8 Stratospheric ozone depletion, ultraviolet radiation and health

Strictly, stratospheric ozone depletion is not part of "global climate change", which occurs in the troposphere. There are, however, several recently-described interactions between ozone depletion and greenhouse gas-induced warming.

Scientists 100 years ago would have been incredulous at the idea that, by the late twentieth century, humankind would be affecting the stratosphere. Yet, remarkably, human-induced depletion of stratospheric ozone has recently begun – after 8,000 generations of *Homo sapiens*.

Stratospheric ozone absorbs much of the incoming solar ultraviolet radiation (UVR), especially the biologically more damaging, shorter-wavelength, UVR. We now know that various industrial halogenated chemicals such as the chlorofluorocarbons (CFCs – used in refrigeration, insulation and spray-can propellants) and methyl bromide, while inert at ambient Earth-surface temperatures, react with ozone in the extremely cold polar stratosphere. This destruction of ozone occurs especially in late winter and early spring.

During the 1980s and 1990s at northern mid-latitudes (such as Europe), the average year-round ozone concentration declined by around 4% per decade: over the southern regions of Australia, New Zealand, Argentina and South Africa, the figure approximated 6-7%. Estimating the resultant changes in actual ground-level ultraviolet radiation remains technically complex. However, exposures at northern mid-latitudes, for example, are likely to peak around 2020, with an estimated 10% increase in effective ultraviolet radiation relative to 1980s levels.[1]

In the mid-1980s, governments recognised the emerging hazard from ozone depletion. The Montreal Protocol of 1987 was adopted, widely ratified, and the phasing out of major ozone-destroying gases began. The protocol was tightened in the 1990s. Scientists anticipate a slow but near-complete recovery of stratospheric ozone by the middle of the twenty-first century.

Main types of health impacts

The range of certain or possible health impacts of stratospheric ozone depletion are listed in Table 8.1, with a summary evaluation of the evidence implicating UVR in their causation.

Many epidemiological studies have implicated solar radiation as a cause of skin cancer (melanoma and other types) in fair-skinned humans.[2] Recent assessments by the United Nations Environment Program project increases in skin cancer incidence and sunburn severity due to stratospheric ozone depletion[1] for at least the first half of the twenty-first century (and subject to changes in individual behaviours).

The groups most vulnerable to skin cancer are white Caucasians, especially those of Celtic descent living in areas of high ambient UVR. Further, culturally-based behavioural changes have led to much higher UV exposure, through sun-bathing and skin-tanning. The marked increase in skin cancers in western populations over recent decades reflects, predominantly, the combination of background, post-migration, geographical vulnerability and modern behaviours.

Table 8.1 Summary of possible effects of solar ultraviolet radiation on human health

Effects on skin

- Malignant melanoma
- Non-melanocytic skin cancer – basal cell carcinoma, squamous cell carcinoma
- Sunburn
- Chronic sun damage
- Photodermatoses

Effects on the eye

- Acute photokeratitis and photoconjunctivitis
- Climatic droplet keratopathy
- Pterygium
- Cancer of the cornea and conjunctiva
- Lens opacity (cataract) – cortical, posterior subcapsular
- Uveal melanoma
- Acute solar retinopathy
- Macular degeneration

Effect on immunity and infection

- Suppression of cell mediated immunity
- Increased susceptibility to infection
- Impairment of prophylactic immunization
- Activation of latent virus infection

Other effects

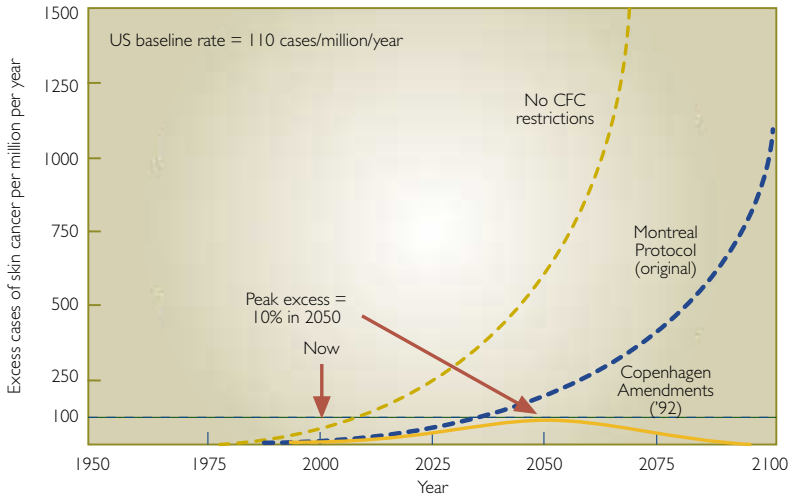
- Cutaneous vitamin D production
  - prevention of rickets, osteomalacia and osteoporosis
  - possible benefit for hypertension, ischaemic heart disease and tuberculosis
  - possible decreased risk for schizophrenia, breast cancer, prostate cancer
  - possible prevention of Type 1 diabetes
- Altered general well-being
  - sleep/wake cycles
  - seasonal affective disorder
  - mood

Indirect effects

- Effects on climate, food supply, infectious disease vectors, air pollution, etc

Scientists expect the combined effect of recent stratospheric ozone depletion and its continuation over the next 1-2 decades to be (via the cumulation of additional UVB exposure), an increase in skin cancer incidence in fair-skinned

Figure 8.1. Estimates of ozone depletion and skin cancer incidence to examine the Montreal Protocol achievements. (Source: Adapted from reference 6)



populations living at mid to high latitudes.[3] The modelling of future ozone levels and UVR exposures study has estimated that, in consequence, a 'European' population living at around 45 degrees North will experience, by 2050, an approximate 5% excess of total skin cancer incidence (assuming, conservatively, no change in age distribution). The equivalent estimation for the US population is for a 10% increase in skin cancer incidence by around 2050.

Laboratory studies demonstrate that exposure to UVR, in particular to UVB, in various mammalian species induces lens opacification. The epidemiological evidence for a role of UVR in human lens opacities is mixed. Cataracts are more common in some (but not all) countries with high UVR levels.

In humans and experimental animals, UVR exposure, including within the ambient environmental range, causes both localised and whole-body immunosuppression.[4] UVR-induced immunosuppression could influence patterns of infectious disease. It may also influence the occurrence and progression of various autoimmune diseases and less certainly, vaccin efficacy.[5]

Finally, there is a wider, ecological, dimension to consider. Ultraviolet radiation impairs the molecular chemistry of photosynthesis both on land (terrestrial plants) and at sea (phytoplankton). This could affect world food production, at least marginally, and thus contribute to nutritional and health problems in food-insecure populations. However, as yet there is little information about this less direct impact pathway.

Conclusion

Encouraging total sun avoidance (with the related notion of solar radiation as a "toxic" exposure) is a simplistic response to the hazards of increased ground-level UVR exposure due to stratospheric ozone depletion, and should be avoided. Any public health messages concerned with personal UVR exposure should consider the benefits as well as the adverse effects. Nevertheless, we must be alert to the potential increase in some particular risks to health posed by stratospheric ozone depletion.