Ocular and Dermatologic Health Effects of Ultraviolet Radiation Exposure from the Ozone Hole in Southern Chile

**ABSTRACT**

**Objectives.** This study sought to investigate numerous reports emanating from Punta Arenas, Chile (population 110,000, latitude 53°S), that associated acute ocular and dermatologic disease in humans and animals with excess ultraviolet-B (UV-B) exposure in the setting of the thinning of the ozone column.

**Methods.** Ophthalmologic and dermatologic records in Punta Arenas were systematically reviewed to enumerate sentinel diagnoses potentially associated with UV-B exposure, ocular examinations on representative animal populations were performed, and the ambient UV-B exposure in the region during the time of maximal thinning was estimated.

**Results.** No increase in patient visits or conditions attributable to UV-B exposure was seen for periods of known ozone depletion compared with control periods. Although ambient UV-B exposure was 1.6 to 2.3 times the habitual exposure on individual days, this excess exposure conferred only a 1% increase in annual exposure on the region.

**Conclusion.** This study does not support existing lay reports of ocular and dermatologic disease in humans and animals that had been associated with the ozone hole over southern Chile. *(Am J Public Health. 1995;85: 546–550)*

**Introduction**

Significant global decreases in total ozone have been documented since 1979, with the greatest depletions found in the Southern Hemisphere in the Antarctic region. The ozone layer is the principal stratospheric barrier to ultraviolet-B (UV-B) radiation (280 to 315 nm) and increases in ground-level UV-B have also occurred since 1979. In the Northern Hemisphere, biologically active UV-B (the annual DNA damage-weighted dose) has increased by approximately 5% per decade at 30°N and about 10% per decade in the polar region. In the Southern Hemisphere, the increase has been still greater, estimated at 5% per decade at 30°S, 15% per decade at 55°S, and 40% per decade at 85°S. In the Antarctic, UV-B exposure has peaked annually in the springtime (from September to November), but until 1991, the excess exposure was essentially limited to the polar region. However, in the Antarctic spring of 1991, the ozone hole enlarged, for the first time exposing large human populations in southern Chile and Argentina to UV-B radiation.

The incremental UV-B exposure that is associated with defects in the ozone layer is widely acknowledged by the scientific community to have potentially wide-ranging consequences. These include effects on human and animal health, on the growth and viability of terrestrial plants and aquatic ecosystems, on the composition of the earth’s atmosphere, and on the integrity of many materials, such as wood and plastic. The principal and best-documented adverse health effects in humans are ocular and dermatologic. The ocular effects of acute UV-B exposure are actinic keratitis (snow blindness) and possible reactivation of herpes simplex keratoconjunctivitis. The chronic ocular effects of exposure include cataract, pterygium, pinguecula, and climatic droplet keratopathy. The acute dermatologic events are principally sunburn and exacerbation of photosensitivity disorders, whereas chronic exposure has been closely linked to nonmelanoma skin cancer. UV-B has long been known to have immunosuppressive effects in laboratory models, and evidence for such an effect in man has recently increased.

At the same time that the ozone hole expanded over the southern reaches of South America, the lay literature reported a wave of potentially related adverse health effects. Most of these reports emanated from Punta Arenas, Chile (population 110,000, latitude 53°S), and Sheila West are with the Dana Center for Preventive Ophthalmology, Wilmer Eye Institute, and James Nethercott is with the Department of Environmental Health Science at The Johns Hopkins University, Baltimore, Md. Donald D. Duncan is with the Applied Physics Laboratory at The Johns Hopkins University in Laurel, Md. Cesar Vicencio and Juan Honeyman are with the University of Chile, Santiago. Kirk N. Gelatt is with the Department of Small Animal Clinical Sciences, University of Florida, Gainesville. Hillel S. Koren is with the US Environmental Protection Agency, Health Effects Research Laboratory, Research Triangle Park, NC.

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Methods

Human UV-B Related Disease

The unconfirmed reports of adverse health effects all concerned either dermatologic or ophthalmologic ailments. It was reasoned that the presence of acute severe disease related to the ozone hole would be reflected at the appropriate times in the records of the region’s medical practitioners. There are three ophthalmologists and one dermatologist practicing in Punta Arenas. Thus, all of their available outpatient medical records (9301) were systematically reviewed, with time periods chosen to coincide with periods of known ozone depletion (October 1991 and 1992) as well as with control periods from other months and earlier years. The records were reviewed by trained medical record reviewers or the physicians themselves. All records that met case definitions for the sentinel diagnoses were then concurrently verified by at least two physician investigators.

The appendix lists the sentinel diagnoses chosen to reflect possible acute UV-B effects. For the ophthalmic conditions, actinic keratitis was chosen because of a possible effect from acute direct exposure, herpetic simplex keratitis because of the acknowledged relationship between acute sunlight exposure and recurrence, Herpes zoster ophthalmicus as a crude indicator of cellular immune status as reflected by ocular disease, and acute conjunctivitis to yield a general index of the frequency of acute ocular infection. For the dermatologic manifestations, sunburn and the various photodermatoses were chosen to reflect acute UV-B exposure. Clinical manifestations of herpes simplex or zoster were also enumerated. Verrucae and mycoses were included to reflect potential effects on cellular immune status as reflected by skin disease.

Assessment of Adverse Ocular Health Effects in Animals

Various animal populations, including sheep, cattle, alpaca, and hares, were examined by an experienced veterinary ophthalmologist (Dr Gelatt) using a standardized examination protocol that included slit-lamp biomicroscopy and direct and indirect examination of the ocular fundi. The animals examined were not chosen on the basis of known diseases but as samples from farms on the basis of their proximity.

Assessment of Ambient UV-B Exposure

Data on the 1992 exposure were obtained from two instruments currently located in Punta Arenas: a Brewer MK4 spectroradiometer and a solar light 501 UV-biometer. Because long-term historical UV-B data for the region are lacking, estimates of annual UV-B exposure were made using locally available data on cloud coverage and the Green model for estimating UV-B irradiance.

Results

Human Effects

In all, 7228 ophthalmic charts were reviewed. This review revealed seven cases of actinic keratitis, five of which clearly occurred in the context of arc welding. A sixth case occurred in October 1989 in an indoor worker who is believed to have been using a UV tanning device. The remaining case, examined on October 17, 1991, after 1 week’s symptoms, was atypical in presentation and course for actinic keratitis. Additionally, 14 cases of herpes simplex keratitis were found, 6 of
which occurred in October 1991; however, no cases were recorded in October 1992. Herpes zoster was very rare overall, and no seasonal or annual variation was seen for the diagnosis of conjunctivitis. Table 1 compares the frequency of sentinel ocular diagnoses in periods of known ozone column depletion (October and November 1991; October 1992) with that in control periods (August, October, November 1989; August 1991; August 1992). No significant differences were found.

A total of 2073 dermatologic charts were reviewed. The time periods were not identical to those of the ophthalmologists because of the travel schedule of the sole dermatologist. Table 2 illustrates the comparative frequency of the sentinel dermatologic diagnoses in months with and without increased irradiance. No differences were seen, except that patients presented with verrucae more commonly in months with increased irradiance.

Animal Effects

Since the majority of lay reports involved blinding disease in sheep, we concentrated on this species, evaluating 224 sheep from five separate ranches. Table 3 summarizes our clinical findings. Mild keratoconjunctivitis, consistent with *Chlamydia psittaci* infection, was indicated in 69% of the total sample, as evidenced by signs of conjunctivitis and mild corneal neovascularization. No corneal scarring consistent with blindness was seen. Cataract of any degree was found in 13.4%; however, bilateral blinding cataract or other blinding disease was not found.

Thirty Hereford cattle were also examined. Of these, 10% had some evidence of cataract, none of which was dense, and 17% had conjunctival tumors clinically consistent with squamous cell carcinoma. An entire herd of 29 alpacas was examined; 23% had some degree of cataract, none dense. And of the eight hares and nine cottontail rabbits that were examined 225 km north of Punta Arenas (despite the lay reports, rabbits are quite rare in the Punta Arenas region), one had unilateral cataract.

**Estimation of Ambient UV-B Exposure**

Figure 1 shows data obtained from August to November 1992 using a Brewer MK4 spectroradiometer located in Punta Arenas. This figure, which shows both the depth of the ozone column and the ambient UV exposure, clearly indicates the presence of the ozone hole on September 23 and 24 and October 4 to 6. October 5 was heavily overcast, so the UV exposure is revealed by a pair of spikes—one associated with October 4 and one with October 6. For these days, the average ozone column was respectively 187, 185, and 192 Dobson units. For September 23 and 24, when the other relative minimum ozone column appears,
the average ozone columns were estimated at 236 and 220 Dobson units, respectively.

For the month of September 1992, the average UV-B dose was 4.92 minimal erythemal doses (MEDs) per day (one MED is defined as 21 mJ/cm² effective integrated energy density using the erythemal action spectrum). This excludes those days on which the ozone hole was present. During the peak occurrence of the ozone hole, the average daily dose was 11.5 MEDs, 2.3 times higher than normal. In October 1992, the average UV-B dose was 9.6 MEDs per day, again excluding those two days of greatest ozone depletion, for which the average dose was 15.5 MEDs per day, or 1.6 times the average. Examined on a monthly basis, the excess UV-B associated with the ozone hole conferred on the region a 9% excess ambient exposure for September 1992 and a 4% excess exposure for October 1992. Customary annual ambient UV-B exposure in the region, using local atmospheric data and the Green model, is estimated at 2190 MEDs. From the perspective of cumulative annual exposure, the ozone hole in 1992 conferred on the region an approximately 1.1% increase in annual ambient UV-B exposure.

**Discussion**

The recent expansion of the geographic area covered by the ozone hole over Antarctica has been accompanied by numerous lay reports of UV radiation-related disease in humans and animals in the region. However, our pilot project provides no convincing evidence to support the reported acute adverse health effects.

No increase in adverse ocular health effects known to be related to acute UV exposure was witnessed by the ophthalmologists practicing in Punta Arenas. More visits to the dermatologist for verrucae were found during time periods associated with increased irradiance, but since no accompanying increase for sunburn, photodermatoses, or other sentinel diagnoses was documented, these visits were probably not related to increased UV irradiation. Moreover, while verrucae may be linked with a decline in cell-mediated immunity, they are usually associated with wet work and are quite common, occurring in 5% to 10% of all persons. They also often involute and recur. The 4% to 11% frequency of visits for verrucae in a dermatologic patient population is, therefore, not striking.

The lack of unusual findings in the systematic chart review was further supported by direct ophthalmologic and dermatologic examinations of small sample populations of fishermen, shepherds, and hospital workers (data not shown). The former two populations were selected because of their outdoor occupational exposure, and the third was selected as a control group. No significant differences in ocular or dermatologic findings were present by occupation. Tinea infections were noted in more than 50% of all subjects examined but were most common in the hospital workers, the group least exposed to UV radiation.

The animal investigations were also not supportive of the lay reports. Although external ocular disease consistent with *C. psittaci* was found in 69% of the sheep evaluated, the findings were not consistent with blindness, nor is this infectious agent known to be associated with UV exposure. The frequency of nonblinding cataract among sheep ranged from 3% to 24% at the five ranches. Unfortunately, comparison data do not exist from elsewhere in Chile or from other countries to put these findings into perspective. However, no bilateral blinding cataract was found. Our examination occurred soon after the ozone hole appeared, so it is unlikely that animal loss due to death or injury from blindness could explain our findings. The acute effects of UV-B exposure in cattle have been documented in experimental studies of infectious keratoconjunctivitis caused by *Mycobacterium bovis*, an infection not seen in the cattle examined in Chile. UV exposure has been linked to squamous cell carcinoma in Hereford cattle in the United States. In the sample of Hereford cattle examined in Chile, the prevalence of presumed squamous cell carcinoma was high (5 of 30 animals). However, a larger sample would need to be examined before this rate could be considered reliable.

The lack of observed adverse health effects is consistent with our estimation of an excess annual UV-B exposure in the region of 1%. It is also important to assess the absolute level of exposure in the region. Using historical cloud cover data from Punta Arenas, ozone column density measurements from a Brewer MK4 spectroradiometer located in Punta Arenas, and the Green model for estimating UV-B irradiance, we estimated an annual exposure in Punta Arenas of approximately 2190 MEDs. This may be compared with the approximately 2500 MEDs estimated for Maryland in 1992. Clearly, the cumulative UV-B exposure in Punta Arenas, even within the context of an ozone hole, is exceeded by that in many temperate climates and is far surpassed by that in tropical locations.

The Ministry of Health in Chile currently advocates a policy of public education and recommends the use of hats, sunglasses, and sunscreen during periods of maximal exposure. This strategy is sound and may now be strengthened by some degree of reassurance concerning the lack of documented recent adverse acute or severe health effects. But despite the negative findings of this study, there is, a priory, a basis for concern regarding long-term health effects and chronic UV exposure. Should the exposure experienced by Punta Arenas and its environs remain constant or decrease in comparison with the exposure of 1992, the likelihood of potential ozone hole-related disease is very low. On the other hand, should the ambient exposure increase over coming years by either its length or its intensity, the probability of UV-related chronic adverse health effects (e.g., cataract, skin cancer) may well increase. Under such an assumption, the initiation of long-term surveillance for UV-related disease in humans and animals would be warranted either in Punta Arenas or in still more exposed parts of the world.

**Acknowledgments**

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**References**

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**APPENDIX—Sentinel Diagnoses for Acute Ultraviolet-B Exposure**

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<th>A. Ophthalmic</th>
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<tr>
<td>1. Actinic keratitis</td>
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<tr>
<td>1. Sunburn</td>
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<td>2. Herpes simplex</td>
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<td>3. Herpes zoster Photodermatoses:</td>
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