
<th>Posterior Subcapsular Only</th>
<th>Cortical Only</th>
<th>Nuclear Only</th>
<th>Mixed Cataract Surgery</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual ambient solar radiation, kJ/cm²</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>516.7-564.6*</td>
<td>0.79 (0.54-1.16)</td>
<td>1.50 (0.82-2.73)</td>
<td>1.36 (0.64-2.20)</td>
<td>2.49 (1.35-4.59)</td>
</tr>
<tr>
<td>≥564.6*</td>
<td>1.05 (0.65-1.72)</td>
<td>3.02 (1.54-5.92)</td>
<td>1.88 (1.04-3.41)</td>
<td>4.43 (2.25-8.74)</td>
</tr>
<tr>
<td>Professional exposure to sunlight</td>
<td>P for trend = .95</td>
<td>P for trend = .001</td>
<td>P for trend = .001</td>
<td>P for trend = .001</td>
</tr>
<tr>
<td>1.75 (1.10-2.80)</td>
<td>1.18 (0.57-2.46)</td>
<td>1.21 (0.68-2.17)</td>
<td>1.18 (0.63-2.20)</td>
<td>1.71 (0.90-3.26)</td>
</tr>
<tr>
<td>Professional exposure to artificial light</td>
<td>P = 0.02</td>
<td>P = 0.01</td>
<td>P = 0.01</td>
<td>P = 0.01</td>
</tr>
<tr>
<td>1.16 (0.40-3.34)</td>
<td>0.67 (0.09-5.06)</td>
<td>0.44 (0.06-3.61)</td>
<td>2.63 (0.37-4.74)</td>
<td>0.60 (0.08-4.58)</td>
</tr>
<tr>
<td>Leisure exposure to sunlight of ≥5 years vs &lt;5 years</td>
<td>P = 0.70</td>
<td>P = 0.70</td>
<td>P = 0.70</td>
<td>P = 0.70</td>
</tr>
<tr>
<td>Sea</td>
<td>P = 0.76</td>
<td>P = 0.76</td>
<td>P = 0.76</td>
<td>P = 0.76</td>
</tr>
<tr>
<td>0.94 (0.65-1.37)</td>
<td>0.69 (0.43-1.09)</td>
<td>0.86 (0.57-1.30)</td>
<td>0.77 (0.51-1.17)</td>
<td>0.83 (0.53-1.31)</td>
</tr>
<tr>
<td>Snow</td>
<td>P = 0.36</td>
<td>P = 0.36</td>
<td>P = 0.36</td>
<td>P = 0.36</td>
</tr>
<tr>
<td>0.78 (0.46-1.33)</td>
<td>0.41 (0.16-1.04)</td>
<td>0.85 (0.45-1.62)</td>
<td>0.97 (0.53-1.79)</td>
<td>0.77 (0.38-1.58)</td>
</tr>
<tr>
<td>Land</td>
<td>P = 0.01</td>
<td>P = 0.01</td>
<td>P = 0.01</td>
<td>P = 0.01</td>
</tr>
<tr>
<td>0.86 (0.61-1.21)</td>
<td>0.85 (0.61-1.48)</td>
<td>0.81 (0.55-1.20)</td>
<td>1.00 (0.67-1.48)</td>
<td>0.83 (0.53-1.29)</td>
</tr>
<tr>
<td>Frequent use of sunglasses</td>
<td>P = 0.04</td>
<td>P = 0.04</td>
<td>P = 0.04</td>
<td>P = 0.04</td>
</tr>
<tr>
<td>0.59 (0.41-0.85)</td>
<td>0.86 (0.55-1.35)</td>
<td>0.95 (0.64-1.41)</td>
<td>0.93 (0.62-1.39)</td>
<td>1.01 (0.66-1.55)</td>
</tr>
<tr>
<td>Like to sunbathe</td>
<td>P = 0.93</td>
<td>P = 0.93</td>
<td>P = 0.93</td>
<td>P = 0.93</td>
</tr>
<tr>
<td>0.99 (0.69-1.40)</td>
<td>1.26 (0.80-1.99)</td>
<td>0.83 (0.55-1.27)</td>
<td>1.04 (0.68-1.57)</td>
<td>0.98 (0.63-1.54)</td>
</tr>
</tbody>
</table>

* Limits of quartiles.
tive association with the use of sunglasses ($P = .01$). In addition to their association with solar radiation, mixed cataracts were associated with professional exposure to artificial light ($P = .04$).

To assess the importance of solar radiation at various stages of life, the annual solar radiation at each age of life was estimated for each type of cataract and for participants free of cataract for those types of cataract that were significantly associated with ambient solar radiation (cortical, mixed, and cataract surgery) (Figure 2). For all 3 types of cataract, it is observed that excess exposure occurs in every year of life from birth to the age of 60 years. After the age of 60 years, the lack of difference is mainly due to the fact that the quasi totality of the subjects lived in Sete since the age of 60 years. The variability of solar radiation is therefore quasi null after the age of 60 years.

**COMMENT**

In the absence of statistics of ambient UV-B levels in France, we estimated ambient solar radiation, a measure of solar energy reaching the ground, which includes all wavelengths. As in the Beaver Dam Eye Study, we then estimated individual annual ambient solar radiation from residential history. This estimate, therefore, represents potential exposure rather than actual ocular exposure, such as that estimated in the studies performed in Maryland, with a detailed assessment of ocular exposure derived from interview, combined with field and laboratory-derived data.

In our study, high ambient solar radiation was associated with a 2.5-fold and 4.0-fold increased risk of cortical and mixed cataracts, respectively. In addition, it was associated with a 2.9-fold risk of cataract surgery. Despite important methodological differences, our results are consistent with the results of previous studies which found an excess risk of cortical opacities with high ocular exposure to UV-B. Our results further confirm that no particular age is important in determining the risk but rather that the risk is a cumulative risk phenomenon, including all life periods, even childhood.

In addition to ambient solar radiation, we studied the association of professional and leisure exposure to light with the different types of cataract. Professional exposure to sunlight was associated with a 1.6-fold increased risk of PSC cataract, although we observed no association of this type of cataract with ambient solar radiation. These results are consistent with 2 studies but not with 3 others. In addition, the frequent use of sunglasses was associated with a 40% decreased risk of PSC cataract. Only 2 studies have given separate results for the use of sunglasses, and neither found any relation with any type of cataract.

Given the number of statistical tests performed in this study, results close to significance must be taken with caution and could be chance findings. Another explanation may be that only very high sunlight exposure is related to PSC cataract. Indeed, in our study, an important part of our sample was exposed to much higher sunlight exposure (particularly in North Africa) in comparison with studies performed on the East Coast of the United States.

Finally, professional exposure to artificial light (mainly arc welding) was associated with a 3-fold increased risk of mixed cataract. To our knowledge, only 1 other study assessed the association of cataract with arc welding. This study was performed only for PSC cataract and showed a 2-fold increased risk, although this result did not reach statistical significance ($0.05<P<0.10$).

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**Table 4. Multivariate Odds Ratios (ORs) and 95% Confidence Intervals (CIs) Between Light Exposure Variables and Types of Cataract in the Pathologies Oculaires Liées à l’Age (POLA) Study**

<table>
<thead>
<tr>
<th>Variable</th>
<th>OR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual ambient solar radiation, kl/cm²</td>
<td></td>
</tr>
<tr>
<td>516.7-564.6</td>
<td>1.32 (0.71-2.45)</td>
</tr>
<tr>
<td>≥564.6</td>
<td>2.48 (1.24-5.00)</td>
</tr>
<tr>
<td>Professional exposure to sunlight</td>
<td>1.63 (1.01-2.63)</td>
</tr>
<tr>
<td>Professional exposure to artificial light</td>
<td>0.62 (0.43-0.90)</td>
</tr>
<tr>
<td>Leisure exposure to sunlight</td>
<td></td>
</tr>
<tr>
<td>≥5 years vs &lt;5 years</td>
<td>0.45 (0.18-1.15)</td>
</tr>
<tr>
<td>Frequent use of sunglasses</td>
<td>0.62 (0.43-0.90)</td>
</tr>
</tbody>
</table>

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* Adjusted for age, sex, education level, oral corticosteroids, cancer, and diabetes.
† Adjusted for age, sex, education level, cardiovascular disease, diabetes, plasma glutathione peroxidase (log10), and brown iris.
‡ Adjusted for age, sex, education level, brown iris, smoking, plasma retinol, and plasma glutathione peroxidase (log10).
§ Adjusted for age, sex, education level, brown iris, diabetes, plasma retinol, and plasma glutathione peroxidase (log10).
¶ Ellipses indicate that the variable was not included in the model (not significant in previous analysis).

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The influence of arc welding and other professional exposure to artificial light needs to be further assessed in other studies.

Our study has several limitations. Our sample underrepresents older persons and overrepresents the middle and upper social classes in comparison with the whole eligible population. Our subjects may thus be healthier and have different lifestyle habits—particularly concerning sunlight exposure—than the general population. This is likely to have affected the prevalence of cataract or the distribution of sunlight exposure variables. However, it is unlikely to have affected the association between cataract and light exposure. To adjust for possible selection bias, multivariate analyses included adjustments for educational level but did not noticeably modify the association between cataract and sunlight exposure variables.

In observational studies, the concern is always about confounding factors. Therefore, we performed multivariate adjustments to take into account all known risk factors for each type of cataract. In addition to age, sex, and educational level, specific factors were used for each type of cataract. The selected factors were those identified in previous analyses of the POLA study, oral corticosteroids, history of cancer, and diabetes for PSC cataract; history of cardiovascular disease, diabetes, GPX, and brown iris for cortical cataract; smoking, plasma retinol, GPX, and brown iris for nuclear cataract; diabetes, plasma retinol, GPX, and brown iris for mixed cataract; and smoking, diabetes, asthma, hypertension, plasma retinol, and GPX for cataract surgery. The associations of sunlight exposure with cortical and mixed cataracts and with cataract surgery remained significant after adjustment for the known risk factors.

Since this study was cross-sectional, recall bias may have affected the results, particularly those concerning professional and leisure exposure to sunlight. All previous studies were either cross-sectional or case-control and may similarly have been subject to recall bias. However, the consistency of the association across different populations, with different methods, and the clear dose-effect relation favors a true association. Data from prospective studies are, nevertheless, needed to confirm these results. This will be done in our study on the incident cases of cataract through a follow-up visit 3 years after baseline.

In conclusion, our study further confirms the role of sunlight exposure in the pathogenesis of cataract, particularly in its cortical localization. It seems that sunlight exposure throughout a lifetime may be important to cataract formation. These results raise the hope that simple preventive strategies, such as avoiding exposure at midday, may reduce the prevalence of cataracts. However, prospective studies are needed to confirm these findings.

Accepted for publication August 22, 1999.

This study was supported by the Institut National de la Santé et de la Recherche Médicale, Paris, France; by grants from the Fondation de France, Department of Epidemiology of Ageing, Paris, the Région Languedoc-Roussillon, Montpellier, France, the Fondation pour la Recherche Médicale, Paris, and the Association Retina-France, Toulouse; and by financial support from Rhône Poulenc, Essilor, and the Centre de Recherche et d’Information Nutritionnelles, Paris.

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