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ABSTRACT

As a result of the decline in the thickness of the atmospheric ozone layer, the surface of the Earth will be exposed to increased levels of solar ultraviolet B radiation. This radiation has been shown to have harmful effects for life on Earth. These include damage to plants, animals, and materials. It has also been linked to many human health impacts such as sunburn, skin cancer, eye damage, and suppression of the body's immune system. In order to protect children from the negative health effects of ultraviolet B radiation, schools must embark on a SUNSafe education program which includes: SUNSafe education including nutritional education on boosting immune function, clothing recommendations, planning and staging of school events, and facilities design. Actions which should be taken include: teaching students about the hazards of excessive exposure to the sun, planning school activities around the peak sun hours, requiring proper protective clothing when outdoors, providing shading around playgrounds and sports fields, providing temporary shading for sports tournament venues, and protecting a child's right to seek protection from the sun. (Author)

THE SKIES ABOVE
FOUNDATION

Guide for *SUNSafe* Schools

By

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SUMMARY

As a result of the decline in the thickness of the atmospheric ozone layer, the surface of the Earth will be exposed to increased levels of solar ultraviolet B radiation. This radiation has been shown to have harmful effects for life on Earth. These include damage to plants, animals and materials. It has also been linked to many human health impacts such as sunburn, skin cancer, eye damage and suppression of the body's immune system.

In order to protect our children from the negative health effects of ultraviolet B radiation, schools must embark on a ***SUNSafe*** education program which includes:

- *SUNSafe* education including nutritional education on boosting immune function,
- Clothing recommendations,
- Planning and staging of school events and
- Facilities design.

Actions which should be taken include:

- Teaching students about the hazards of excessive exposure to the sun.
- Planning school activities around the peak sun hours of 10 a.m. to 3 p.m. (LST).
- Requiring proper protective clothing when outdoors (wide-brimmed hat, long sleeved shirt, long pants/skirt, eyewear).
- Providing shading around playgrounds and sports fields.
- Providing temporary shading for sports tournament venues.
- Protect a child's right to seek protection from the sun.

A GUIDE FOR *SUNSafe* SCHOOLS

INTRODUCTION

The Ozone Layer

Between 18 km and 37 km above the Earth in a region of the atmosphere known as the stratosphere, we find high concentrations of **ozone**, a gas composed of three oxygen atoms. Approximately 90% of all naturally occurring ozone can be found in this **ozone layer**. Ozone is formed by highly energetic solar rays striking molecules of oxygen (two oxygen atoms) and splitting them apart. When one of the free oxygen atoms collides with an oxygen molecule, it is captured and ozone is formed. The ozone molecule is much less stable than a normal oxygen molecule and is naturally broken down by sunlight or various chemical reactions. In an unpolluted atmosphere, there is a balance between ozone production and ozone destruction. As a result, the total ozone concentration in the ozone layer remains relatively constant, varying slowly with the seasons. Thinly spread across a deep layer in the atmosphere, the ozone molecules if concentrated at sea-level pressure would form a layer only 3 mm thick.

When the natural balance of ozone production and destruction is tipped in favour of destruction, the ozone layer may become depleted. Although several natural phenomena may cause temporary loses of ozone, synthetic chemicals containing chlorine, bromine and fluorine are now known to be the main cause of an ongoing **ozone depletion**. The most infamous of the **ozone depleting substances** (ODS) are the class of chemicals known as the chlorofluorocarbons or CFCs. The CFCs are especially destructive because their very stable nature allows them to remain in the atmosphere for many decades and reach the ozone layer intact. Each chlorine atom reaching the ozone layer can destroy 100,000 ozone molecules before it is finally purged from the stratosphere.

The depletion of the ozone layer has been observed since the late 1970s. The first evidence of major ozone depletion was announced in 1985 when British scientists discovered a "hole" above the Antarctic continent. The **Antarctic Ozone Hole** has reoccurred each spring and has continued to become deeper and larger. In October of 1993, the Hole reached 23 million square kilometres in extent (an area larger than the North American continent) with minimum ozone thickness less than one quarter of that measured in the early 1970s. Ozone depletion has not been limited to the Antarctic region. Except for the equatorial latitudes, there has been a fairly steady decline in ozone layer thickness across much of the globe. Between 1979 and 1991, global stratospheric ozone has decreased by about 3%. Over Canada in 1993, the average decrease in ozone layer thickness was 10 to 15% below pre-depletion "normal" levels. In the Spring of 1993, the ozone layer over Toronto and Edmonton thinned to 25% below normal.

Ozone and Ultraviolet Radiation

Why should we be concerned over the decrease in the ozone layer? One of the important properties of the ozone molecule is that it absorbs radiation known as **ultraviolet radiation** (UVR), a portion of the sun's radiant energy falling on the Earth. Ultraviolet radiation, especially that portion of the radiation known as UV-B, has harmful effects for life on Earth. In fact, life as we know it was not able to move from the ocean depths into shallow waters or onto land until a protective ozone layer formed over the planet. Prior to the establishment of the ozone layer, simple cellular organisms could only exist in deep waters where UVR could not penetrate.

Ultraviolet radiation is radiation with wavelengths shorter than visible light and longer than x-rays. UVR is invisible to the human eye and cannot be directly felt. Biologists divide UVR into three categories: UV-A, UV-B and UV-C. Almost all UV-A penetrates the atmosphere and reaches the surface of the Earth. Under normal conditions, most of the UV-B radiation is absorbed by the ozone layer. All of the UV-C is absorbed by the ozone layer and oxygen molecules in the upper atmosphere. UV-C is the most dangerous wavelengths to life, UV-B is slightly less damaging and UV-A is the least damaging with some beneficial properties.

UV-B radiation has been shown to damage plants, animals and materials. It has also been linked to many human health impacts such as sunburn, skin cancer, eye damage and suppression of the body's immune system. The degree of damage is dependent both on the amount of radiation received and the length of exposure. Impacts such as sunburn, some eye injury and immune suppression occur with short exposures. Long-term exposures may result in skin aging, chronic eye damage such as cataracts or tumours, or in skin and other cancers.

Exposure to Solar UV-B Radiation

Human exposure to sunlight and solar UV-B radiation is dependent upon a number of factors. The amount of radiation to which the body is exposed is determined by the product of the strength of the radiation reaching the body and the length of time of the exposure. This is called the dosage. Exposure for short periods to UV-A, for example, produces Vitamin D in the body and tanning, the body's natural defense against sunburn. High dosages of UV-A, however, will produce a sunburn and may be the cause of some cancers many years later.

The strength of the UV-B in the sun's radiation is dependent upon several factors in addition to the thickness of the ozone layer above. These include: latitude, season, time of day, altitude, cloud cover, rain, the nature of the surface and air pollution.

Latitude: The sun's rays impact the equatorial regions of the Earth at nearly a right angle. The greatest intensity of solar UV radiation is therefore found at the equator. At higher latitudes, the angle is smaller and the radiation is spread over a greater area. For example, at 60° latitude, solar radiation falling on the surface is half that at the equator. In addition, the lower sun angle forces the radiation through more of the atmosphere, thus increasing the potential for absorption by ozone.

Season: During the summer months, the sun is higher in the sky and its radiation is strongest. During the winter, the solar rays strike the higher latitudes at a more oblique angle. Thus, the rays must pass through a greater amount of atmosphere in the winter than in the summer which increases the potential for absorption. Such changes are not important in the tropics where the sun is generally overhead all year long.

Time of day: The solar angle changes during the course of a day. Most of the solar radiation reaches the surface around mid-day when the sun is highest in the sky. In the hours immediately after dawn and prior to sunset, the level of radiation is the least.

Altitude: The air is thinner and generally less polluted as one ascends from the Earth's surface. Thus, more UV radiation would be received at a mountain top than at lower elevations.

Cloud Cover: Clouds may either increase or decrease the amount of UV radiation reaching the surface. Thick clouds covering the sky will reduce the amount of UV radiation. A thin overcast may reduce the radiation slightly, but often not to a large degree. Thin, scattered clouds may actually increase the amount of UV radiation reaching the surface by reflecting it downward.

Rain: During most rainfall, UV radiation is decreased. However, large cumulus clouds associated with widely scattered showers may reflect UV radiation toward the surface.

Air Pollution: Air pollution in the form of dust particles may scatter and absorb UV radiation. Pollutant gases such as ozone and sulphur dioxide in the lower atmosphere may also absorb UV radiation.

Surface Character: All natural and artificial surfaces reflect UV radiation to some degree. Snow reflects up to 100% of the radiation falling upon it. Dry sand reflects from 16 to 30% while concrete and asphalt reflects about 10%. Grass, forest and crops reflect less than 10% of the radiation falling on them. Water reflects from 5 to 10% depending upon the angle of incidence and roughness of the surface. Thus a person exposed to UV radiation while over a reflecting surface wil' receive a greater exposure.

Shading: The best protection from the negative impacts of the sun is physical shading. Of course, solid barriers such as buildings can protect against all UV radiation. In some instances, reflection off clouds, the surface, or buildings can allow radiation to reach areas not in direct line with the sun. Materials such as glass and many plastics allow sunlight to pass but not its UV components. Trees provide a varying degree of shading beneath them depending upon the canopy thickness and the angle of the sun.

HEALTH IMPACTS OF ULTRAVIOLET-B RADIATION

For years, North Americans have believed that a deep tan and prolonged exposure to the sun are required elements for good health and appearance. Indeed, we do need some sunlight for the body to produce Vitamin D. Many of us also require high levels of sunlight to fight depression, falling into Seasonal Affect Depression when the solar light diminishes each winter. Exposure to sunlight is also an effective therapy for several skin diseases.

But in the summer of 1993, a fair-skinned individual outdoors in Southern Ontario could have burned with as little as 14 minutes exposure to the sun, a rate normally seen only in tropical latitudes. Something was wrong with the sunlight, deadly wrong. And, there was more to this rain of radiant energy than just sunburn. Now as the sun ascends over the horizon, it shines a little stronger and a little deadlier.

The most well-known impacts on human health from exposure to UV radiation are sunburn and skin cancer. Skin cancer generally ranks first in the minds of most people. Recent research, however, has expanded the list of negative impacts to include eye damage and the suppression of the body's immune system response to both infectious disease and chemical sensitivities.

Sunburn

The exposure of the human skin to sufficient quantities of sun will first produce a reddening of the skin and ultimately a burn. White skin is more prone to burning than black or brown skin. The fair skin of those deriving from Northern European ancestry are the most vulnerable to sun damage of the skin, especially for those receiving their exposure in the tropical latitudes where the radiation is strongest. **Young children are under the greatest risk. Because of their more transparent skin, infants should never be exposed to direct sun.**

Both UVA and UVB cause sunburn. The degree of burn and rate at which burning occurs are directly related to the intensity of solar UV radiation, the time of exposure and the skin type. For example, under solar UV intensities typical of the noon-day sun in the tropics, a fair-skinned person would burn in less than 15 minutes. At latitudes such as along the U.S.-Canada border (49°N), minimum burning times are generally in excess of 17 to 18 minutes for even the fair-skinned. The thinning of the ozone layer over Ontario in 1993, however, reduced burning times to as short as 14 minutes according to Dr. Wayne Evans of Trent University in Peterborough, Ontario.

Sunburn can be simply avoided by reducing exposure to the sun. Avoiding the direct sun does not always provide total health protection however. UV radiation reflected off clouds, snow, buildings, sand, asphalt and water can significantly increase the amount of radiation received. Even moderately overcast skies are not totally safe since UVR may pass through a cloud layer in significant quantity to induce immune suppression. Indeed, UV exposure during cloudy conditions or through reflection from snow and water may be more damaging since the cooler temperatures which often prevail during these conditions give a false sense of security.

Skin Cancers

The relation between exposure to the sun and several forms of skin cancers has been established for many years. UVB radiation, the portion of the UV affected by ozone depletion, is the most carcinogenic portion of the solar spectrum reaching the Earth's surface. Skin cancers have been most commonly found in individuals with outdoor occupations such as fishers and farmers.

There are three types of skin cancers induced by UV radiation: basal cell, squamous cell and melanoma. Basal cell and squamous cell cancers, also called non-melanomas, account for 93% of all skin cancers. They are rarely fatal and easily cured if treated early. Melanoma, while the rarest of the three forms, is the most deadly as it spreads quickly to the blood, lymphatic system and other organs. Research indicates that melanomas may be caused by short, intense exposure to sunburn-inducing sunlight, particularly during childhood. In addition, UV radiation may increase the risk of skin cancers resulting from contact of chemicals with the skin.

Unlike sunburn which quickly occurs with excessive exposure to solar radiation, skin cancers, both melanomas and non-melanomas, only appear after many years. It is now believed that a single acute burn, especially one received during the early years of life, may initiate cancers several decades later. Long-term exposures without severe burning, however, may also result in skin cancers.

Eye Damage

The damage caused by UV radiation to the eyes ranges from acute "sunblindness" to chronic damage such as cataracts, tumours and presbyopia, the inability of the eye to accommodate changes in focal length. Damage known as "sunblindness" or "snowblindness" has been seen in intense exposures to sunlight over fresh snow, sand and water surfaces. In these cases, sight generally recovers within days, apparently without permanent effect. Young children are very susceptible to UV damage.

The principal form of chronic damage linked to UV radiation is cataracts, the development of opacities in the lens of the eye. There are several forms of cataracts that studies have shown are linked to UV exposure. Cataracts are currently the third leading cause of blindness in the United States. Tumours of the eye are also related to long-term exposures to UV radiation, especially in blue-eyed individuals.

Eye damage from UVB radiation may be reduced by wearing sunglasses which absorb UV radiation. The glasses must be highly UVB absorbent, however, to be effective. Sunglasses which do not absorb UVB radiation, or do so poorly, may be more detrimental than not wearing sunglasses at all. The iris of the eye opens more fully when wearing sunglasses to account for the weaker light intensity allowed through the glasses (i.e., darker conditions). This allows more UVB to enter the eye, however, if the radiation is not absorbed by the lens. Without sunglasses, the iris closes in response to the increased light intensity, reducing all wavelengths of light entering the eye including the UVB.

Prescription eyeglasses may be treated with a absorbent coating to reduce the penetration of UVB rays. Most eye care practitioners will test the glasses absorptive ability for free. Coating of plastic lenses with UVB absorbent is generally an inexpensive procedure.

Immune System Suppression

The impact of UVB on human disease appears to work on at least three levels. One is the increase in activity of viruses, the second is the decrease in the immune system's response to viral and bacterial infection, and the third is the decrease in tolerance to chemical exposure. Exposure to UVB increased the activity of viruses such as herpes and HIV. At present, no evidence indicates that this will result in an increase in the spread of the disease. Exposure to UVB may greatly stimulate the activity of the virus which might otherwise remain latent in infected individuals. Such elevated activity could also increase the rate of disease progression and its severity.

Exposure to even low levels of UVB radiation has been shown to suppress half of the human immune system known as the cell-mediated immune system for as long as two weeks. The function of the cell-mediated immune system is to act as the skin's defense against infectious agents such as bacteria, viruses and chemicals. The work of Dr. Ed DeFabo, Dr. Francis Noonan and colleagues at George Washington University has indicated that relatively low levels of sunlight activated immune suppression. Unlike sunburn and skin cancers, human immunity suppression has been shown to be independent of skin colour.

The minimum UVB exposure needed to suppress the immune system may be less than that required to burn or tan. Researchers at the University of Michigan led by Dr. K.D. Cooper have found immune suppression resulting from an exposure less than 10% of that received in producing a mild, weekend sunburn. Even brief midday summer or high altitude exposures may easily exceed this dosage.

Since UVB is know to damage or alter DNA, we must also seriously consider that increased UVB may promote the development of new strains of existing viruses and bacteria injurious to humans or produce new disease organisms. Recent mysterious diseases and new, more virulent, strains of old diseases such as cholera, bubonic plague and tuberculosis add fuel to this hypothesis although no studies specifically linking UVB radiation to these diseases have been located.

The good news is that research is showing that many foods such as garlic and shitake and reishi mushrooms contain compounds which boost the body's immune system. Use of these foods and a diet rich in antioxidants, such as Vitamins A, C and E and the mineral selenium, may convey a degree of protection from excessive exposure to UVB radiation as well as improve the immune system's ability to fight infection and disease. Schools should focus attention on how students can boost their immune systems.

A *SUNSAFE* UV-B EXPOSURE PREVENTION STRATEGY

A *SUNSafe* Program for Schools to prevent excessive exposure to harmful ultraviolet radiation should encompass several topics including:

- *SUNSafe* education including nutritional education on boosting immune function,
- Clothing recommendations,
- Planning and staging of school events and
- Facilities design.

A *SUNSafe* Education Program

A *SUNSafe* education program must reach several audiences. First, it must reach administrators and teachers who will be responsible for the delivery of the program and who must push for changes in programs and facilities. The second level is the students who must understand why we must make these changes. It is especially important to the adolescent ages who must be convinced that over exposure to the sun is no longer safe. This task may be even more difficult than anti-smoking and anti-drinking campaigns where the harm is more readily apparent. The third level of the program is the parents. Without parental support in reducing exposure away from the schools, the best programs will be sadly compromised.

Nations such as Australia and New Zealand where the impacts of UV radiation on health have been well recognized have established effective public education programs aimed at youth. Among these are the "Slip, Slap, Slop" campaigns complete with rap videos and young actors. These multimedia presentations urge youth to "Slip on a shirt, slap on a hat, and slop on sunscreen on unprotected areas of the body". These messages coupled with altered school policies seem well received.

Many groups now wish to further downplay the role of sunscreens as protection for more than sunburn. A study by the U.S. Environmental Protection Agency found there is a "complete lack of evidence that sunscreens provide protection against ultraviolet light-induced immunological effects." They also stated that "there is no evidence in humans that sunscreens prevent photocarcinogenesis." Recent research has indicated that PABA and Parsol, two commonly used chemicals in sun screen may initiate or promote skin tumours.

Health education materials on the potentially severe consequences of increased UV exposure must be carefully prepared to avoid developing a fatalistic attitude and resignation to fate to rather scary impacts. A main point of such programs must be that direct impacts on health are avoidable through the use of sensible precautions, many of which have been part of tropical cultures for centuries. Nutritional education should likewise stress those foods, vitamins and minerals which strengthen the body's immune system.

Clothing

Proper clothing is an important aspect of personal, physical UV protection. Long-sleeved shirts and skirts/pants and wide-brimmed hats can be an effective physical block against excessive exposure. Schools in Australia and New Zealand have mandated such clothing for students participating in outdoor school activities. In Canada and the United States, the subject of dress codes and regulations is highly controversial. However, would a student be sent out into sub-freezing temperatures without proper outer clothing?

Protective eye wear is also important. The major concern here is the use of sunglasses which do not filter most of the UV radiation and may therefore pose more of a danger than no protection. It should be noted that some prescription eyewear may prevent the penetration of UVB radiation to the eyes and that all plastic-lens, prescription eyewear may be coated at a nominal cost to reduce or eliminate UVB penetration.

School Activities

Many school-sponsored activities and programs have a potential for excessive exposure to solar UV radiation. These include recesses and lunch breaks, outdoor physical education programs, athletic activities and school outings.

Because the normal school day falls mainly within the peak sun hours of 10 a.m. to 3 p.m (LST), regular school activities such as recess, lunch break and physical education cannot be rescheduled around peak sun hours. Therefore, provision of physical sun barriers and requirements for proper clothing is important. This is especially true during the spring when the sun is strong, the ozone layer weak and the first warm days draw us to removing clothing and being in the sun.

School-sponsored athletic events should be scheduled for non-peak sun hours whenever possible, and, when not possible, provisions should be made for added shading and proper protective clothing and safe sunscreen or block should be required. Since many minor sports programs use school facilities, the schools should use their influence to see that information on being sun-smart is conveyed to the executive and coaches of these sports. **It is also vitally important that a child's right to protection from the sun not be abrogated by uniform codes or other such rules.**

Many outdoor school athletic meets such as district track and field and baseball/softball are held in the spring. Such meets generally encompass the peak sun hours which in spring are potentially the most injurious because of strong sun, a weakened ozone layer and either cool temperatures for which sun exposure often goes unnoticed or hot temperatures which encourage removal of clothing.

A variety of school outings such as field trips to the zoo or a local nature area potentially place students in strong sun conditions. Since we do not wish to discourage such activities and they cannot be easily scheduled for low sun hours, it is recommended that personal physical protection be required by all participants.

Facility Design

Unfortunately, most schools and school playgrounds are not designed for protection against exposure to solar UV radiation to students while outdoors. Most playgrounds lack any shade at all, especially near playground equipment. In addition, many play areas have extensive asphalt or sand surfaces. Asphalt and sand reflects much more UV radiation than grass. They are even more highly reflective than water surfaces. Thus, children get an added dose from reflected radiation. Reflected radiation may also negate the protection of hats by reflecting radiation under the brim. Thus grass should replace asphalt and sand wherever possible.

Schools and playgrounds should be designed with provisions for shade, both natural shade such as provided by trees and bushes and by constructed shade devices such as canopies. There are several methods by which constructed devices can provide UV shading yet still be transparent to light and heat. An extreme example is a greenhouse-like structure which is completely enclosed. However, open-sided structures such as awnings or free-standing tents such as those used at picnics could also provide protection.

Natural shading could be placed within and around a school yard which would also help cool the building, retard noise and reduce pollution from off-property sources. Programs to plant trees around school property could be combined with community, government and private programs to increase our tree cover.

Temporary shade structures should also be considered for all sporting events such as baseball/softball or soccer tournaments and track and field competitions. Such structures would provide protection between games/events for coaches and athletes.

The Skies Above Foundation was formed by a group of citizens initially concerned over the potential harmful impacts of depletion of the Earth's ozone layer and attendant increase in ultraviolet radiation. Its mandate is to inform and educate the public on environmental issues related to the atmosphere. The Foundation will achieve this mandate by:

1) Sponsoring and fostering public education and scientific research respecting atmospheric environmental matters, in particular stratospheric ozone depletion, ultraviolet radiation increases, global warming and air pollution, in British Columbia and elsewhere;
2) Disseminating educational materials to the British Columbia and Canadian public, schools and media;
3) Facilitating community planning for a sustainable environment.

The Skies Above Foundation has been involved in several educational programs. Their feature event for 1994 is an International Conference on Ozone Depletion and Ultraviolet Radiation: Preventing and Preparing for the Impacts to be held April 27-29, 1994 in Victoria, British Columbia. From that conference, the Foundation has produced several hours of video programming and has published the conference proceedings.

Keith C. Heidorn, Ph.D., ACM, has nearly a quarter century of experience in meteorology, climatology and air quality assessment. Dr. Heidorn specializes in the fields of air quality assessments, micrometeorology, climatology, environmental impacts and global change issues and currently is focusing on environmental and atmospheric education. Dr. Heidorn is recognized by the Canadian Meteorological and Oceanographic Society as an Accredited Consulting Meteorologist specializing in applied meteorology and climatology, micrometeorology and microclimatology and air pollution dispersion. Dr. Heidorn is a founder and executive director of The Skies Above Foundation and a founding director and co-chair of The Skies Above Foundation and Skies Above Canada Foundation.

Bruce Torrie, LLB, is a lawyer and environmental policy analyst who has produced over 30 hours of television documentaries on the effects of ozone depletion and global warming. He was the founding chair of the Atmospheric Caucus of the Canadian Environmental Network and serves on the boards of many environmental groups and foundations. Mr. Torrie is a founding director and co-chair of The Skies Above Foundation and Skies Above Canada Foundation.