Skin Cancer Prevention in Canada

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Publication of this special peer-reviewed insert on Skin Cancer Prevention in Canada has been funded by Alberta Health Services and the Canadian Partnership Against Cancer.
In this special insert to the Canadian Journal of Public Health, six articles reviewed: 1) the UV Index, its geographic distribution, and the factors affecting it, 2) the methodology for a recent Canadian population-based survey about sun exposure and sun protection behaviours, 3) sun behaviour in Canadian children, 4) work-time sun behaviours among Canadian outdoor workers, 5) the burden of malignancy subsequent to primary skin cancer, and 6) a comprehensive skin cancer prevention framework. The report\(^1\) that there has been a 2.5% to 5% increase in the UV Index in Canada since the 1970s is both consistent with prior reports\(^2,3\) and reflects the importance of efforts to reduce excess exposure to ultraviolet radiation (UVR) in many diverse Canadian recreational and occupational contexts.

The two papers that review sun behaviour among children\(^4\) and among outdoor workers\(^5\) in Canada are both based on the second national sun survey that consisted of two questionnaires administered to two samples of adults (ages 16+ years).\(^6\) Data were collected in 2006, 10 years after the first national sun survey. The base sample (7,121 adults) provided in-depth information on UVR exposure, protective behaviours, tanning, and knowledge, attitudes and beliefs about sun safety for adults, as well as some sun behaviour information from a subsample of parents about their children (ages 1-12).\(^6\) In addition, a smaller comparison sample yielded 2,115 interviews which provided an opportunity to compare changes in sun behaviours since 1996.

The focus on sun behaviours in children, and how to reduce excessive sun exposure during the key developmental years when UV damage can significantly increase the risk of subsequent development of skin cancers, is a concern around the world.\(^7,9\) In the Canadian survey of 1,426 parents responding about one of the children in their family aged 1-12, the majority of children were found to spend at least 30 minutes in the sun. However, only parents (85%) with children ages 1-5 reported routinely covering the child’s head and protecting them with sunscreen. The heavier reported use of sunscreen versus seeking shade and wearing sun protective clothing suggests that new health promotion approaches, focused on changing attitudes and addressing pro-tanning peer pressure, need to be developed, particularly targeted to older children.

The report on sun behaviours among 1,330 outdoor workers,\(^3\) ages 16-64, who reported having a job that required working outdoors during the months of June-August 2006, described the amount of time spent in the sun during the average work day and the extent to which the workers reported covering their head, using protective clothing, wearing sunglasses, and using sunscreen. While there was significant variation among the provinces in the percentage of adults who reported being outdoor workers, there was no significant variation among workers in different provinces with respect to sun exposure or sun protective behaviours.

Overall, gender differences in what types of sun protection are used, and age differences in the frequency with which sun protection practices are reported by the youngest age group versus the older age groups of outdoor workers, suggest that many outdoor workers are accumulating an unsafe level of lifetime UV exposure from the outdoor work experiences. Expanded efforts are needed to increase sun protective practices among the over five million Canadian outdoor workers who may be required to work outdoors during the summer months when UVR exposure is highest.

Given the diverse Canadian populations that appear to be at risk for developing skin cancer from an excessive lifetime exposure to UV radiation, both in recreational and occupational contexts, and the fact that individuals with skin cancer are subject to a high risk of recurrence, multiple skin cancers, and second primary cancers,\(^10\) a more comprehensive approach to skin cancer prevention may need to be considered above and beyond health promotion and health education interventions targeted solely at individual behaviour change. In the final paper\(^11\) in this special insert, the skin cancer prevention team of Alberta Health Services-Cancer Prevention Program describe the development of a comprehensive framework for skin cancer prevention and control that included: 1) utilization of an ecological approach to population health, 2) functionality as a dynamic tool for planning, implementation and evaluation, and 3) recognizing and addressing limitations in existing approaches. The resulting framework, which complements both World Health Organization and U.S. Centers for Disease Control and Prevention models for skin cancer prevention, may be adopted and adapted by other jurisdictions, but should be carefully evaluated both within Alberta and in other jurisdictions that may choose to adopt it.

Skin cancer prevention and sun safety promotion also present some interesting public health challenges. Particularly in northern latitudes, sun safety and the role of UV exposure in helping the human body produce adequate levels of Vitamin D have led some to evaluate current sun safety messaging in relation to Vitamin D supplementation.\(^12,13\) Thus, integrating skin cancer prevention approaches with related chronic disease prevention efforts (e.g., increased physical activity), and harmonizing competing risk fac-

Note: The views expressed herein represent the views of the research and writing teams and, as such, do not necessarily represent the views of the Partnership.
tor reduction strategies, may be important in addition to risk factor-specific approaches. The papers in this special insert provide useful data and a potential framework for identifying integration and alignment opportunities between skin cancer prevention and other cancer and chronic disease prevention priorities.

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REFERENCES

The UV Index: Definition, Distribution and Factors Affecting It

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ABSTRACT

The UV Index was introduced in Canada in 1992 in response to growing concerns about the potential increase of ultraviolet (UV) radiation due to ozone depletion. The index was adopted as a standard indicator of UV levels by the World Meteorological Organization and World Health Organization in 1994. This survey article gives an overview of the UV Index and the main features of its geographical distribution.

UV index values are determined from measurements made by ground-based spectrometers, broad-band filter radiometers and multi-filter radiometers. Radiative transfer models are used to estimate UV Index values from other types of geophysical observations, primarily column ozone and cloud thickness. UV Index values can also be retrieved from satellite measurements of atmospheric ozone and cloud cover. Forecasts of UV Index values are now widely available and are intended to be used by the public as a guide to avoid excessive exposure to UV radiation.

Over the US and Canada, mean noontime UV Index values in summer range from 1.5 in the Arctic to 11.5 over southern Texas and can be as high as 20 at high elevations in Hawaii. The UV Index is also often used to quantify UV levels in studies investigating the impact of UV on other biological and photochemical processes. Factors affecting the UV Index, such as the sun elevation, total amount of ozone in the atmosphere, cloud cover, reflection from snow and local pollution, are also discussed.

Since its introduction in 1992, the UV Index has become a widely used parameter to characterize solar UV. Information about it can be useful for helping people avoid excessive levels of UV radiation.

Key words: UV Index; ozone; solar UV; UV radiation

The UV Index was based on the erythemal (skin reddening) action spectrum (Figure 1), since this has the most immediate short-term impact on humans. The UV Index was designed to represent erythemally weighted UV radiation in a simple form, as a single number. The goal of this survey article is to provide an overview of the UV Index, the factors affecting it and the main features of its geographical distribution. The overview briefly covers a wide range of topics related to the UV Index and provides references where more in-depth information can be found.

Solar UV radiation at the earth’s surface passes through the atmosphere, where many complicated absorption and scattering processes occur. UV radiation is classified as UV-A (315-400 nm), UV-B (280-315 nm) and UV-C (200-280 nm). Atmospheric gases absorb very little UV-A radiation. Atmospheric oxygen and ozone absorb all UV-C radiation and prevent it from reaching the troposphere and the earth’s surface. Absorption by ozone increases rapidly with decreasing wavelength in the UV-B range and causes surface radiation to fall off sharply with decreasing wavelength (Figure 1).

The fractions of solar energy above the atmosphere in the UV-B and UV-A ranges are approximately 1.5% and 7% respectively. Radiation at progressively shorter wavelengths in the UV range increases energetically and becomes increasingly harmful to most biological species. An action spectrum for a particular biological effect expresses the effectiveness of radiation at each wavelength as a fraction of the effectiveness at a certain standard wavelength.

The UV Index is based on the erythemal (skin reddening) action spectrum (Figure 1), since this has the most immediate short-term impact on humans. The UV Index is an irradiance scale computed by multiplying the erythemal irradiance, in watts m⁻², by 40.

UV measurements and estimates

There are several ways to obtain information on UV radiation at the surface. It can be measured by spectrophotometers (i.e., instruments that measure the UV intensity at individual wavelengths). These instruments yield accurate spectral data, but they are relatively expensive, and their operation and maintenance can be complex. There are only nine sites in Canada where such measurements are carried out on a regular basis by Canadian-designed Brewer spectrophotometers. Filter instruments are less expensive, but they measure UV intensity weighted over a broad spectral interval. The weighting function is determined by the filter characteristics that can mimic, for example, erythemal response. Filter instruments are less stable than spectrophotometers and have various systematic errors.

UV-B irradiance can also be reconstructed from long-term records of other geophysical parameters, primarily total ozone and charac-

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teristics of cloud cover. Ground-based and satellite total ozone measurements are the sources of ozone data. Global solar radiation (i.e., total radiation in the entire spectral range from UV to infrared) is often used to quantify cloud effect.\(^3\) Cloud cover or measurements of sunshine duration are also used for UV reconstruction.\(^4\) Cloud reflectivity measured from satellites is also used as a source of information about cloud cover for UV estimates. Some satellite instruments can measure both cloud reflectivity and column ozone. For example, total ozone mapping spectrometer (TOMS) observations made it possible to produce global UV maps starting from 1978.\(^5\) There are, however, certain problems with these estimates: they produce systematically higher UV irradiance values (by typically 10%-15% but as much as 60% in extreme cases) than ground-based measurements,\(^6,7\) because of absorption by aerosols in the boundary layer, and up to 60% lower values when snow is on the ground.\(^8\)

Factors affecting surface UV

The absolute intensity of UV irradiance at the earth's surface at all wavelengths is directly proportional to that of the solar spectrum. The intensity of solar UV-C radiation is about 6%-9% higher when solar activity is at a maximum than at a solar minimum.\(^9\) However, the variability in UV-A and UV-B radiation has been found to be relatively small (<1%) over the 11-year solar cycle. The earth is closest to the sun in early January and farthest from the sun in early July. The difference in intensity of solar radiation between the January maximum and the July minimum is nearly 7% at all wavelengths.

The intensity of UV radiation falling on a horizontal surface decreases with an increase in the zenith angle (i.e., the angle between the local zenith and the line of sight to the sun). This is caused by two effects. First, the intensity of down-welling solar irra-
time of day and season. Changes of the noon solar zenith angles are responsible for the annual cycle in noon UV Index, as illustrated by Figure 2.

Several trace atmospheric gases absorb solar radiation at UV-B wavelengths. The most significant absorber is stratospheric ozone, which allows less than 3% of erythemal radiation to reach the lower troposphere and earth’s surface. A 1% decline (or increase) in column ozone yields about a 1.2% increase (or decline) in UV Index. Day-to-day fluctuations in the estimated clear sky UV Index (the grey line in Figure 2) with the amplitude up to 20% are caused by natural fluctuations in column ozone. Over northern midlatitudes, column ozone is higher in spring and lower in autumn, although ozone variability is also higher in spring.

Other naturally occurring absorbers of UV-B radiation include sulfur dioxide (SO\(_2\)) and nitrogen dioxide (NO\(_2\)). Large eruptions from volcanoes can emit enough SO\(_2\) to cause significant absorption of up to 50% of erythemal UV. However, the overall effect of absorption of erythemal UV by SO\(_2\) and NO\(_2\) is small.

Clouds can substantially reduce UV and visible solar radiation although they do not significantly absorb UV radiation. In the UV-A range, irradiance can be reduced by a factor of more than 100 under heavy thunderclouds compared with that of clear sky conditions, and the reduction can be even stronger in UV-B. UV Index values in Figure 2 that are much lower than those expected under a clear sky are caused by cloud effects.

Atmospheric aerosols are nongaseous particles that are suspended in the atmosphere. There are many sources of atmospheric aerosols, both natural and manmade, and a wide variety of aerosol types. Sources include volcanoes, forest fires\(^3\) and deserts,\(^12\) as well as emissions from power plants, factories, biomass burning,\(^13\) automobiles and aircraft. Absorption by aerosols under typical urban conditions reduces UV by 10%-15%, although this can be substantially higher over heavily polluted sites.

The intensity of radiation falling on a horizontal sensor can be enhanced with an increase in the reflectivity of the earth’s surface, even when the earth’s surface is not in view of the sensor. This is the result of the sky being brighter because of higher surface albedo. For water and most land surfaces the albedo is generally quite low (<5%) in the UV range.\(^14,15\) Sand surfaces can have higher albedo.\(^16\) In general, spatial differences in land type have little optical effect on surface UV radiation.

The main cause for variable UV albedo is snow or ice on the earth’s surface.\(^17,18\) UV enhancements due to snow cover vary significantly from site to site. For example, a smooth terrain covered by snow in the Arctic (Churchill) causes an enhancement of about 36%, whereas snow at an urban site (Halifax) causes an enhancement of only 7%.\(^10\) An abrupt decline in UV Index values at Resolute in May, shown in Figure 2, is related to the melting of snow.

Surface UV radiation increases with altitude so, in general, sites at higher elevation receive more UV radiation than those near sea level. Radiation increases with decreasing pressure, since there is less scattering. UV-absorbing gases that are often present in the troposphere, particularly near urban regions, reduce surface UV radiation. Also, there can be absorbing or non-absorbing aerosols that reduce UV radiation at the surface. In general, measurements show that erythemal UV increases between 7% and more than 15% per kilometer of altitude.\(^19,20\)

**UV Index climatology**

Over the US and Canada, mean noontime UV Index values in summer range from 1.5 in the Arctic to 11.5 over southern Texas near sea level; in countries such as Australia they often reach values of 15-16. In Canada, the highest UV index values (about 10.5) were measured in Toronto. The highest UV Index values in the world occur at high altitude sites in the tropics (e.g., values of about 20 have been observed at Mauna Loa observatory, Hawaii\(^21,22\)), and satellite-based estimates of the UV Index have exceeded 25 in the Altiplano area of Peru.\(^23\)

Figure 3 shows maps of the mean UV Index values at solar noon for spring (March) and summer (July).\(^24\) Maps for other months are

![Figure 3. Maps of mean UV Index values at noon (11 a.m.-1 p.m. local solar time) for the US and Canada in March and July](image-url)
available from http://exp-studies.tor.ec.gc.ca/e/ozone/uv.htm. As one would expect, UV Index values are typically higher at low latitudes owing to the lower solar zenith angle there than those at high latitudes. However, the latitude is clearly not the only factor affecting UV. For example, mean UV Index values for July are higher over Colorado, located at 40°N, than over southern Florida (26°N) owing to the difference in altitude, cloud conditions and, perhaps, absorbing aerosols. There are also longitudinal differences. Summer values over the west Coast are typically higher than the values over the east coast at the same latitudes.

Long-term changes
Since the UV Index depends on multiple factors, long-term changes of these factors yield long-term changes in the UV Index. Long-term decline in column ozone over northern midlatitudes is about 2% in summer and 4% in winter-spring, yielding a 2.5% and 5% increase in UV Index respectively. Long-term changes in cloud cover can also affect UV Index values. Analyses of reconstructed data sets over central and eastern Europe since the 1960s indicate a ~10% change in UV Index due to variations in cloud cover.25,26 Local trends in absorbing aerosols can also have a noticeable effect on the UV Index. For example, a more than 10% increase in UV-B at Thessaloniki, Greece, is likely due to a decrease in aerosols.27,28

Figure 4 shows long-term fluctuations in mean daily erythemal UV doses for Toronto calculated from actual spectral UV measurements and reconstructed from global solar radiation and ozone. The somewhat elevated UV level in the 1990s and 2000s is related to the ozone decline, and the large year-to-year fluctuations are caused by natural fluctuations in cloud cover and ozone.

Forecasts and public awareness program
Environment Canada issues the UV Index in its weather forecasts to increase awareness of the harmful affects of UV radiation, support the education of the public on UV risks and encourage people to take action for protection. Comparisons of forecasted UV Index values with measurements show that the overall agreement between predicted and observed values is about ±1.4 Index units. Dividing the comparison into various weather conditions indicates that agreement is best under sunny or mainly sunny conditions (±0.7 units). In general, the agreement degrades (>1.5 units) under other conditions, such as partial clouds, overcast skies or precipitation.

Environment Canada introduced a renewed UV Index program in February 2004 based on the recommendations contained in the World Health Organization’s Global Solar UV Index Practical Guide of 2002.30 The UV Index is categorized into low (less than 2), moderate (3 to 5), high (6 and 7), very high (8 to 10) and extreme (11 and above), as shown in Figure 2.

Media coverage of the UV Index varies considerably by region. Most newspapers, many TV and some radio stations carry the daily UV Index forecast. It is available from Environment Canada in the public weather forecasts whenever the maximum value is expected to reach 3 or higher. Newspapers extract the forecast from a bulletin that is available all year, and so they generally cover it year-round. However, TV and radio obtain the UV Index from public forecast bulletins and hence report when values are 3 or more. Many stations still choose to report it on a seasonal cycle, typically from at least May through August. The frequency of coverage varies substantially from outlet to outlet.

SUMMARY
The UV Index program was developed with the goal of providing information on surface UV radiation to the general public. In the early 1990s, concerns had arisen regarding the implications of reduced ozone levels, which had become more evident to scientists and more prominent in the media. In response to these concerns, Environment Canada developed the UV Index program in 1992 to quantify levels of UV radiation at the surface. It was later adopted as a standard indicator of UV levels by the World Meteorological Organization and World Health Organization in 1994. The goal was to provide an easily understood number that would be forecast to quantify UV levels expected for the following day. Since its introduction in 1992, the UV Index has become a widely used parameter to characterize solar UV radiation. Information about it can be useful in helping people avoid excessive levels of UV radiation. More information about the UV Index can be found in survey articles, as well as in the World Meteorological Organization/United Nations Environment Programme ozone assessments.
UV INDEX


Les valeurs de l’indice UV sont déterminées à partir des mesures prises par des spectrométries au sol, des radiomètres à large bande et des radiomètres multifiltres. Au moyen de modèles de transfert radiatif, on estime ces valeurs à partir d’autres types d’observations géophysiques, principalement la colonne d’ozone et l’épaisseur des nuages. On peut aussi les obtenir à partir des mesures satellitaires de l’ozone atmosphérique et de la couverture nuageuse. Les prévisions de l’indice UV sont maintenant largement diffusées; on veut que le public s’en serve pour éviter les expositions excessives aux rayons ultraviolets.

Pour les États-Unis et le Canada, l’indice UV moyen à midi en été varie entre 1,5 dans l’Arctique et 11,5 pour le Sud du Texas et peut atteindre 20 dans les hautes d’Hawaï. L’indice UV sert aussi souvent à chiffrer les niveaux de rayonnement ultraviolet dans les études portant sur l’incidence des rayons UV sur d’autres processus biologiques et photochimiques. Les facteurs qui influent sur l’indice UV, comme la hauteur du soleil, la quantité totale d’ozone dans l’atmosphère, la couverture nuageuse, la réflexion des rayons sur la neige et la pollution locale, sont également abordés.

Depuis son adoption en 1992, l’indice UV est devenu un paramètre très utilisé pour caractériser les ultraviolites solaires. L’information à ce sujet peut être utile pour aider les gens à éviter les niveaux d’exposition excessifs aux rayons ultraviolets.

**Mots clés :** indice UV; ozone; ultraviolites solaires; rayons ultraviolet
The Second National Sun Survey: Overview and Methods

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ABSTRACT

The Second National Sun Survey (NSS2) was carried out in 2006 to estimate ultraviolet radiation (UVR) exposure, sun protection and related knowledge, attitudes and beliefs among Canadians. This paper provides a detailed overview of NSS2 methods and discusses the strengths and limitations of the survey. The NSS2 consists of two questionnaires administered to two samples of adults (age 16+ years). The base sample provides in-depth information on UVR exposure, protective behaviours, tanning, and knowledge, attitudes and beliefs about sun safety for adults, as well as some sun behaviour information for a sample of their children aged 1-12 years. The shorter comparison sample facilitates direct comparison with the 1996 first national sun survey. Data were collected using computer-assisted telephone interviewing, and sample weights were computed for all respondents for estimation and analysis of both adult and child data. Base sample interviews were completed for 7,121 adults, of whom 1,437 reported on the sun behaviour of one of their children, and the comparison sample yielded 2,115 interviews. Response rates were 63% for both surveys. The NSS2 provides in-depth and up-to-date UVR exposure information among Canadians. The results of this survey will aid health promotion experts and policy-makers in developing effective programs to minimize UVR exposure. A public use data file and training in statistical analysis of the NSS2 has been made available to data analysts from across Canada. Key strengths and limitations identified in this survey will inform the development and implementation of future sun surveys.

Key words: Survey methods; ultraviolet radiation exposure; skin neoplasms

Skin cancer, including basal cell carcinoma, squamous cell carcinoma and melanoma, is the most common cancer in Canada and is primarily attributable to ultraviolet radiation exposure (UVR).1,2 Reducing UVR exposure among Canadians would reduce the incidence and overall health burden of these largely preventable cancers. Developing health promotion and awareness programs to reduce UVR exposure requires up-to-date information about how much time people spend in the sun, their use of sun protection and their knowledge, attitudes and beliefs (KAB) concerning sun exposure, sun protection and tanning. The objectives of the Second National Sun Survey (NSS2) were to estimate levels of UVR exposure and related indicators among Canadians during the summer of 2006, building upon the first national sun survey (NSS1) conducted in 1996.3 This paper provides an overview of NSS2 methods, including questionnaire development and contents, sampling, data collection, weighting and estimation, as well as a discussion of survey strengths, limitations and recommendations for future sun surveys.

METHODS

Questionnaire development and contents

NSS2 content was developed collaboratively by the National Sun Safety Committee* and the Institute for Social Research (ISR).† Using the NSS1 as a starting point, existing questions were modified and new questions were developed, including several KAB questions regarding sun safety. Questions that were changed significantly or newly developed were pilot tested using structured telephone interviews (n=184) and two focus group discussions (n=17) with convenience samples drawn from the geographic area surrounding ISR. Other key modifications included increased sample size, increased number of analytic geographic regions, separate weekend and weekday sun exposure, revised sun exposure response categories and an improved child sampling strategy. For many questionnaire design changes, split ballot experiments were implemented to permit later evaluation of the impact of these changes.

* Members of the National Sun Safety Committee (now the National Skin Cancer Prevention Committee) were Joel Claveau (Hôtel-Dieu de Québec), Yves Deslauriers (Health Canada), Angus Fergusson (Environment Canada), Lynn From (Women’s College Hospital), Loraine Marrett (Cancer Care Ontario), David McLean (British Columbia Cancer Agency), Natalie Parry (Canadian Cancer Society), Patti Payne (Canadian Cancer Society, Ontario Division), Judith Purcell (Cancer Care Nova Scotia), Pascale Reinhardt (Health Canada), Marc Rhainds (Institut national de santé publique du Québec), Jason Rivers (University of British Columbia), Cheryl Rosen (Toronto Western Hospital), Monica Schwann (Alberta Cancer Board), Jean Shoveller (University of British Columbia), Marni Wiseman (CancerCare Manitoba), Mary Louise Yarema (Toronto Public Health).
† The ISR is a survey research centre at York University. The NSS2 was conducted under the direction of David Northrup at ISR.

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The final NSS2 consisted of two questionnaires administered independently to two distinct samples of adult respondents: the base sample questionnaire and the comparison sample questionnaire. The base sample questionnaire was designed to estimate sun exposure, protective behaviours, use of tanning equipment and KAB about sun safety in adults aged 16 years or older, as well as sun exposure and protective behaviours in children aged 1 to 12 years. Table 1 provides an overview of the base sample questionnaire. Additional pretesting of the newly developed NSS2 questionnaires was conducted by ISR before data collection. The comparison sample questionnaire was designed to permit direct comparison of UVR exposure and behaviours in adults aged 16 or older between the NSS1 and NSS2 for Canada as a whole. It comprised a key set of NSS1 questions.

Sampling
The target population consisted of all persons 16 years or older living in Canada, with the following exceptions: residents of the Canadian territories, full-time residents of institutions (nursing homes, penal institutions, group homes, etc.: 1.7% of Canadians living in the provinces), residents not fluent in one of Canada’s official languages (1.7% of Canadians living in the provinces) and residents without any telephone service (1.2% of Canadian households in the provinces).4–6

As noted earlier, two distinct samples of adults were identified. The base sample was allocated across the following six Canadian regions: Atlantic Canada, consisting of Newfoundland and Labrador, Prince Edward Island, Nova Scotia and New Brunswick; Quebec; Ontario; Manitoba/Saskatchewan; Alberta; and British Columbia. As with the NSS1, the NSS2 comparison sample was distributed across the following five regions: Atlantic Canada (n=292), Quebec (n=494), Ontario (n=600), Manitoba/Saskatchewan/Alberta (n=403) and British Columbia (n=326).

For both NSS2 samples, sampling was carried out by provincial strata using a two-stage probability selection process: household selection followed by respondent selection. For household selection, residential telephone numbers were used as a surrogate for households, and a modified form of random digit dialing was used to select numbers. Selected households were sent an introductory letter before the first call attempt, and at first contact the eligibility of the household was assessed (i.e., whether the household contained at least one adult from the target population). For households with more than one eligible adult, the person with the next birthday was selected to participate. Base sample respondents were also asked whether they were the legal guardian of one or more children aged 1 to 12 years; if yes, they were asked to answer a series of questions reporting on the sun exposure and sun protective behaviours of the child with the next birthday.

Data collection
Data collection was completed using computer-assisted telephone interviewing with the Computer-Assisted Survey Methods Program (Berkeley, CA) from August 2 to November 22, 2006. ISR undertook the majority of interviews, although Jolicoeur & Associates – a survey house in Quebec – conducted 18% of the base sample interviews and 23% of the comparison sample interviews, restricted to participants in Quebec, Ontario and New Brunswick. Both survey houses conducted interviews in English and French. Call attempts were made during both daytime and evening hours, and on weekdays and weekend days. Over two thirds of the interviews were completed within the first four call attempts, 175 interviews were completed on the twentieth or more call attempt, and over 1,000 interviews were completed with households that initially refused to participate. The majority of base sample interviews (over 70%) were completed within 13 to 19 minutes and the majority of comparison sample interviews within 9 to 12 minutes. Approximately 10% of interviews conducted by ISR were monitored by supervisors to establish consistency of interviewing and data entry. Interim data files of 100 and 1,230 completed interviews were evaluated for additional quality control.

Data editing and imputation
Data editing included ensuring that the data were consistent with skip patterns, re-coding open-ended responses and imputing values for variables essential for survey weighting, such as age group, household size and number of telephones per household. For example, to assign an age group to all respondents based on time of interview and year of birth, year of birth was imputed for the
Weighting and estimation

To generate population estimates for both children and adult parameters, sample weights were computed for all survey respondents. Weighting was based on the probability of household selection within sampling strata, proportion of non-responding households, number of telephone lines per household and number of adults/children per household. Weights were also post-stratified to match the regional, sex and age distribution of the target populations according to the 2006 census estimates (post 2001 census adjusted).  

NSS2 weights are appropriate for estimation and analysis using procedures for complex survey data, such as those available in SAS (SAS Institute, Cary, NC) and STATA (StataCorp, College Station, TX). As with reporting guidelines for the NSS1, estimates based on fewer than 10 respondents or with a coefficient of variation greater than 33.3% were not released, and estimates based on 10 or more respondents with a coefficient of variation between 16.6% and 33.3% were flagged to be interpreted with caution because of marginal precision.

RESULTS

Response rates

In total 7,121 and 2,115 adults were interviewed for the base and comparison samples, respectively, and 1,437 adults in the base sample reported on the behaviour of one of their children. To achieve a base sample of 7,121 respondents, 15,425 telephone numbers were sampled, and of these 3,947 were determined to be ineligible as a result of either household characteristics (e.g., language barrier, ill health) or the telephone number being non-residential or not in service. Of the remaining 11,478 telephone numbers, 7,121 yielded a completed interview, 3,911 reached an individual who refused to be interviewed or asked to be called back, and 446 were repeatedly called but no contact was made. For the purpose of response rate calculations, there are various ways of considering the eligibility of households with which no contact is made. By assuming that these 446 numbers have the same proportion of eligible households found among numbers successfully contacted (11,032/14,979 = 74%), 328 of these numbers would be considered eligible households. This yields a total of 11,360 eligible houses for a response rate of 63%. By treating all 446 “ring no answer” numbers as eligible, the response rate would be 62%, and by treating all of them as ineligible, the response rate would be 64.5%. The latter method was used when reporting a response rate of 69% for the NSS1. The response rate for the comparison sample was 63% when applying the eligibility proportion to households with which contact was made, with a range from 62% to 68% for the other two scenarios, respectively.

Item non-response

Respondent refusals occurred on 51 of the 94 survey items, with the highest number of refusals occurring on the household income question (n=973). Item non-response also occurred on 37 of 94 survey items when skip patterns were introduced in an attempt to retain respondents who reported that they never spend time in the sun or who felt that the questions did not apply to them because of the color of their skin. For certain analyses, it has been possible to impute answers for some of the missing data, after additional tests to validate these imputations.

Sample representativeness

Compared with 2006 Canadian census estimates, the unweighted NSS2 base sample had a higher proportion of females (59% versus 51%) and older respondents (38% versus 33% aged 45 to 64 years and 19% versus 16% aged 65 or older). Participant characteristics with proportions adjusted with survey weights are shown in
Table 2. Age, sex and region characteristics for the weighted sample were distributed as in the general population because they were weighted to do so. Comparing selected other characteristics of the sample, after weighting, with the target population revealed that adults with the following characteristics were over-represented in the NSS2 base sample:

- Caucasians/whites (88% of NSS2 base sample versus 85% according to the 2006 census);
- Canadian-born (83% of sample versus 76% of population); and
- having a university degree (27% of sample versus 18% of population).

Residents relying on cellphone use only are also typically under-represented in telephone surveys; however, approximately 5.3% of NSS2 base sample respondents reported living in a cellphone-only household, and it is believed that approximately 5% of Canadian households had cellphone service only in 2006.

DISCUSSION

The NSS2 provides in-depth and up-to-date data on UVR exposure, sun protection and related KAB among Canadians. The survey content and structure were designed by experts in the field with the advantage of building upon the previously conducted NSS1. As a result, many of the questions are improved, and the scope of the survey content is much broader than that of the NSS1. This, combined with the larger sample, should permit a wider range of analysis. The response rate is comparable with that of the NSS1, despite the general decline in survey response rates noted elsewhere. The earlier start of data collection (August rather than September) should permit evaluation of and reduce recall bias, which generally increases as more time passes between exposure and reporting of sun behaviour. The reporting of time in the sun for weekends and weekdays separately yields a more detailed description of sun exposure than questions referring only to leisure time in the sun, and the reference to peak sun hours from 11 a.m. to 4 p.m. ensures that there is a more consistent reference period across respondents.

Future sun surveys may also be able to build on the limitations noted in the NSS2. For example, additional strategies to accommodate respondents who feel that questions are irrelevant because of their skin colour or their limited sun exposure could be developed. Also, respondent feedback identified that some questions were “double-barreled” in that they asked respondents to agree/disagree with more than one statement at once; a closer examination of this, as well as other respondent feedback, is warranted.

To facilitate data analysis and broad dissemination of results, an NSS2 base sample public use data file was distributed to analysts across Canada, who were provided with training on the data file specifically and on survey analysis more generally during two workshops held September 2007 and March 2008. This public use data file and an accompanying Data User Guide are available upon request from the study’s principal investigator, Loraine Marrett.

REFERENCES

ABSTRACT

Childhood sun exposure is a particularly important determinant of skin cancer, yet little data are available for children. This paper describes sun behaviour among Canadian children for the summer of 2006. As part of the Second National Sun Survey (NSS2), 1,437 parents reported on the time spent in the sun, and the frequency of sun protection behaviours and sunburning for one of their children aged 1 to 12 years. Analysis was carried out using complex survey procedures in SAS and STATA. The majority of children (94%) spend at least 30 minutes in the sun on a typical summer day; however, regular sun protection is only commonly reported for young children (1 to 5 years) and involves covering their heads and wearing sunscreen (85%). The frequency of other protective behaviours is much lower, and sun protection decreases with age. Older children are also twice as likely to spend extended time in the sun and to get a sunburn. Among older children, boys are more likely to cover their heads and girls are more likely to wear sunscreen. Regular sun protection among Canadian children is low, given their sun exposure. Heavy reliance on sunscreen is consistent with previous reports and indicates that other measures, such as seeking shade and wearing protective clothing, need to be promoted. Riskier sun behaviour among older children may reflect decreased parental control, as well as changing attitudes and peer pressure, and highlights the importance of adult role models and targeted interventions for this age group.

Key words: Child behaviour; solar radiation exposure; skin neoplasms

METHODS

Second National Sun Survey (NSS2)

The NSS2 was conducted across Canada’s provinces between August and November 2006. A total of 7,121 adults aged 16 years and over participated (response rate 63%), 1,437 of whom reported on the sun behaviour of one child aged 1 to 12 years living in his/her household.

The Second National Sun Survey (NSS2) is the largest study with comprehensive data on skin cancer risk behaviours, including sun exposure and protection behaviours, among Canadians. It involved a large sample of parents reporting on the sun behaviours of one of their children for the summer of 2006. The first National Sun Survey (NSS1) found that children of all ages had high levels of sun exposure; older children in particular (those aged 6-12) both spent a lot of time in the sun and practised poor sun protection. The NSS2 provides updated information that can be used to identify priorities and develop risk reduction strategies. This paper uses these data to describe recent typical daily sun exposure, sun protection behaviours and sunburning among Canadian children aged 1 to 12 years.

S

olar radiation is the primary cause of skin cancer, the most commonly diagnosed cancer among Canadians. Sun exposure during childhood is a particularly strong risk factor for this largely preventable disease and is thought to have a greater impact than adult sun exposure on increasing the risk of melanoma, the least common but most fatal form of skin cancer, as well as basal cell carcinoma, the most common form of skin cancer.

Migration studies provide the best evidence supporting a strong association between childhood sun exposure and melanoma. These studies have shown that a younger age at migration from a region with low ambient solar radiation to a region with higher ambient solar radiation increases the risk of melanoma compared with an older age at migration. Childhood sun exposure has also been shown to increase the development of nevi, and nevi are a well-established risk factor for development of melanoma later in life. Case-control studies have reported an association between childhood sun exposure, especially sunburning, and melanoma, although study results are somewhat inconsistent. Findings are more consistent for basal cell carcinoma, with which sunburning and other measures of intense sun exposure in childhood have been shown to have a stronger association than similar exposures occurring in adulthood. For squamous cell carcinoma, both childhood and adult sun exposure are believed to be important risk factors.

Given the importance of childhood sun exposure as a risk factor for skin cancer, as well as evidence showing that sun behaviours established early in life influence those adopted in adolescence and adulthood, skin cancer prevention strategies targeting children and parents are essential for reducing the skin cancer burden in Canada. Up-to-date knowledge of sun behaviours practised by children is needed to inform the development of such strategies.

The Second National Sun Survey was supported primarily by funds from the Canadian Cancer Society with supplemental funding from the Public Health Agency of Canada, the Canadian Partnership Against Cancer, and Cancer Care Ontario. It was conducted under the auspices of the National Skin Cancer Prevention Committee, Canadian Partnership Against Cancer.
In households with more than one child, parents reported on the child with the next upcoming birthday. One parent refused to provide the sex of the child, yielding a final sample of 1,436 children, composed of 679 boys and 757 girls. Additional details regarding NSS2 sampling, data collection and analytic methods are described elsewhere.9

**Survey questions**

Sun exposure was assessed by asking “[Since June/during June, July, or August], how much time each day, on average, was your child in the sun between 11 am and 4 pm?” Response categories were as follows: less than 30 minutes, 30-60 minutes, 1-2 hours, 2-3 hours, 3-4 hours and 4 or more hours. Sun protection questions were asked only of respondents whose children spent at least 30 minutes in the sun on a typical day and were worded as “[Since June/during June, July or August], when [he/she] was in the sun for 30 minutes or more between 11 a.m. and 4 p.m. how often did he/she...” for each of the following behaviours: seek shade/avoiding sun; cover his/her head; wear clothing to protect his/her skin from sun such as a long sleeve shirt, long pants or a t-shirt; wear sunglasses; use sunscreen on his/her face; and use sunscreen on his/her body. Response categories were Always, Often, Sometimes, Rarely, Never. For children who always, often or sometimes wore sunscreen either on their face or body, parents were asked what sun protection factor (SPF) the child usually used. Sunburning was assessed for the months of June, July and August and was defined as “reddening or discomfort of his/her skin that lasted longer than 12 hours after their exposure to the sun”.

**Analysis**

Proportions and 95% confidence intervals (CIs), as well as tests of association using the adjusted Wald method, were generated using complex survey procedures in SAS 9.1 (SAS Institute, Cary, NC) and STATA 10.0 (StataCorp., College Station, TX) with weights adjusted for the probability of child selection and post-stratified to the regional, age and sex distribution of Canadian children.7 For regional comparisons, proportions were age-standardized according to the distribution of children aged 1 to 5 years, 6 to 9 years and 10 to 12 years in the 2001 Canadian population.10

**RESULTS**

As shown in Table 1, one third of children aged 1 to 5 years spend two or more hours in the sun during peak hours on a typical summer day and almost twice as many older children spend that amount of time in the sun. Only 3% of children aged 6 to 12 years and 11% of younger children spend less than 30 minutes in the sun on a typical day (95% CI 1.3-5.3 and 7.1-14.2, respectively). Among those typically spending at least 30 minutes in the sun, younger children are more likely to practice sun protection behaviours, with the exception of wearing sunglasses, which is infrequent in all age groups at 15%-18%. The incidence of summer sunburn increases with age, at 10% among children aged 1 to 5 years (CI 6.4-13.2) to 27% among children aged 10 to 12 years (CI 21.5-32.3).

As shown in Figure 1, sun behaviours vary somewhat by sex, especially among older children. There are no statistically significant differences between boys and girls overall for time spent in the sun, although older boys (aged 10-12 years) are slightly more likely to spend two or more hours in the sun than older girls (68% vs. 59%, p=0.107). Boys aged 6 to 12 years are more likely to cover their heads than girls of the same age (62% versus 45%, p<0.001), and girls aged 10 to 12 years are more likely to use sunscreen than boys of the same age (63% versus 46%, p=0.007). Boys are also more likely to wear protective clothes than girls for all ages combined (45% versus 36%, p=0.007), although within age groups this difference is apparent only among the youngest and oldest children.

Among children who at least sometimes wear sunscreen, less than 1% use an SPF less than 15, 6% use SPF 15, 42% use SPF 30, and 52% use an SPF greater than 30. Using an SPF greater than 30 is more common among children aged 1 to 5 years than those aged 6 to 12 years (65% versus 44%, p<0.001).

**DISCUSSION**

This study shows that a high proportion of Canadian children, especially older children, spend extended time in the summer sun. Those aged 6 to 12 years are the most likely (64%) of any age group examined in the NSS2 to spend two or more hours in the sun on a typical summer day, followed by 40% of adults aged 16 to 24 years, 33% of children aged 1 to 5 years and 25% of adults aged 25 years or older (13- to 15-year-olds not included in NSS2).11 These findings are unlike those of recent reports that children are now spending the same amount of time in the sun as adults and that adolescents spend the least amount of time in the sun.12 Comparisons of adult and child sun behaviours must be interpreted carefully because, while the former were self-reported, the latter were provided by proxies (parents/guardians).

**Table 1. Sun Exposure, Sun Protection and Sunburning, by Age**

<table>
<thead>
<tr>
<th>Sun Behaviour Variables</th>
<th>1-5 Years (n=542)</th>
<th>6-9 Years (n=445)</th>
<th>10-12 Years (n=449)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time in the sun</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;60 min</td>
<td>31 (26.1-36.5)</td>
<td>12 (8.2-15.1)</td>
<td>13 (9.0-16.4)</td>
</tr>
<tr>
<td>1-2 hours</td>
<td>37 (31.2-41.8)</td>
<td>26 (20.9-31.3)</td>
<td>23 (18.3-28.7)</td>
</tr>
<tr>
<td>2-3 hours</td>
<td>22 (16.8-26.2)</td>
<td>28 (22.6-33.8)</td>
<td>30 (24.2-35.3)</td>
</tr>
<tr>
<td>≥ 3 hours</td>
<td>11 (7.4-13.9)</td>
<td>34 (28.1-40.0)</td>
<td>34 (28.6-39.6)</td>
</tr>
<tr>
<td>Always/often practising sun protection</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spending &lt;30 minutes in the sun*</td>
<td>11† (7.1-14.2)</td>
<td>3† (1.3-5.3)</td>
<td>3† (1.4-5.5)</td>
</tr>
<tr>
<td>Covering his/her head</td>
<td>84 (80.1-88.8)</td>
<td>60 (53.5-65.8)</td>
<td>48 (41.7-53.7)</td>
</tr>
<tr>
<td>Wearing protective clothing</td>
<td>53 (47.6-59.1)</td>
<td>35 (29.4-40.9)</td>
<td>34 (27.9-39.5)</td>
</tr>
<tr>
<td>Using sunscreen SPF 15+ on face and body</td>
<td>86 (81.8-89.3)</td>
<td>66 (60.3-72.5)</td>
<td>54 (47.7-59.7)</td>
</tr>
<tr>
<td>Wearing sunglasses</td>
<td>18 (15.2-22.0)</td>
<td>15 (10.5-18.9)</td>
<td>15 (10.3-18.7)</td>
</tr>
<tr>
<td>Sunburn</td>
<td>10† (6.4-13.2)</td>
<td>13 (9.3-16.9)</td>
<td>27 (21.5-32.3)</td>
</tr>
</tbody>
</table>

* Denominator for “spending <30 minutes in sun” includes all children; denominator for all other sun protection behaviours includes only children spending at least 30 minutes in sun.
† Figures should be interpreted with caution: N=10 but coefficient of variation 16.6%-33.3%.
CI = confidence interval.
Most children (94%) typically spend at least 30 minutes in the sun each day, indicating that virtually all Canadian children should be regularly using sun protection throughout the summer months. Regular sun protection was commonly reported at 85% among young children (1 to 5 years) and involves covering their head and wearing sunscreen, whereas wearing protective clothing and seeking shade/avoiding the sun are only regularly practised by about half of all young children. These sun protection behaviours are much less commonly practised by older children. Regularly wearing sunglasses was uncommon, at about 15% of children of all ages.

The incidence of summer sunburn lasting for longer than 12 hours was relatively low, at 10%, among young children but more than doubled to 27% among children aged 10 to 12 years.

This is the first large-scale Canadian study of child sun behaviour since the NSS1 was carried out in 1996. Overall sun exposure and sun protection behaviours reported in 2006 are comparable with those reported in 1996, with the exception of considerably fewer children regularly wearing protective clothing in 2006 and children generally using sunscreen with a higher SPF in 2006. Comparisons with previously published NSS1 results are limited because...
parents reported on their children aged 12 years or less collectively in the NSS1, whereas in the NSS2 one child aged 1 to 12 years was randomly selected as the interview subject. By restricting the NSS1 data to parents with only children aged 1 to 5 years and to parents with only children aged 6 to 12 years, we found that 70% of parents with the younger children reported regular use of protective clothing compared with 53% of children of the same age in 2006; among parents with only children aged 6-12 years, 50% reported this behaviour in 1996 compared with 34% of this age in 2006 (NSS1, unpublished). Sunburn appears to have been more common reported in 1996 than 2006; however, sunburn questions were significantly different between the two surveys.

Sun exposure during childhood, especially intense exposure causing sunburn, is a particularly strong risk factor for skin cancer and is largely preventable by following good sun protection practices. Since the mid-1990s, sunscreen has been the most commonly practised form of sun protection among Canadian children, and this is consistent with reports in other countries. Although sunscreen is an important component of good sun protection, with evidence indicating that when used properly it reduces the risk of sunburn and development of new skin during childhood, most adults and children do not adequately apply sunscreen and should not rely on this as a sole means of protecting against the sun. Other measures, such as seeking shade during peak sun hours and wearing protective clothing, need to be promoted, especially among children.

Sun protection behaviours among children are highly influenced by parental sun safety behaviours, and sun protection education programs aimed at parents and caregivers, as well as community-wide programs, have been shown to improve sun-safe behaviours among children. As children get older, however, they spend less time under the direct supervision of their parents and begin to take more responsibility for their own behaviours. Furthermore, barriers to sun protection, such as positive attitudes towards tanning and peer-group influence, become more pervasive between the ages of 8 and 15 years. As a result, as shown in the present study, extended time in the sun increases and regular sun protection decreases among older children.

Preferences for different types of sun protection between boys and girls also appear to develop at this age. The findings that boys result, as shown in the present study, extended time in the sun protection preferences by sex observed and girls also appear to develop at this age. The findings that boys were significantly different between the two surveys.

Sun protection behaviours among children are highly influenced by parental sun safety behaviours, and sun protection education programs aimed at parents and caregivers, as well as community-wide programs, have been shown to improve sun-safe behaviours among children. As children get older, however, they spend less time under the direct supervision of their parents and begin to take more responsibility for their own behaviours. Furthermore, barriers to sun protection, such as positive attitudes towards tanning and peer-group influence, become more pervasive between the ages of 8 and 15 years. As a result, as shown in the present study, extended time in the sun increases and regular sun protection decreases among older children.

Preferences for different types of sun protection between boys and girls also appear to develop at this age. The findings that boys were significantly different between the two surveys.

REFERENCES

d’appliquer un écran solaire. La protection solaire systématique chez les enfants canadiens est faible compte tenu de leur exposition au soleil. Le recours massif aux écrans solaires, également observé dans d’autres travaux de recherche, montre qu’il faut promouvoir les autres mesures, comme de rester à l’ombre et de porter des vêtements pour se protéger. La diminution des comportements de protection chez les enfants plus vieux pourrait s’expliquer par le moindre contrôle parental, les changements d’attitudes et la pression à l’uniformité, d’où l’importance d’avoir des modèles adultes à émuler et des interventions ciblées pour ce groupe d’âge.

**Mots clés :** comportement de l’enfant; exposition au rayonnement solaire; tumeurs de la peau
Work-time Sun Behaviours Among Canadian Outdoor Workers:
Results From the 2006 National Sun Survey

Loraine D. Marrett, PhD,1,2 Erin C. Pichora, MSc,1 Michelle L. Costa, MHSc1

ABSTRACT

The objective of the study was to describe summer work-related sun behaviours among Canadian outdoor workers. Information on time in the sun and sun protection practices at work during the summer of 2006 were collected from 1,337 outdoor workers aged 16-64 years as part of the Second National Sun Survey. Proportions (and 95% confidence intervals) were estimated using procedures appropriate for complex survey designs. Twenty-six percent of all Canadians, 39% of males and 33% of those aged 16-24 years work outdoors during the summer. Although 41% spend four or more hours daily in the sun at work, just over half always or often protect themselves by covering their heads (58%), wearing protective clothing (56%) or wearing sunglasses (54%), and only 29% use sunscreen. Males and those aged 16-24 spend the most work time in the sun but are the least likely to use protection. The prevalence of outdoor work and sun behaviours varies among regions. Study findings confirm the need for strategies to reduce time in the sun and increase the use of sun protection among outdoor workers. In order to be effective, these strategies must include both enhanced workplace policies and practice, and increased individual use of sun protection.

Key words: Outdoor workers; solar radiation exposure; skin neoplasms

METHOD

The Second National Sun Survey (NSS2)

The NSS2 was conducted between August and November 2006. The content and methods of sampling, data collection and basic analysis are described in detail elsewhere.6 Briefly, survey data were collected through a computer-assisted telephone interview administered to households selected through modified random digit dialing and containing at least one adult (aged 16 years of age and older). A total of 7,121 adults participated, with a response rate of 63%. Sampling was stratified by Canadian provinces, and sample allocation ensured that the sample size was adequate for basic analysis within each of six regions: Atlantic Canada, Quebec, Ontario, Manitoba and Saskatchewan, Alberta and British Columbia. The territories (Yukon, Northwest Territories, Nunavut) were not included. NSS2 builds on the first Canadian sun survey (NSS1) conducted in 1996.7

Outdoor workers

Of the 7,121 NSS2 participants aged ≥16 years, 1,490 were "outdoor workers", defined as those who reported having a job that required them to work outdoors during the summer months of June, July and/or August of 2006. Analysis was restricted to outdoor workers who were aged 16-64 and not retired at the time of the survey (N=1,337).

For comparison purposes, NSS1 data were extracted for those aged 16-64,7 and the proportion reporting outdoor work in June to August 1996 was estimated.

Sun-related behaviours

Outdoor workers were asked about their average daily time in the sun between 11 a.m. and 4 p.m. when at work (response categories: <30 minutes, 30-60 minutes, 1-2 hours, 2-3 hours, 3-4 hours and 4+ hours). Extended work time in the sun was defined as 4+ hours daily.

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WORK-TIME SUN BEHAVIOURS AMONG CANADIAN OUTDOOR WORKERS

Table 1. Estimated Daily Work Time in the Sun and Use of Sun Protection Among Canadian Outdoor Workers Aged 16-64, by Sex and Age

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Overall (N=1,330)</th>
<th>Male (N=941)</th>
<th>Female (N=389)</th>
<th>16-24 Years (N=254)</th>
<th>25-44 Years (N=568)</th>
<th>45-64 Years (N=515)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(%) (95% CI)</td>
<td>(%) (95% CI)</td>
<td>(%) (95% CI)</td>
<td>(%) (95% CI)</td>
<td>(%) (95% CI)</td>
<td>(%) (95% CI)</td>
</tr>
<tr>
<td>Daily work time in the sun</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;30 min</td>
<td>5 (3.9-7.0)</td>
<td>3 (1.9-4.6)</td>
<td>12 (7.2-16.4)</td>
<td>3* (0.1-6.3)</td>
<td>6 (3.3-8.4)</td>
<td>7 (3.9-9.1)</td>
</tr>
<tr>
<td>30-60 min</td>
<td>9 (7.2-11.0)</td>
<td>8 (5.9-10.2)</td>
<td>12 (8.5-16.3)</td>
<td>4* (1.7-6.8)</td>
<td>8 (5.2-10.2)</td>
<td>15 (10.3-18.7)</td>
</tr>
<tr>
<td>1-2 hr</td>
<td>19 (16.0-21.3)</td>
<td>16 (13.0-19.0)</td>
<td>27 (20.8-32.2)</td>
<td>17 (11.4-22.3)</td>
<td>21 (16.8-25.3)</td>
<td>17 (12.3-21.4)</td>
</tr>
<tr>
<td>2-4 hr</td>
<td>26 (22.7-28.7)</td>
<td>26 (22.2-29.4)</td>
<td>25 (20.1-30.9)</td>
<td>27 (20.2-33.0)</td>
<td>26 (21.3-30.6)</td>
<td>25 (19.8-29.7)</td>
</tr>
<tr>
<td>4+ hr</td>
<td>41 (37.6-44.6)</td>
<td>47 (42.7-51.1)</td>
<td>49 (41.8-56.4)</td>
<td>39 (34.0-45.0)</td>
<td>37 (31.4-43.2)</td>
<td></td>
</tr>
<tr>
<td>Sun protection: always/often†</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Covers head</td>
<td>58 (54.3-61.2)</td>
<td>62 (58.2-66.3)</td>
<td>44 (37.9-50.6)</td>
<td>55 (47.8-62.2)</td>
<td>59 (53.4-63.9)</td>
<td>59 (52.6-64.4)</td>
</tr>
<tr>
<td>Wears protective clothing</td>
<td>56 (52.4-59.5)</td>
<td>59 (55.0-63.4)</td>
<td>46 (39.9-52.4)</td>
<td>44 (37.5-50.8)</td>
<td>59 (53.4-64.0)</td>
<td>62 (55.6-67.5)</td>
</tr>
<tr>
<td>Uses sunscreen</td>
<td>29 (26.0-32.5)</td>
<td>30 (16.8-24.1)</td>
<td>24 (18.6-29.0)</td>
<td>24 (18.6-29.0)</td>
<td>24 (18.6-29.0)</td>
<td>24 (18.6-29.0)</td>
</tr>
<tr>
<td>Wears sunglasses</td>
<td>54 (50.0-57.1)</td>
<td>52 (47.4-55.8)</td>
<td>45 (34.0-48.2)</td>
<td>48 (35.6-50.8)</td>
<td>59 (52.6-63.7)</td>
<td>57 (50.8-62.5)</td>
</tr>
</tbody>
</table>

* Figures should be interpreted with caution: N=10 but coefficient of variation 16.6%-33.3%.
† When in the sun for 30 minutes or more at work.

Using a 5-point Likert response scale ranging from “always” to “never”, outdoor workers were asked to report “…when you were at work and in the sun for 30 minutes or more, between 11 a.m. and 4 p.m., how often did you…” for each of four sun protective behaviours: cover your head; use protective clothing such as a long-sleeved shirt, long pants, or a t-shirt; wear sunglasses; and use sunscreen on your face. Sunscreen on the face is considered an indicator of overall sunscreen use, since facial and body sunscreen use are highly correlated in outdoor workers (NSS1, unpublished). For each sun protection behaviour, the proportion of outdoor workers who reported always or often engaging in that behaviour was estimated.

Seven subjects had some missing sun behaviour data, leaving 1,330 outdoor workers for these analyses.

Statistical analysis

Proportions and their 95% confidence intervals (CI) were estimated using complex survey procedures in SAS 9.1 (SAS Institute, Cary, NC) and STATA 10.0 (StataCorp., College Station, TX) with weights adjusted for the probability of household and respondent selection, and were post-stratified to the 2006 regional age/sex distribution of Canadians. Tests of association were based on the adjusted Wald method.

For comparisons among regions (and with NSS1), proportions were age-standardized to the Canadian 2001 population using weights for age groups 16-24, 25-44 and 45-64.

RESULTS

Approximately 26% (N=1,337) of Canadians aged 16-64 years report having a job that required them to work outdoors during the summer of 2006. Outdoor workers are predominantly male (75%).

The proportions of adult Canadians who are outdoor workers differ between sexes and among regions (Figure 1). Overall, a significantly greater proportion of males than females are outdoor workers (39% vs. 13%, respectively, p<0.001); this is true within every region (p<0.001).

A significantly lower proportion of those from Quebec and Ontario report being outdoor workers (23%), compared with those from western Canada (Manitoba and Saskatchewan 35%, British Columbia 33%, Alberta 29%) and Atlantic Canada (29%). Similar regional patterns are evident for both males and females.

A significantly higher proportion of Canadians aged 16-24 years (33%) are outdoor workers than those aged 25 to 64 years (24%) (p<0.001).

Sun-related behaviours

Overall, 67% of outdoor workers spend 2 or more and 41% spend 4 or more working hours in the sun daily. Males spend more work time in the sun than females (Table 1): significantly more males than females spend 2 or more hours in the sun daily (73% vs. 46%, p<0.001), and the difference is even greater for 4 or more work hours in the sun (47% of males and 24% of females, p<0.001). This male-female difference is significant only among workers aged 25 years or older (data not shown). Younger workers (aged 16-24 years) are significantly more likely to spend 4 or more hours in the sun than those aged 25 years or older (49% vs. 39%, respectively, p=0.013).

Slightly more than half of all outdoor workers always or often cover their head (58%), wear protective clothing (56%) or wear sunglasses (54%) at work; less than one third (29%) always or often use sunscreen (Table 1). Sun protection preferences at work differ by sex: males are significantly more likely to cover their heads (62% of males vs. 44% of females, p<0.001) or wear protective clothing (59% of males vs. 46% of females, p=0.002), whereas females are significantly more likely to use sunscreen (56% of females vs. 20% of males, p<0.001) or wear sunglasses (59% of females vs. 52% of males, p=0.023).

Sun protection practices are similar for outdoor workers aged 25-44 and 45-64. However, compared with those aged 25 years and older, younger workers are significantly less likely to wear protective clothing (44% of younger vs. 60% of older outdoor workers, p<0.001) or sunglasses (41% of younger vs. 58% of older outdoor workers, p<0.001).

There were no significant differences among regions in the proportions of male outdoor workers spending 4 or more hours in the sun per day at work nor in any specific sun protection practices (data not shown). (Sun-related behaviours were examined regionally for male outdoor workers only because of the small number of female outdoor workers and the sex differences in these behaviours for Canada as a whole.)

DISCUSSION

About 26% of Canadians aged 16 to 64 years report having a job that required them to work outdoors during summer 2006. This is significantly higher than in 1996, when 21% of those participating in NSS1 worked outdoors during the summer months. Almost all (95%) of those reporting outdoor work in 2006 spent 30 or more minutes in the sun daily during work time; only 50%-60% of these...
always or often covered their heads, wore protective clothing or wore sunglasses; and only 29% used sunscreen. Forty-one percent spent extended time in the sun (4 or more hours) on a daily basis. The majority (75%) of outdoor workers were male, and they spent more time in the sun than their female counterparts. Younger outdoor workers (under age 25) were more likely to be in the sun than those who were older and were in general less likely to use sun protection than older workers.

These findings are consistent with other studies showing that outdoor workers experience high levels of sun on a routine basis. Differences in work time in the sun between the sexes and among age groups may relate to differing types of jobs or job requirements. In their review, Glanz et al. note that, as in NSS2, preferred sun protection practices differ between male and female outdoor workers, males being more likely to wear hats and females to use sunscreen. They found also that methods of sun protection varied across occupational groups. This could not be examined in NSS2 because no data were collected about type of outdoor work.

Leisure-time sun behaviours mirror those associated with work: males and young adults (aged 16–24 years) spend more leisure time in the sun than females and those who are older; females are more likely than males to use sunscreen; and younger people (ages 16–24) are less likely than older adults to use sun protection. The proportion of adults who are outdoor workers varies significantly across the country. Lower proportions in Ontario and Quebec may reflect different types of jobs than elsewhere. For example, those living on farms in 2006, an indicator of one kind of outdoor work, made up 1.5% of the Ontario population compared with 11.5% in Saskatchewan. NSS2 did not collect information on type of outdoor job, thereby prohibiting further investigation of this issue.

This is the first study since NSS1, conducted in 1996, to describe summer work time in the sun and sun protection behaviours in a broad sample of Canadian outdoor workers. As with any scientific study, it has strengths and limitations. The substantial number of survey respondents (over 7,000) and the regional allocation of the sample have produced a relatively large number of outdoor workers, enabling examination of demographic factors in relation to sun behaviours. However, questions about outdoor work were only a small part of the survey, and details such as type of work, sun-related policies in the workplace and specific details of head covering and protective clothing were not captured. While the survey was designed to be representative of the Canadian adult population, certain groups are under-represented, including non-Caucasians, those born outside Canada and those with lower levels of attained education. As a result, the sample may not be truly representative of the outdoor worker population.

NSS2 results suggest that 5,410,213 Canadians aged 16–64 (26%) may be required to work outdoors in the summertime. The high levels of sun exposure and low levels of protection among outdoor workers are of concern because of the strong link between excessive sun exposure and increased risk of skin cancer and some other diseases. These risks are at least partly associated with cumulative, lifetime exposure to ultraviolet radiation; for those who work outdoors during the summer, when the sun's rays are strongest, work time sun exposure likely contributes substantially to overall lifetime dose.

These findings confirm the need for strategies aimed at outdoor workers to reduce time in the sun, including increased use of sun protection during both work and leisure time. In order to be effective, these strategies must include both enhanced workplace policies and practice, and increased individual use of sun protection. The Canadian Dermatology Association (CDA) currently recommends that employers schedule outdoor work tasks to limit midday sun exposure and provide employees with both structures to create shade and personal protective equipment (such as wide-brimmed hats, protective clothing with a high ultraviolet radiation protection factor, and broad-spectrum sunscreen with a sun protection factor of 30 or greater). The CDA also recommends that outdoor workers protect themselves by limiting their sun exposure at work as much as possible, including seeking shade during work breaks; wearing personal protective equipment throughout the workday; and using sunscreen, including reaplication when appropriate.

Further, since young adults are most likely to have outdoor jobs, spend extended time in the sun and use the least protection, strategies that are geared specifically to them should be developed.

**REFERENCES**

WORK-TIME SUN BEHAVIOURS AMONG CANADIAN OUTDOOR WORKERS


RÉSUMÉ

Notre étude vise à décrire les comportements au soleil liés au travail, en été, chez les travailleurs extérieurs canadiens. Nous avons recueilli des informations sur le temps passé au soleil et l’utilisation d’une protection solaire au travail durant l’été 2006 auprès de 1 337 travailleurs extérieurs âgés de 16 à 64 ans dans le cadre de la Deuxième Enquête nationale sur l’exposition au soleil. Les proportions (et les intervalles de confiance de 95 %) ont été estimées par des méthodes convenant aux enquêtes complexes. Vingt-six p. cent des Canadiens, 39 % des hommes et 33 % des personnes de 16 à 24 ans travaillent dehors l’été. Bien que 41 % passent quatre heures ou plus par jour au soleil au travail, un peu plus de la moitié seulement se protègent toujours ou souvent en se couvrant la tête (58 %), en portant des vêtements de protection (56 %) ou des lunettes de soleil (54 %), et à peine 29 % appliquent un écran solaire. Les hommes et les personnes de 16 à 24 ans passent le plus d’heures de travail au soleil, mais sont les moins susceptibles de se protéger. La prévalence du travail à l’extérieur et des comportements au soleil varie d’une région à l’autre. Les résultats de cette étude confirment le besoin de stratégies pour réduire le temps passé au soleil et pour augmenter l’utilisation d’une protection solaire par les travailleurs extérieurs. Pour être efficaces, ces stratégies doivent améliorer à la fois les politiques et les pratiques en milieu de travail et l’utilisation individuelle des mesures de protection solaire.

Mots clés: travailleurs extérieurs; exposition au rayonnement solaire; tumeurs de la peau
ABSTRACT

The current paper summarizes relevant recent research on the high risk of recurrence, multiple skin cancers and second primary cancers in the growing number of people with a history of skin cancer; the ultimate purpose is to better assess the burden of malignancy following skin cancer.

A number of challenges exist in identifying and tracking both melanoma and non-melanoma skin cancer (NMSC) cases. Most jurisdictions do not routinely track NMSC cases and, even if they do, it is customary to only include the first diagnosis. There are variable rules for counting multiple melanoma cancers, and recurrences are not considered for either major type of skin cancer. Applying insights from recent studies of this issue to Canadian cancer statistics would increase reported diagnoses of NMSC by about 26% and melanoma by 10% in this country. This approach to a fuller assessment of the burden of skin cancers has been called a “diagnosis-based incidence approach” as compared with a “patient-based incidence approach”. A further issue that is not usually taken into account when assessing the burden of skin cancers is the 20% to 30% elevated risk of non-cutaneous second primary cancers following a primary skin tumour.

In summary, individuals with skin cancer are subject to a high risk of recurrence, multiple skin cancers and second primary cancers. This burden should be a special concern in the large and growing pool of individuals with a history of skin cancer, as well as among prevention planners.

Key words: Skin neoplasms; second primary neoplasms; recurrence; prevention & control

Skin cancers are the most common form of cancer. Current estimates suggest that 78,250 Canadians will be given a diagnosis of skin cancer in 2009, and that 1,200 will die from the disease. This represents 31.8% of the new cases of cancer in the country each year but just 1.6% of deaths due to cancer. The vast majority (93.7%) of skin cancers are non-melanoma skin cancers (NMSC), the balance of cases being cutaneous malignant melanoma (hereafter referred to as melanoma). Whereas it is relatively common for melanoma to turn deadly, the mortality rate of NMSC has been estimated at just 0.4%.

The combination of high incidence and generally successful treatment, and therefore high survival rates, has led to a large and growing population with a history of skin cancer. This especially applies to NMSC. In New Brunswick, the lifetime risk of having basal cell carcinoma and squamous cell carcinoma, the two most common types of NMSC, has been calculated at 13% and 5%, respectively. In Manitoba, 2.9% of people 20 years and older living in that province on December 31, 2004, had been given a diagnosis of NMSC between 1984 and 2004 (personal communication: Drs. Alain Demers and Zoann Nugent, CancerCare Manitoba, July 17, 2009).

The impact associated with the incidence and prevalence of skin cancer is substantial; however, the full burden related to skin cancer in Canada is, in fact, higher still. Specifically, there is an elevated risk of various categories of subsequent cancer following a primary skin cancer. This includes the risk of a) recurrence, b) a multiple skin cancer of the same type or c) a second primary cancer (SPC). The plan of this paper is to provide a summary of relevant recent research on the high risk of recurrence, multiple skin cancers and SPCs among individuals with a primary skin cancer, with the ultimate aim of better assessing the burden of malignancy associated with skin cancer.

Definitions

A recurrence is defined as a cancer that represents a re-emergence of the original malignancy (see Figure 1). In its simplest manifestation, recurrence refers to a cancer (such as a skin tumour) that reappears at a site after an attempt to remove it by surgery or some other means. Recurrences are sometimes classified as a local recurrence, a regional recurrence (usually related to lymph node metastases) or a distant recurrence (metastases in other organs).

A multiple skin cancer is clinically different from a recurrence. Although similar to a local recurrence in that it appears in the same type of skin tissue as the original tumour (e.g., basal cells, squamous cells or melanocytes), a multiple skin cancer is defined as a tumour found at a different site and/or after a delay in time. The most commonly used term for a multiple primary cancer in melanocytes is “multiple primary melanoma”.

The issue of timing of multiple skin cancers is most relevant in the case of a new tumour developing in the same tissue at or near
the site of the original skin tumour. According to the rule adopted for the Surveillance, Epidemiology and End Results (SEER) program in the US, for a newly identified invasive tumour to be classified as a multiple skin cancer it must emerge 60 days or more after the first primary; otherwise, it should be considered a local recurrence.5

An SPC arises independently as a new primary in a different tissue and/or body site, rather than having spread (or metastasized) to that area from an original primary tumour.6 Second primaries following skin cancer fall into two broad categories: second primary skin cancers (e.g., a melanoma following a case of basal cell carcinoma) and second primaries in an organ other than the skin.

### Challenges in tracking skin cancers

In Canada, counts of cancer incidence (including melanomas) are kept by the various provincial/territorial cancer registries, which obtain their data from a variety of sources and may use different approaches to coding and recording instances of, for example, multiple skin cancers.7 To address this variation, Statistics Canada assembles two files with the information it receives from the provincial/territorial cancer registries. The first is the Canadian Cancer Registry tabulation master file. This file includes data based on a mix of rules used by the Canadian Cancer Registry and the International Agency for Research on Cancer (IARC) to determine multiple skin cancers. The second file is the IARC master file, which is ultimately used in preparing and disseminating Canadian cancer statistics (for example, those included in Cancer Surveillance Online).

IARC coding rules tend to be conservative in terms of counting multiple cancers. Comparison between the IARC approach and, for example, the SEER approach indicates that the difference in capturing multiple primary cancers has the greatest impact on the incidence rates of breast, colon and melanoma cancer. Various researchers have found that using the SEER approach increases the number of melanoma cases by 2.0%, 3.7% and 4.0%/5.2%.

### Second primary cancer

As noted earlier, SPCs following skin cancer fall into two broad categories: second primary skin cancers (e.g., a melanoma following a case of basal cell carcinoma) and second primaries in an organ other than the skin.

![Figure 1. Terminology for cancer subsequent to a primary skin tumour](image)

**Table 1. Percentage of Basal Cell Carcinoma and Squamous Cell Carcinoma After a Primary Diagnosis, by Sex and Age Group**

<table>
<thead>
<tr>
<th></th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basal cell carcinoma</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0-39</td>
<td>0.0%</td>
<td>0.0%</td>
</tr>
<tr>
<td>40-59</td>
<td>2.4%</td>
<td>18.6%</td>
</tr>
<tr>
<td>60-79</td>
<td>36.5%</td>
<td>41.8%</td>
</tr>
<tr>
<td>≥80</td>
<td>59.0%</td>
<td>22.6%</td>
</tr>
<tr>
<td>All ages</td>
<td>32.7%</td>
<td>31.3%</td>
</tr>
<tr>
<td>Squamous cell carcinoma</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0-39</td>
<td>0.0%</td>
<td>0.0%</td>
</tr>
<tr>
<td>40-59</td>
<td>0.0%</td>
<td>0.0%</td>
</tr>
<tr>
<td>60-79</td>
<td>0.0%</td>
<td>0.0%</td>
</tr>
<tr>
<td>≥80</td>
<td>55.6%</td>
<td>21.4%</td>
</tr>
<tr>
<td>All ages</td>
<td>17.2%</td>
<td>11.3%</td>
</tr>
</tbody>
</table>

Source: Stang A, Ziegler S, Buchner U, et al.17

and 2004, Francken and co-authors found that, on average, 6.6% of melanomas are, in fact, recurrences that would not be captured in cancer registries according to standard rules.11

A final issue with respect to tracking melanoma cases in Canada is the fact that the number of melanoma cases in the Quebec cancer registry is underestimated by 35%, because of that province’s dependence on hospital data for tracking melanoma cases, as noted in Canadian Cancer Statistics 2008.12,13

The challenges associated with tracking NMSCs are even more substantial than those related to melanomas. Indeed, few cancer registries routinely track NMSCs, in part because of their frequent occurrence coupled with a high rate of successful treatment.14 Estimating the true incidence of NMSCs in Canada is therefore difficult. Even if NMSCs are recorded, only the first diagnosis is usually included.3,15 Yet individuals with an initial case of squamous cell carcinoma, for example, have a 16-fold increased risk that another skin cancer of the same type will develop.16 The absolute impact of the elevated risk is notable. Research by Stang and colleagues from Germany suggests that, within a five-year period after the original diagnosis, more than 30% of basal cell carcinomas and 14% of squamous cell carcinomas are a second or subsequent skin cancer of the same type, as indicated in Table 1.17 The difference is particularly relevant in elderly populations, where as many as one third to half of all NMSC may be a recurrent or multiple skin cancer.

### A more comprehensive estimate of the burden of skin cancers in Canada

Adjusting for these various challenges leads to a more complete assessment of the burden of skin cancer that is consistent with adopting a “diagnosis-based incidence approach” as compared with a “patient-based incidence approach.”17 A patient-based incidence approach leads to a significant underestimate of the true burden of skin cancers in the population, since both recurrences and SPCs will be undercounted. A recent Canadian report has estimated that a diagnosis-based incidence approach would raise the estimated number of NMSC in 2009 from 73,300 to 92,200, representing a 26% increase. A similar approach for melanoma would result in 5,460 diagnoses in 2009 rather than the 4,950 estimated using a patient-based approach (an increase of 10%).1
than the skin. The elevated risk of another type of skin cancer following a first primary skin cancer has been well demonstrated. For example, according to various studies an individual with an NMSC has a 2.4 to 3.0 times higher risk of a melanoma, and those with a melanoma have a 3.5 times elevated risk of an NMSC. The topic of SPCs outside of the skin is less well known but arguably of clinical importance from the perspective of surveillance and secondary prevention, as it points to another aspect of the combined cancer burden linked to skin cancer and its risk factors.

Table 2 summarizes the standardized incidence ratio of a non-cutaneous SPC after a first primary skin cancer. The data included in the summary represent the most substantial population-based studies published to date. Only data indicating statistically significant elevation (or reduction) in risk are noted in the table. To offer some scale of relevance, the inventory of SPCs is ordered in terms of decreasing disease burden (as measured by potential years of life lost across the population for each cancer). Individuals with melanoma have a 27% increased risk of acquiring an SPC compared with the general population. For individuals with squamous cell carcinoma and basal cell carcinoma, the increase in risk is approximately 30% and 19%, respectively.

The specific SPC associations observed by Wassberg et al. (with squamous cell carcinoma) and Milan et al. (with basal cell carcinoma) are consistent with numerous other reports. The variety of SPCs associated with squamous cell carcinoma and basal cell carcinoma is much greater than found with melanoma. Non-cutaneous SPCs with elevated risk following melanoma appear to be limited to non-Hodgkin’s lymphoma, kidney cancers in males and oral cancers in females. It should be noted that this recent inventory of SPCs following melanoma is smaller than the list identified by some older studies.

Table 2. Standardized Incidence Ratio (95% Confidence Interval) of Non-Cutaneous Second Primary Cancers at Elevated and Reduced Risk Following First Primary Skin Cancers, by Sex

<table>
<thead>
<tr>
<th>Second Primary Cancer</th>
<th>Melanoma</th>
<th>Squamous Cell†</th>
<th>Basal Cell‡</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Males</td>
<td>Females</td>
<td>Males</td>
</tr>
<tr>
<td>Lung</td>
<td>0.65 (0.47-0.86)§</td>
<td>1.7 (1.5-2.0)</td>
<td>1.7 (1.5-2.0)</td>
</tr>
<tr>
<td>Colon</td>
<td>1.3 (1.1-1.4)</td>
<td>1.2 (1.0-1.5)</td>
<td>1.30 (1.15-1.46)</td>
</tr>
<tr>
<td>Rectum</td>
<td>1.2 (1.1-1.4)</td>
<td>1.4 (1.1-1.7)</td>
<td>1.37 (1.11-1.66)</td>
</tr>
<tr>
<td>Female breast</td>
<td>1.8 (1.5-2.3)</td>
<td>2.0 (1.5-2.8)</td>
<td>1.50 (1.27-1.75)</td>
</tr>
<tr>
<td>Non-Hodgkin’s lymphoma</td>
<td>1.48 (1.26-1.72)*</td>
<td>1.32 (1.10-1.56)*</td>
<td>1.22 (1.15-1.29)</td>
</tr>
<tr>
<td>Leukemia</td>
<td>1.8 (1.3-2.3)</td>
<td>1.8 (1.1-2.9)</td>
<td>1.22 (1.15-1.29)</td>
</tr>
<tr>
<td>Prostate</td>
<td>1.2 (1.1-1.4)</td>
<td>1.4 (1.1-1.7)</td>
<td>1.23 (1.04-1.43)</td>
</tr>
<tr>
<td>Stomach</td>
<td>2.11 (1.39-3.07)§</td>
<td>2.1 (1.1-3.5)</td>
<td>1.17 (1.04-1.30)</td>
</tr>
<tr>
<td>Kidney</td>
<td>3.06 (1.58-5.35)§</td>
<td>3.5 (1.3-7.7)</td>
<td>1.88 (1.07-3.05)</td>
</tr>
<tr>
<td>Esophagus</td>
<td>2.8 (1.4-5.0)</td>
<td>4.28 (3.02-5.90)</td>
<td>2.49 (1.62-3.64)</td>
</tr>
<tr>
<td>Bladder</td>
<td>2.2 (1.4-3.2)</td>
<td>2.9 (1.2-5.7)</td>
<td>1.40 (1.12-1.72)</td>
</tr>
<tr>
<td>Oral</td>
<td>1.2 (1.0-1.5)</td>
<td>1.4 (1.1-1.8)</td>
<td>1.82 (1.20-2.64)</td>
</tr>
<tr>
<td>Nasopharynx/sinus</td>
<td>2.3 (1.4-3.5)</td>
<td>2.3 (1.4-3.5)</td>
<td>1.34 (1.05-1.67)</td>
</tr>
<tr>
<td>Hypopharynx/pharynx</td>
<td>5.3 (3.2-8.3)</td>
<td>6.1 (2.9-11.2)</td>
<td>4.28 (3.02-5.90)</td>
</tr>
<tr>
<td>Multiple myeloma</td>
<td>2.1 (1.1-2.4)</td>
<td>1.3 (1.2-1.4)</td>
<td>2.06 (1.03-3.67)</td>
</tr>
<tr>
<td>Cervix</td>
<td>4.6 (3.6-5.7)</td>
<td>10.5 (6.3-16.4)</td>
<td>2.07 (1.75-2.43)</td>
</tr>
<tr>
<td>Hodgkin’s disease</td>
<td>1.27 (1.19-1.35)§</td>
<td>1.26 (1.15-1.38)§</td>
<td>1.20 (1.17-1.24)</td>
</tr>
</tbody>
</table>

Sources: * Lens & Newton-Bishop† Adapted from Wassberg et al.‡ Adapted from Milan et al.*

Potential Role of Human Papillomavirus

A review of the data in Table 2 suggests a key clustering of elevated risks among both males and females in head and neck cancers (salivary gland, nasopharyngeal, lip, oral) and, among females, in anogenital cancers (cervix, vagina, vulva). This is suggestive of an association with human papillomavirus and possibly with tobacco consumption (especially in head and neck cancers).

Human papillomavirus is not a single entity. Over 100 types of the virus have been characterized to date. All human papillo-
mavirus types are marked by an affinity for one or other of two categories of epithelial tissues: almost half of the known human papillomavirus types have a tropism for the skin, and the balance have an affinity for the mucosal epithelia in the anogenital and head and neck regions of the body. About 20 of the skin-oriented human papillomavirus types have been implicated in the development of skin cancer. The mechanisms involved in an initial skin infection with one of these viral types may also increase the risk of a persistent infection with other human papillomavirus types elsewhere in the body. The additional human papillomavirus infections include those associated with tumours in the anogenital and head and neck regions; this could explain the elevated risk of non-skin second primaries in these regions following skin cancer. The implication is that prevention efforts related to the human papillomavirus, including recently implemented vaccines, could be an important part of controlling certain SPCs after skin cancer.

Protective Effect?
The decreased risk following melanoma for lung and liver cancers observed by Crocetti et al. (seen bolded results in Table 2) is consistent with some other research. For example, studies by Soerjomataram and colleagues in the Netherlands suggest a decreased risk of prostate, colorectal and breast cancers following a diagnosis of skin cancer. A mechanism posited to explain this phenomenon involves the connection between sun exposure and vitamin D production, and a consequent decreased risk of solid internal tumours. However, the reliability of the basic conclusion about a protective effect has been questioned by other researchers. In fact, there are studies that have found no reduction in risk for carcinomas of the prostate, colon or breast following melanoma. Furthermore, research in Switzerland actually detected an increased risk of cancers of the breast (standardized incidence ratio of 1.18; CI=1.08-1.30), colon (1.15; CI=1.06-1.25) and prostate (1.20; CI=1.11-1.29) following a histologically confirmed diagnosis of skin cancer. The mixed results suggest that further investigation is required. The posited protective effect has public health implications. Evidence of such an effect, even if not confirmed, could lead to a reduction in sun protection behaviours, as has recently been observed in Australia.

Clinical and public health implications
Individuals with skin cancer are at a high risk of recurrence, of multiple skin cancers and of SPCs. This burden, including the 20% to 30% higher risk of non-cutaneous SPCs, should be a special concern in the large and growing pool of individuals with a history of skin cancer. The data presented in this paper point to three priorities:

- The need for additional research in a number of areas, including the relationship between human papillomavirus infection and SPC following skin cancers and the posited "protective" relationship between skin cancers and certain solid organ tumours.
- Enhanced risk factor control and secondary prevention measures among individuals with skin cancer in order to reduce the additional burden specific to SPC development. While the risk of an SPC does decline with time after certain types of skin tumour, surveillance and protective behaviours continue to be important throughout the life of an individual with a history of skin cancer.
- An increased emphasis on primary prevention of known risk factors for skin cancer in order to reduce the combined burden associated with first primary skin cancers, recurrences, multiple skin cancers of the same type, and SPCs in a different tissue from the first primary.

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22. Canadian Cancer Society’s Steering Committee. Table W1: Potential Years of Life Lost Due to Cancer (Web-only Content). Available at: www.cancer.ca/statistics (Accessed February 16, 2010).


**RÉSUMÉ**

Cet article résume les récents travaux de recherche sur le risque élevé de récurrence, les cancers de la peau multiples et les seconds cancers primitifs chez le nombre croissant de gens ayant eu un cancer de la peau, ceci afin de mieux évaluer le fardeau des tumeurs malignes après un cancer de la peau.

Recenser et suivre les cas de cancer de la peau, tant les mélanomes que les non-mélanomes (NM), présente des difficultés. La pluspart des autorités ne font pas le suivi systématique des cas de NM; même lorsqu’elles le font, elles n’incluent d’habitude que le premier diagnostic. Il y a différentes règles pour compter les mélanomes multiples, et l’on ne tient pas compte des récurrences pour les deux grands types de cancer de la peau. Si l’on appliquait aux chiffres canadiens sur le cancer les éclairages apportés par les études récentes sur la question, on augmenterait d’environ 26 % les diagnostics déclarés de NM et de 10 % les diagnostics déclarés de mélanome au Canada. Cette évaluation plus globale du fardeau des cancers de la peau s’appelle « approche de l’incidence fondée sur le diagnostic », par opposition à une approche fondée sur les patients. Un autre aspect dont on ne tient généralement pas compte lorsqu’on évalue le fardeau des cancers de la peau est le risque de 20 % à 30 % plus élevé de second cancer primitif non cutané après une tumeur primitive de la peau.

Pour résumer, les sujets ayant un cancer de la peau présentent un risque élevé de récurrence, de cancers de la peau multiples et de second cancer primitif. Ce fardeau devrait être un sujet de préoccupation pour le bassin vaste et grandissant des sujets ayant eu un cancer de la peau, ainsi que pour les planificateurs en prévention.

**Mots clés :** tumeurs de la peau; secondes tumeurs primitives; récurrence; prévention et contrôle.
The Skin Cancer Prevention Framework: A Comprehensive Tool for Population-level Efforts in Skin Cancer

J.A. Petersen, MSc, S.D. Quantz, BA, F.D. Ashbury, PhD, J.K. Sauvé, MSc

ABSTRACT

The Skin Cancer Prevention Team (SCPT) required a comprehensive approach for guiding its efforts in population-level skin cancer prevention. After identifying and reviewing several models, it concluded that an appropriate population-level model applicable to the Alberta context did not exist. Thus, the SCPT, under the Alberta Health Services – Cancer Prevention Program, developed and evaluated a model for Alberta. Three inclusion criteria for a comprehensive framework were identified: 1) use an ecological approach to population health; 2) function as a dynamic tool for planning, implementing and evaluating population-level efforts; and 3) address weaknesses in existing theory in population health and health promotion. Theoretical constructs were layered together, on the basis of the criteria, to develop an omnibus framework. The resulting Framework represents a layering of several constructs used in popular health promotion and population health theories. It merges principles of the realist approach to scientific enquiry with principles of ecological theory. The Framework outlines a three-step, dynamic process for planning, implementing and evaluating population-level efforts. It also provides insight into the larger, unifying influences for changes in health outcomes and the complex mechanisms of behaviour change processes at the population level.

Key words: Skin cancer; prevention; population health; health promotion; population health intervention; theory

Corinne Parker, Lisa Petermann, Graham Petz and Silvana Lawvere for their hard work and support with this report.

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Conflict of Interest: None to declare.
complex interventions to bring about change at the community level. In the past, several community intervention efforts that focused on behaviour change related to chronic disease prevention have been implemented with comparatively limited success. Taking into account these findings, the SCPT determined that the framework must incorporate ecological theory to facilitate change contingent upon context. Understanding the intervention in context facilitates interpretation of its potential impact. Second, the comprehensive model must provide a process for moving through different and dynamic stages of prevention activities (planning, implementation and evaluation). Finally, the framework should account for weaknesses in previous theories and models developed for population health approaches. This article is not intended to be a systematic review of existing models. It focuses on how this Framework was developed and, most importantly, explains its utility in skin cancer prevention efforts at the population level.

METHODS

Development and design of the Skin Cancer Prevention Framework

The SCPT studied existing skin cancer prevention models, as well as popular theory in health promotion and population health. This included a close examination of popular planning tools, such as PRECEDE-PROCEED, the Population Health Template working tool, as well as ecological theory, social change theory, complexity theory, the population health model, the transtheoretical model, the theory of planned behaviour, social cognitive theory and realist theory. The SCPT Framework was developed through an evolutionary process, whereby different theoretical constructs were integrated and evaluated on the basis of three criteria: 1) determine which planning frameworks best fit our needs; 2) determine which combinations of the different planning frameworks were most suitable and theoretically sound; and 3) assess the feasibility of the comprehensive framework for program development and planning. Specific theoretical constructs were included according to their recognition of the factors influencing population-level health outcomes and their meaningfulness with respect to skin cancer prevention. Constructs that focused solely on individual-level behaviour change were excluded. The elements of these theories and planning frameworks, as seen in Figure 1, were selected to guide, provide support for and inform the development of the Framework. The resulting Framework is described in more detail in the next section.

RESULTS

The Skin Cancer Prevention Framework

The model, entitled the “Skin Cancer Prevention Framework” (Figure 1), is the result of a series of discussions and critical appraisal by the SCPT. This section describes the Framework, including the existing models/theories that were used in its creation and at what stage.

Realist-Ecological Perspective

The realist perspective asserts that the “same” intervention can never be implemented in a manner identical with what was originally intended and that the particular plan for success in one context may not work in another. Consistent with the realist perspective, the ecological perspective emphasizes the interaction between, and the interdependence of, the different factors within and across all levels of a health issue. Ecological theory defines the linkages between communities of people and the social environment, and it helps identify the broad determinants that influence population health outcomes. Both the realist and ecological perspectives are congruent in emphasizing interdependencies in the social environment. The SCPT emphasized using this realist-ecological perspective to fill the void of other theoretical approaches, as discussed earlier.

How to Use the Framework

On the basis of the Population Health Template, the SCPT selected three key process steps to guide population health interventions: 1) defining the problem, 2) situational analysis and 3) program development: planning, implementation, evaluation. The nature of this three-step approach is dynamic and intended to be sufficiently flexible to respond to new evidence, changes in population demographic characteristics, changes in policy direction, and existing socio-cultural conditions. For all three steps the Framework drew on the realist-ecological perspective with its emphasis on sit-
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three questions: 1) What should we take action on? 2) How should we take action? and 3) With whom should we act? With regard to the first question, the Framework focused on skin cancer prevention and was based on previous models (i.e., the WHO model, PRECEDE-PROCEED model).

With respect to how we should take action, we realized that the role of the health sector in skin cancer prevention, diagnosis and care was crucial. The prevention of skin cancer is a responsibility that is shared by all. Alberta Health Services recognized the importance of the role health practitioners have in the prevention, diagnosis and care of skin cancer and the role of the person in self-education and self-management; it also recognized its own role to facilitate skin cancer prevention within and across sectors, social settings and groups.

With respect to the third question, in accordance with previous models from Australia we decided to incorporate and discuss the social environment as relationships between the different players involved in the intervention (i.e., local government, manufacturers, health care workers, schools, media, workplaces, communities).

Now that there was more of a focus on population health, health promotion and population-based interventions, a literature review was conducted. In gathering information about the health problem and potential solutions, it is important to conduct a realist review of the literature. Traditional systematic reviews, in contrast with the realist review process, follow a formalized review protocol to achieve a high degree of reliability. A realist review is an iterative process and is more flexible in making comparisons and combining theoretical thinking about interventions with empirical evidence for understanding how others might implement an intervention within their own environmental context.

1. Defining the problem

The Population Health Template started by affirming that a population health approach assesses the health of the population over the lifespan at an aggregate level. It implied that before any in-depth analysis of the determinants of a particular health issue was undertaken it was important to define health status and health status inequities. Furthermore, it was important to determine indicators for analyzing health status and health inequities in addition to assessing contextual factors. The first step of the Framework was to define the problem according to two questions implicit in the Population Health Template: 1) “What are the incidence and mortality rates of skin cancer and are they changing?” and 2) “Who is getting skin cancer?” These questions were addressed at regular intervals through ongoing surveillance activities in a population, to monitor progress and adapt programs and policies as needed.

A realist-ecological perspective was crucial at this step, since the factors identified as causes of the problem depend on which lens you are viewing it through. The social environment was a key factor that needed to be examined in order to understand the nature of the problem and develop an accurate picture of the context in which an intervention for skin cancer prevention could be developed.

2. Situational analysis

Once the parameters of the problem had been established, an in-depth examination of its elements was conducted. The Alberta Health Services – Cancer Prevention Program conducted a situational analysis, which is defined as “a strategic, multi-layered analytic process assessing community profiles, literature reviews and best-practice scans to identify gaps that will then direct various initiatives in chronic-disease prevention”.

Several categories of information were collected: community profiles, information from a literature review and best practice scan, and asset maps (“maps” of existing programs, policies and services throughout a defined geographic area); these were then subject to systematic layering and critical analysis, called a needs assessment.

This step in the Framework was primarily influenced by Population Health Promotion: An Integrated Model of Population Health and Health Promotion (PHP). To avoid confusion, it is important to point out that this model is different from the Population Health Template. The PHP is a resource for understanding the intersection between population health and health promotion, and a guide for population-based interventions. The model attempted to answer three questions: 1) What should we take action on? 2) How should we take action? and 3) With whom should we act?

With respect to the third question, the Framework included three evaluation components: 1) the evaluation assessment, which includes a participatory method for developing the plan in collaboration with stakeholders; 2) the RE-AIM framework for outcomes and indicators; and 3) process, impact and outcome evaluation, based on the PRECEDE-PROCEED framework. An evaluation plan and evaluation resources must be identified and implemented at the outset of program planning.

Thurston and Potvin proposed that an evaluation plan for a social change program requires a similar process to that used in planning and implementing a program. They further described the term “evaluation” as “a feedback system between the program and its environment”. An important purpose of this feedback system is to produce information that facilitates local program improvement and decision-making. Furthermore, the approaches adopted for

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evaluation must be relevant to the work of those coordinating the intervention. To ensure that the components to be evaluated will be valued by the stakeholders, an evaluability assessment should be conducted. This can be described as “a set of procedures for planning evaluations so that stakeholders’ interests are taken into account in order to maximize the utility of the evaluation”. The Framework incorporated this assessment as the first step in conducting an evaluation of skin cancer prevention programs in Alberta, to ensure that the stakeholders involved would find the information from the program evaluation valuable.

In the Framework, as the evaluability assessment took place the RE-AIM evaluation framework23 (Reach, Efficacy/Effectiveness, Adoption, Implementation and Maintenance) acted as the guide for what should be evaluated in an intervention. RE-AIM also fits well within the realist paradigm, as a primary focus is to assess the “real world” impact of research and its applicability in applied settings. Reach refers to the percentage of participants involved and how representative they are of the target population. Efficacy/effectiveness refers to the intended impacts of an evaluation, as well as the possible unintended consequences of the intervention on quality of life and expected health outcomes. Adoption refers to the participation rates and representativeness of the settings (e.g., workplaces, schools) and the adoption agents (employers, teachers, principals, etc.). Implementation refers to the extent to which various components of an intervention are delivered as intended in real-world evaluations. Finally, Maintenance refers to the long-term impact as well as the sustainability of an intervention.23 RE-AIM is especially useful in evaluating population health interventions, in that it hypothesizes that the overall impact of an intervention is a function of all five components. Furthermore, it takes into account individual behavioural outcomes, as well as outcomes at the setting or environment level.

According to PRECEDE-PROCEED, a population-level intervention can be evaluated at three different levels: process, impact and outcome. The three different levels of evaluation are to be conducted at different stages in the intervention’s implementation; thus each level has different types of indicators, as well as different ways of collecting data. These indicators and methods selected to collect data should be identified in the first two stages of the evaluation process.9

DISCUSSION AND APPLICATION

The dramatic increase in skin cancers in Alberta has precipitated an urgent need for effective solutions. The absence of integrated, theory-guided, evidence-informed approaches to skin cancer prevention led the SCPT to develop a comprehensive framework for planning, implementing and evaluating skin cancer prevention initiatives. The SCPT’s Framework is complementary to the models designed by the WHO and CDC for the prevention of skin cancer. Yet a fundamental difference is that it was founded on theories of behaviour change and health promotion that coincide with a situational analysis of current population health initiatives at multiple levels (i.e., national, provincial, regional and community-based). An examination of these initiatives in terms of their relative successes and weaknesses provided insight into the larger unifying influences of behaviour changes on health outcomes and the complex mechanisms that mediate change processes at the population level. This Framework can be used to guide the development of a specific skin cancer intervention, or it may be used by other cancer control agencies to develop strategic and long-term plans in skin cancer prevention.

As pointed out earlier, this article is not intended as a systematic review, neither is it intended as an original piece of research. Its contribution is an attempt to describe the process that the SCPT has identified as a guide for thinking through how to improve skin cancer outcomes in a large population affected by complex contextual factors. The SCPT will evaluate the effectiveness of the Framework to understand its impact on skin cancer prevention and its ability to be sufficiently flexible to respond to changing conditions (e.g., changes in population demographic characteristics, policies and available services). The Framework was built on existing resources and community development efforts, and therefore should easily be assimilated into broader population health strategies. It required sufficient multidisciplinary resources to facilitate planning, implementation and evaluation (i.e., the situational analysis, asset mapping and literature review, evaluability assessment, population health promotion, evaluation framework, surveillance and monitoring, and evaluation). This tool may have been limited by the availability of skills and expertise to undertake the essential components of the planning, implementation and evaluation step. It may be adapted to other population health problems that require a comprehensive framework to address population health issues. The strengths of the SCPT’s Framework are its reliance on existing evidence and an integration of population health assessment and behaviour change theories that are sensitive to individual, sociocultural, demographic, community and socio-political environments.

REFERENCES

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RÉSUMÉ

Notre équipe de prévention du cancer de la peau (ÉPCP) avait besoin d’une approche globale pour orienter ses efforts de prévention du cancer de la peau axés sur la population. Après avoir recensé et examiné plusieurs modèles, elle a conclu qu’il n’existait pas de modèle axé sur la population pouvant s’appliquer au contexte de l’Alberta. L’ÉPCP, dans le cadre du programme de prévention du cancer des Services de santé de l’Alberta, a donc mis au point et évalué un tel modèle. Nous avons cerné trois critères d’inclusion pour un cadre global. Celui-ci devait : 1) aborder la santé des populations selon une approche écologique; 2) fonctionner comme un outil dynamique de planification, de mise en œuvre et d’évaluation des efforts axés sur la population; et 3) tenir compte des faiblesses des théories actuelles en santé des populations et en promotion de la santé. Les construits théoriques ont été stratifiés, d’après ces critères, pour former un cadre composite. Le cadre résultant est une stratification de plusieurs construits utilisés dans les théories populaires en promotion de la santé et en santé des populations. Il fusionne les principes de l’approche réaliste de la science et les principes de la théorie écologique. Il définit un processus dynamique en trois étapes : planifier, mettre en œuvre et évaluer les efforts axés sur une population. Il donne aussi un aperçu des grands facteurs qui influencent globalement les changements dans les résultats sanitaires, ainsi que des mécanismes complexes des changements de comportement à l’échelle d’une population.

Mots clés : cancer de la peau; prévention; santé des populations; promotion de la santé; intervention en santé des populations; théorie...