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Potential Health Effects of Climatic Change: Effects of Increased Ultraviolet Radiation on Man

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There is scientific evidence that stratospheric ozone concentration has declined over the Northern Hemisphere in the past 20 years, and projections based on various assumptions about future release of chlorofluorocarbon gases and other contaminants suggest that this decline will continue into the next century. The effects on human health secondary to increase in biologically effective ultraviolet radiation are expected to consist of increases in nonmelanoma skin cancer and malignant melanoma of the skin, possible alteration of immune response, and development of lens cataracts. The recent and projected increases in skin cancer and changes in human immune responses are discussed.

Introduction

Current scientific evidence indicates the existence of a significant decline of stratospheric ozone between latitudes 40° N and 52° N has been more than 5% in the winter and spring months, less than 2% in summer, and not significant in fall. Observations in the equatorial zone and Southern Hemisphere (except Antarctica) are too sparse to be evaluated at this time (*1*).

Although the ozone decrease has been small, but significant, the increase in biologically effective ultraviolet radiation (UVR) (UV-B) to date has been minimal. This is due to the seasonal distribution of ozone reduction. The major effects are in the winter months, when because of low sun angle (and therefore a path length through several thicknesses of atmosphere), UV-B radiation is normally low. Thus the increase in UVR at the earth's surface over ambient levels are quantitatively very small (*2-4*). Estimates have been made that for a 1% decrease in stratospheric ozone, the biologically effective ultraviolet radiation could increase by 1.5 to 3.0% (*2,5*). Actual measurements of biologically effective UVR in the past 15 years have not shown any ground level increases (*4,6*).

The changing ozone column has three different kinds of effects: one biological, due to increase in biologically effective ultraviolet radiation, one chemical, and one related to climate change. The chlorofluorocarbon gases that are implicated in the ozone layer depletion are also "greenhouse" gases that currently contribute 10 to 15% of the global warming calculated by models (*6*).

The health effects, largely secondary to increases in biologically effective UVR, are expected to consist of increases in nonmelanoma skin cancer (NMSC) and malignant melanoma skin cancer (MM); possible alterations to immune responses; and effects on eye disease (primarily cataracts).

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Increases in Skin Cancer

Among the best-documented human health effects are increases in skin cancer. The most definitive evidence exists for NMSC being linked to chronic, repeated exposure to mid-range UVR (UV-B: 290-320 nm) and therefore being likely to increase due to ozone depletion. Individuals differ greatly in susceptibility, primarily for genetic reasons, but the major determinant of the occurrence of skin cancer is the quantity and quality of exposure to sunlight. Populations with great constitutive pigmentation and those capable of pigmenting easily on exposure to UVR are minimally affected. Thus, increases in NMSC incidence are likely to affect primarily the 20% of the world's popultion with light-colored skin (*7-9*).

Because ozone begins to absorb UVR significantly below 325 nm, the segment of the solar UVR spectrum that will be augmented in the anticipated diminution of atmospheric ozone concentration is the small waveband between 290 and 325 nm. For most biologically active spectra, this will result in disproportionate increases in biologically effective UV irradiance (*10,11*).

The increase in NMSC incidence that has taken place in the past two decades is not likely to be due to ozone decrease, given the long latency (2-3 decades) associated with the UVR effects on skin. However, knowledge of the action spectra for NMSC development and projections for the quantity and quality of UVR changes that can be expected in the future allow for reasonable estimates of effects. For a 1% depletion in stratospheric ozone, NMSC may be expected to increase, at equilibrium, by about 3% (*2,9*).

Depending on the scenario chosen and on the model used for calculation of effects on stratospheric ozone, NMSC could increase between 12 and 36% after the year 2050. However, these increases may be much larger in the Southern Hemisphere at high latitudes, where observed total ozone depletions have been larger, and tropospheric ozone may have declined outside of industrialized areas (*3,12*).

The evidence for the role of UVR exposure for development of MM is less certain. There is considerable evidence that sunlight exposure plays a role, but the mechanism is certainly different from that operating in NMSC. Although it is much more difficult to estimate numerical effects, epidemiological studies in the United States suggest that for a 1% reduction in ozone, MM might increase by 0.6% (*11,13,14*).

Possible Alteration in Immune Responses

In recent years, evidence has accumulated in animal model studies that exposure to high does of UV-B radiation produces selective alterations in immune function, which are mainly evidenced in the form of suppression of normal delayed-type cutaneous immune responses. In animals, this immune suppression is important for the development of nonmelanoma skin cancer, may influence the development and course of infectious deseases, and may possibly protect against autoimmune reaction (*6–8*).

The evidence that UVR-induced immune suppression occurs in humans is less compelling and incomplete. The wavelengths of UVR most affected by possible depletion of the stratospheric ozone layer are those known to be most immunosuppressive in animals, and it is possible that such depletion may increase any existing effect of sunlight on immunity in humans (*17*).

Studies are required to establish whether or not UV-B radiation can cause suppression of immune function in humans, determine whether melanin pigmentation can provide protection against such suppression, determine the role of such suppression in the pathogenesis of human skin cancer, affect the development of infectious diseases and vaccine effectiveness, and affect the capacity for human skin to develop protective mechanisms that can limit such damage (*16,18*).

Adaptation of Man to Increased UVR

Under normal conditions, human skin adapts to chronic UVR exposure by thickening of the horny layer and pigmentation. These phenomena can significantly decrease acute and chronic UVR effects, but the degree of possible adaptation is greatly influenced by genetic background. However, in addition to physiologic adaptation, alteration in behavior by avoiding midday exposure and use of more extensive clothing, hats, and eyeglasses will provide significant protection. Furthermore, modern chemical sunscreens have become very effective, if used properly.

It seems reasonable that, by mostly minor modifications of behavior of populations, which are neither energy intensive nor expensive, the risks of increasing UVR for man can be mitigated.

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