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Tanning and skin cancer: a brief review

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Summary

- The prevalence of intentional solar tanning in Canada ranges from 4 to 49% depending on age and sex. The prevalence of tanning using artificial tanning devices in Canada ranges from 4 to 27% depending on age and sex. Both solar and artificial tanning are much more frequent in younger persons and in females.
- Although both solar and artificial ultraviolet radiation is categorized as a human carcinogen by IARC, less is known about the relationship between skin cancer and artificial tanning.
- In a review of available meta-analyses, the use of artificial tanning devices was associated with increased risks for cutaneous malignant melanoma and squamous cell carcinoma, but not basal cell carcinoma.
- In general, skin cancer is more common in individuals who have light skin colour, freckles, skin moles, and easy-to-burn skin that does not tan well. In addition, early-age exposure to ultraviolet radiation (both solar and artificial) was found to further increase the risk of skin cancer.
- Given the current knowledge on cancer risk and sunbed tanning, more comprehensive regulations are needed to control the artificial tanning industry. The suggested focus for regulations include on prohibiting the use of sunbeds by youths, prohibiting claims of health benefit, requiring tanning facilities to provide customers with accurate information conveying the risks of artificial tanning, requiring supervision of tanning devices by trained operators, and discouraging the use of sunbeds for individuals with susceptible skin characteristics.

Purpose

This short review aims to provide a brief introduction to tanning (primarily focused on artificial tanning), tanning prevalence, the relationship between tanning and three major kinds of skin cancer: cutaneous malignant melanoma (CMM), basal cell carcinoma (BCC) and squamous cell carcinoma (SCC), as well as current research and regulatory gaps for sunbed use. In this document, tanning is defined as intentional exposure of skin to ultraviolet radiation (UVR), from both solar and artificial sources, in order to darken the skin colour of the exposed area.

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Ultraviolet radiation

UVR is an invisible electromagnetic radiation with wavelengths longer than x-rays but shorter than visible light.[1] UVR can be further divided into three categories with separate wavelength ranges: UVA (315-400 nm), UVB (280-315 nm) and UVC (100-280 nm).[1] Both UVA and UVB contribute to skin tanning by simulating the production or darkening of melanin molecules in the skin. UVA is responsible for immediate pigment darkening, where skin darkens upon exposure.[1] UVB is responsible for delayed tanning, where new melanin molecules are produced by melanocytes in the skin, in days following exposure.[1] The most significant source of ultraviolet radiation is the sun.[1] Virtually all solar UVC, as well as some solar UVA and UVB are blocked by the Earth's atmosphere.[1] Solar UVR that reaches the surface of the Earth is approximately 95% UVA and 5% UVB at noon, during summertime in subtropical and temperate regions.[2]

Artificial tanning devices

Since the 1960s, artificial UVR emitting devices have been available for cosmetic tanning.[3,4] Artificial tanning devices are commonly referred to as sunbeds, tanning beds, or tanning booths. Unless otherwise specified, the use of the term sunbed in this review is non-specific and may refer to any or all artificial tanning devices.

When first introduced, artificial tanning devices emitted UVR with a similar UVA and UVB ratio as solar UVR (up to 5% UVB).[3] Due to increasing concerns over UVB carcinogenicity in the 1980s and 1990s, predominately high UVA emitting sunbeds were invented and marketed as safe, even though the devices still emitted small amounts of UVB.[3-5] Because UVB is responsible for causing sunburn,[1,6] the reduction of emitted UVB allowed sunbed users to tan much longer without getting sunburns, thus increasing the odds of receiving a larger dose of UVA compared to sunbathing.[5] In the late 1990s, the trend of artificial tanning reverted back to using devices which emitted a more "natural" UVR, again increasing the emitted UVB ratio up to 4%.[3] Recently, in order to achieve more efficient tanning in shorter sessions, high-intensity UVA emitting lamps have been introduced.[3,5] These high intensity sunbeds are capable of emitting up to 10-15 times more UVA compared to midday sunlight.[5]

Today in Canada, due to the lack of technical regulations on artificial tanning devices, a wide variety of tanning devices with different emitted UVR spectra and irradiances are present in the indoor tanning industry and available to sunbed users. As a result, precise UVA/UVB exposure assessments are difficult to perform as part of epidemiologic studies, making it particularly challenging to study the health effects of specific UVA/UVB exposure and to determine if some sunbeds are safer than others.

Prevalence of solar and sunbed tanning

The prevalence of artificial and sun tanning in Canada has been investigated by a few studies (Table 1). In Canada, the prevalence of artificial tanning was found to be between 4 and 27% and the prevalence of intentional sun tanning was between 4 and 49%.[7-11] These values are fairly similar to those found in a large-scale US study conducted by Coups et al.[12] Although the latitudes of most Canadian cities are similar to many cities in Europe, frequencies of sun and artificial tanning are generally lower in Canada compared to those reported in European studies. A notable trend, consistently found in tanning prevalence studies around the world, shows that females and younger individuals are more likely to tan using both the sun and artificial tanning devices. A US survey conducted by the Center for Disease Control (not included in Table 1) found that 8.7% of teens, between the ages of 14 and 17, used sunbeds in the last 12 months.[13] Teen sunbed use increased with age from 14 to 17 years. In addition, girls surveyed were seven times more likely to have used artificial tanning devices compared to boys.[13]

Table 1. *The prevalence of sunbed use and intentional tanning and sun exposure in Canada and other countries*

Reference	Study Location and Period	Sample Size	Tanning Type and Prevalence		Metric
			Solar	Artificial	
Genuis et al. (2009)[7]	Alberta, Canada; 2001-2007	1,433	12%	9.2%	Solar: *lots of sun* in recent sun exposure Artificial: ever used sunbeds
Ontario Sun Safety Working Group (2008)[11]	Nationwide Canada; 2006	7,000+	Average 21% Males 9-28% (age dependent) Females 7-49% (age dependent)	Males 4-8% (age dependent) Females 8-27% (age dependent)	Solar: seeking a tan from the sun in the past year Artificial: used tanning equipment in the past year
Rhainds et al. (1999)[8]	Quebec, Canada; 1991-1996	1,003	-	20.2	Used sunbeds in the last 5 years
Walter et al. (1990)[9]	Ontario, Canada; 1984-1986	608 (controls)	-	Males 14% Females 21%	Ever used sunbeds/sunlamps
Campbell and Bridsell. (1994)[10]	Alberta, Canada; 1984-1994	3,873	Males 20.3% Females 19.4%	-	Spending more than 5 hours per week outdoors during summertime
Coups, et al. (2008)[12]	US; 2004-2005	28,235	19.8-35.4% (age dependent)	7.8-20.4% (age dependent)	Solar: staying in the sun when outside on a sunny day Artificial: indoor tanning device use in the past year
Branstrom et al. (2004)[14]	Sweden; 2000-2001	1,752	44%	35%	Solar: intentional tanning in the past year Artificial: current use of sunbeds
Stott (1999)[15]	Great Britain; 1995-1996	1,858	Males 34% Females 39%	-	Tried to acquire a tan in the last 12 months
Ezzendine et al. (2008)[16]	France; 1996-2001	7,200	Male 68.7% Female 66.1%	Male 6.8% Female 26.4%	Solar: intentional sun exposure during the hottest part of the day (11 am-4 pm) Artificial: ever used sunbed
Borner et al. (2009)[17]	Germany; 2007	1,501	-	Male 23% Female 34%	Ever used sunbed
Branstrom et al. (2010)[18]	International (mostly Europe); 2006-2008	8,178	70.3%		Intentional tanning in the past year

Tanning and skin cancer

Solar tanning and skin cancer

Solar radiation is a well-established human carcinogen, classified by the International Agency for Research on Cancer (IARC) in Group 1 or carcinogenic to humans.[19] Extensive experimental and epidemiological evidence shows that there are causal relationships between excessive exposure to solar UVR and three major kinds of skin cancer: cutaneous malignant melanoma (CMM), basal cell carcinoma (BCC) and squamous cell carcinoma (SCC); for recent reviews, see.[6, 20]

CMM is a malignant tumour of melanocytes in skin. CMM is not the most common type of skin cancer but accounts for most Canadian skin cancer deaths (more than 75%).[21] In Canada, the estimated incidence of CMM was 15.2 per 100,000 in 2009.[21] The Canadian incidence rates of CMM increased by more than 3-fold over the last 35 years.[21, 22] The increase in CCM incidence rates is likely to be associated with better disease detection as well as increased sun-seeking behaviour without adequate UVR protection.[21] Individuals with light skin colour, freckles, skin moles, and easy-to-burn skin that tans poorly have increased risks of CMM compared to individuals without these characteristics.[6, 20] Most epidemiologic studies show that intermittent exposure to solar UVR, rather than total or chronic solar exposure, is associated with increased risks of CMM.[20] Other study findings suggest the timing of exposure is also important. Early life exposure has been associated with higher risks of CMM.[2, 4, 20]

BCC and SCC, also classified as non-melanocytic skin cancer (NMSC), are malignant tumours of the basal cells and squamous epithelial cells of skin, respectively. In Canada, the estimated incidence of NMSC was 227.6 per 100,000 in 2009.[21] Despite the high incidence, NMSC accounts for only 25% of Canadian skin cancer deaths.[21] Studies have shown that early life UVR exposure increases the risks of BCC, whereas chronic or total exposure is associated with increased risks for SCC.[2, 4, 20]

The precise lengths of latency period for CMM and NMSC are difficult to determine because the first solar UVR exposure usually occur early in life and the precise time of initial DNA damage is almost impossible to determine. In the US from 2003 to 2007, the median age of CMM diagnosis was 60 and more than 60% of new cases were diagnosed in individuals over 55 years of age.[31] Similarly, incidence rates of CMM were also found to be the greatest for people over 60 years of age in Manitoba,[32] British Columbia[33] and the UK.[34] For NMSC, the average time of diagnosis was 66.9 for males and 67.8 for females in Canada between 1960 and 2000.[35] During the same period in Canada, 71.7% of all NMSC cases were diagnosed in people aged 60 or older.[35] Compared to CMM, NMSC diagnosis is likely to occur more often in older individuals. One Danish study suggested that CMM incidence rates increase linearly with age while NMSC incidence rates increase exponentially with age.[36]

Artificial tanning and skin cancer

Compared to solar UVR exposure, the association between artificial UVR exposure and CMM, BCC, and SCC is less well-established. Although ultraviolet-emitting tanning devices were recently upgraded by IARC to Group 1: carcinogenic to humans,[19] relatively few well-designed studies have focused on identifying the relationship between sunbed use and skin cancer. Table 2 summarizes recent publications which performed meta-analyses that investigated the association between sunbed use and skin cancer. Overall, statistically significant increased CMM risks were found consistently with the use of artificial tanning devices in all three meta-analyses reviewed. Gallagher et al.[23] reported that a summary odds ratio (OR) of 1.25 (95% CI 1.05-1.49) is associated with ever using a sunbed versus no use of indoor tanning facilities. Increased relative risks (RR) of CMM in sunbed users were also reported by meta-analyses from IARC {RR: 1.15 (95% CI 1.00-1.31)} as well as Gordon and Hirst {RR: 1.22 (95% CI 1.07-1.39)}.[2, 4] Similar to sunlight exposure and CMM, early-age exposure to artificial UVR was found to further increase the risks of CMM,[2, 4, 23]suggesting that artificial and natural UVR may play similar roles in the aetiology of CMM.

Relatively few studies have investigated the risks of NMSC in sunbed users. Overall, the meta-analyses included show that artificial UVR exposure was associated with an increased risk of SCC. Gordon and Hirst reported that the RR of SCC is 1.78 (95% CI 1.19-2.67) for sunbed users compared to non-users.[4] IARC reported an RR of 2.25 (95% 1.08-4.70) for SCC for indoor tanners.[2] Sunbed use was also linked to slightly increased risks for BCC, but the increases were not statistically significant.

Table 2. *Summary conclusions from recent meta-analyses about the cutaneous carcinogenic effect of artificial UVR-emitting tanning devices*

Reference	Disease of Interest	Number of Studies Included (type of study)	Selected Summary Measures (95% CI)
Gallagher et al. (2005)[23]	CMM	10 (9 case-control, 1 cohort)	Overall; ever versus never exposed: OR: 1.25 (1.05-1.49) First exposure as young adult (5 studies): OR: 1.69 (1.32-2.18) Subjects with the longest duration or highest frequency of exposure (6 studies): OR: 1.61 (1.21-2.12)
IARC (2006)[2]	CMM	19 (18 case-control, 1 cohort)	Overall; ever versus never exposed: RR: 1.15 (1.00-1.31) First exposure in youth (7 studies): RR: 1.75 (1.35-2.26) Exposure distant in time (5 studies) RR: 1.49 (0.93-2.38) Exposure recent in time (5 studies) RR: 1.10 (0.76-1.6)
	BCC	4 (case-control)	Overall; ever versus never exposed RR: 1.03 (0.56-1.90)
	SCC	3 (case-control)	Overall; ever versus never exposed RR: 2.25 (1.08-4.70)
Gordon and Hirst (2007)[4]	CMM	21 (20 case-control, 1 cohort)	Overall; ever versus never exposed: RR: 1.22 (1.07-1.39) Women only (6 studies): RR: 1.71 (1.39-2.10) Studies adjusted for confounding (9 studies): RR: 1.36 (1.15-1.61) Studies with more than 100 exposed (10): RR: 1.17 (0.99-1.39) Frequent sunbed users (6 studies): RR: 1.33 (0.92-1.93) First use sunbed under 35 years-old (13 studies): RR: 1.98 (1.60-2.45)
	BCC	5 (case control)	Overall; ever versus never exposed: RR: 1.18 (0.92-1.52)
	SCC	4 (case control)	Overall; ever versus never exposed: RR: 1.78 (1.19-2.67)

Policy and research gaps

Currently, artificial tanning devices in Canada are regulated by the Radiation Emitting Devices Act and Regulations (Tanning Equipment).[24] The Act was amended in 2005 with specific requirements for tanning equipment, which includes the mandatory use of warning labels on new sunbeds and some guidance on sunbed UVR power and spectra output. The Regulations are not retroactive and apply only to tanning equipment sold after the date of promulgation. Further, enforcement of the Regulations is mostly reactive and based on complaints.[25, 26] A set of guidelines published by Health Canada in 2005, *Guidelines for Tanning Salon Owners, Operators and Users*, also contains a number of recommendations for sunbed operators and users.[27] However, since the recommendations in the Guidelines are not legally binding, adherence in the tanning industry largely relies on self-regulation. Current evidence suggests that the tanning industry is not effective at self-regulation.[25, 26]

Given our current knowledge on the link between sunbed use and skin cancer, introducing more comprehensive legislation to control tanning equipment and its use will reduce the public's exposure to artificial UVR and decrease the incidence of skin cancer. The World Health Organization (WHO) has published a list of suggestions for regulating the tanning industry.[28] The key recommendations include: prohibit sunbed use by youths under 18, require the presentation of detailed information and consent forms to sunbed users, prohibit claims of health benefit, require tanning equipment supervision by specially trained operators, and exclude individuals with skin cancer prone characteristics.

On the research front, a few specific challenges are present for studying the carcinogenicity of artificial UVR exposure. Due to the long latency between UVR exposure and skin cancer, the true association between exposure and disease may not be currently detectable since artificial tanning devices were only introduced and popularized in recent decades. Individuals who use sunbeds are also much more likely to have solar UVR exposure,[29, 30] which is a confounding factor for skin cancer. As most investigations on artificial UVR exposure and skin cancer rely on self-reports for past exposure, recall bias from subjects could significantly affect research findings. A non-differential recall bias in cases and controls could lead to a bias toward the null. Conversely, because many subjects are aware that UVR exposure is linked to skin cancer, a recall bias in skin cancer subjects is also possible,[29] leading to a differential bias that would increase the skin cancer risk predicted in a study.

Currently, studies with more accurate exposure assessment and sufficient power are needed to better understand the relationships between artificial UVR exposure and CMM/SCC. Better exposure assessment may be achieved through utilizing a prospective study design, controlling for confounding factors such as solar exposure, and performing actual UVR exposure measurements for subjects. In addition, more research is necessary to investigate the relationship between artificial UVR exposure and BCC, as well as the role UVA plays in the aetiology of skin cancer.

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