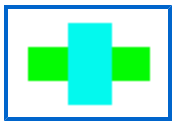

CIESIN Thematic Guides

Overview of Health Effects from Increased Ultraviolet-B Exposure due to Ozone Depletion

Small quantities of ultraviolet-B radiation (UV-B) are essential to human health, acting as a catalyst in the generation of vitamin D. Large amounts of UV-B, however, are harmful to a wide range of biological systems. The extent of DNA damage depends upon the level and duration of exposure as well as the susceptibility and resilience of the exposed organism. The key human health effects from exposure to UV-B include skin cancer, cataracts, and immunosuppression. In addition, other dermatological effects include severe photo-allergies and accelerated aging of the skin. Although cataracts and cataract-related blindness are related to cumulative exposure to UV-B, acute exposures may cause photokeratitis or "snow-blindness." Damage to the skin by UV-B reduces its immunological defenses, impeding resistance to infectious diseases as well as to skin tumors, and diminishing the effectiveness of vaccines. The strongest evidence of a causal relationship between UV-B exposure and human health effects is for nonmelanoma skin cancer. Research is still needed to confirm the dose-response relationships for other ailments. As the 1989 United Nations Environment Programme (UNEP) Environmental Effects Panel Report points out, the amount of quantitative research that exists for a health effect is not necessarily a reflection of its relative importance. Health effects for which only qualitative data are currently available may have a tremendous impact on human populations.

Several governmental and nongovernmental organizations focused on global environmental change have convened panels and workshops, and solicited papers to study the effects of stratospheric ozone depletion. Concern over the resulting health effects for human populations has grown over the past two decades. The chapter "Biological and Medical Effects of Nitrogen Oxide Emissions" of the 1975 National Research Council report *Environmental Impact of Stratospheric Flight* cites the hazards of ultraviolet radiation exposure for living organisms and evidence of cancer for human populations. The 1979 National Research Council report *Protection against Depletion of Stratospheric Ozone by Chlorofluorocarbons* devotes the chapter "Human Health Effects" to this issue. Focusing again on skin cancer, the report presents epidemiological evidence that ultraviolet light is responsible for the development of nonmelanoma skin cancer and associated with malignant melanoma. The authors also describe the role of demographic variables, such as skin color, age, latitudinal location, and occupational and recreational activities.

The proceedings of the International Conference on Health and Environmental Effects of Ozone Modification and Climate Change, sponsored by the Environmental Protection Agency (EPA) and UNEP, were summarized in the 1986 report *Effects of Changes in Stratospheric Ozone and Global Climate*. The report includes more than a dozen papers covering a wide-range of health effects in the section "Human Health" (Titus 1986). Included here are the following contributions: Armstrong's "Sunlight and Malignant Melanoma in Western Australia"; De Fabo's and Noonan's "Urocanic Acid: On its Role in the Regulation of UVB-Induced Systemic Immune Suppression"; Fisher et al.'s "Sunscreens Do Not Abrogate UV-Induced Suppression of Contact Hypersensitivity"; Giannini's "Effects of UV-B on Infectious Diseases"; Ilyas' "Ozone Modification: Importance for Developing Countries in the Tropical/Equatorial Region"; Kollias' and Baqers' "The Role of Native Pigment in Providing Protection against UV-B Damage in Humans"; and Scotto's "Nonmelanoma Skin Cancer--UV-B Effects."

The 1988 International Conference on the Health and Environmental Consequences of Stratospheric Ozone Depletion was sponsored primarily by the European Commission along with a number of advocacy groups. The conference proceedings include Jones' (1989) overview paper, "Consequences for Human Health of Stratospheric Ozone Depletion," which concentrates on direct health effects such as skin cancer and cataracts. The figure "Mechanisms by which CFCs and Other Trace Gases Might Exert Effects on Human Health" illustrates that several aspects of global environmental change may interact to intensify negative health effects.

In the chapter "Human Health" of the 1989 UNEP *Environmental Effects Panel Report*, van der Leun, Takizawa, and Longstreth summarize what is known about the effects of UV-B exposure and damage to the eye, skin, and immune response. Longstreth et al. (1991) also contribute to the chapter "Human Health" of UNEP's report *Environmental Effects of Ozone Depletion*. They comment that scientific research over the intervening two years seems to confirm what was presented in the earlier report with only a few additions. These additions include the identification of three more forms of ocular damage: age-related near-sightedness, anterior lens-capsule damage, and nuclear cataract. The update provides additional information to support the view that UV-B radiation increases the incidence and/or severity of certain infectious diseases, regardless of an individual's skin color.

The 1992 proceedings of a workshop supported by the Scientific Committee on Problems of the Environment (SCOPE) and UNEP contain the summary "Effects of UV-B on Animal and Human Health," which offers up-to-date information on skin cancer, ocular damage, and immunosuppression with consequences for infectious diseases and vaccination. The U.S. Department of Energy 1993 report *UV-B Critical Issues Workshop* also provides a listing of efforts to address the observed and potential hazards associated with increased exposure to UV-B in "Prior Workshops and Conferences."

Several other good papers review the known and anticipated health effects from UV-B exposure due to ozone depletion. Both Leaf (1989) in "Potential Health Effects of Global Climatic and Environmental Changes" and Last (1993) in "Global Change: Ozone Depletion, Greenhouse Warming, and Public Health" consider increased ultraviolet radiation due to stratospheric ozone depletion one of the key global environmental changes that will have serious consequences for human health. In "Effects of Ozone Depletion on Human Health," his contribution to the 1991 book *Ozone Depletion: Implications for the Tropics*, van der Leun surveys those health effects for which increased UV-B radiation may create a significant threat. Van der Leun contends that more funds are needed for research on this critical issue. Although the problems are complex, scientific tools exist to undertake the studies necessary to predict future health effects.

Leaf (1993) provides an interesting description of the depletion of the ozone layer and associated health effects in "Loss of Stratospheric Ozone and Health Effects of Increased Ultraviolet Radiation." Bentham's 1993 paper "Depletion of the Ozone Layer: Consequences for Non-infectious Human Diseases," reviews the quality of the research on the health effects of UV-B. Bentham concurs that there is now strong evidence linking UV-B exposures to cutaneous malignant melanoma, as well as to nonmelanoma skin cancer. The research covering ocular damage, particularly cataracts, is more controversial. Bentham also mentions the growing concern that immunosuppression from UV-B radiation may exacerbate infectious diseases. His paper focuses primarily on key uncertainties that must be considered before any of these health effects can be properly addressed: changes in the stratospheric ozone layer, future levels of UV-B radiation in populated areas, changes in biologically significant doses to humans given both environmental and behavioral changes, and limitations of existing epidemiological knowledge of exposure to UV-B.

One of the more detailed reviews of the health implications from increases in UV-B radiation is Diffey's 1991 paper "Solar Ultraviolet Radiation Effects on Biological Systems." The section on the effects of

solar ultraviolet radiation (UVR) on humans discusses different environmental, demographic, and socioeconomic factors influencing the occurrence and severity of several health effects: sunburn, tanning, photo-aging, non-melanoma skin cancer, malignant melanoma, and eye damage. Table 7 of the paper provides a chart of sun-reactive skin types.

Finally, van der Leun and de Gruijl examine the complicated chain of events between exposure to increased UV-B irradiance and the occurrence of anticipated health effects in the chapter "Influences of Ozone Depletion on Human and Animal Health" of the 1993 book *UV-B Radiation and Ozone Depletion*. The authors explain their basis for predicting whether the incidence or severity of specific health effects will significantly increase, not change appreciably, or possibly even diminish.