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Tanning bed use and melanoma: Establishing risk and improving prevention interventions☆

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ABSTRACT

Purpose. Exposure to ultraviolet radiation (UVR) from indoor tanning devices is thought to cause melanoma and other negative health consequences. Despite these findings, the practice of indoor tanning in the United States remains prevalent. In this paper we aim to present a clear discussion of the relationship between indoor tanning and melanoma risk, and to identify potential strategies for effective melanoma prevention by addressing indoor tanning device use.

Basic procedures. We reviewed relevant literature on the risks of indoor tanning, current indoor tanning legislation, and trends in indoor tanning and melanoma incidence. Study was conducted at the University of Southern California, Los Angeles, CA between the years of 2014 and 2015.

Main findings. Our findings reaffirm the relationship between indoor tanning and melanoma risk, and suggest a widespread public misunderstanding of the negative effects of indoor tanning.

Principal conclusions. This review argues for an aggressive initiative to reduce indoor tanning in the United States, to design prevention efforts tailored towards specific high risk groups, and the need to better inform the public of the risks of indoor tanning.

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Introduction

Since entering the United States in the 1970s, indoor tanning devices now support a $3 billion a year industry (Tanning Salons in the US, 2015). Despite an encouraging small decrease in indoor tanning behaviors noted between 2010 and 2013, a 2013 study from the National Health Interview Survey estimates that 7.8 million women and 1.9 million men in the United States tan indoors each year (Guy et al., 2015). Additional

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reports confirm similar findings (*J. Am. Acad. Dermatol.*, 1985). The high incidence of indoor tanning in the United States remains concerning in the setting of strong evidence in support of an association between the use of indoor tanning beds and melanoma risk (Group IAfRoCW, 2007) (El Ghissassi et al., 2009).

In 2009, as a response to data highlighting the risks associated with indoor tanning, the World Health Organization International Agency for Research on Cancer (IARC) classified ultraviolet light emitted from tanning beds as carcinogenic, and placed artificial sources of ultraviolet radiation alongside tobacco and asbestos in the highest category of carcinogen (El Ghissassi et al., 2009). The Society of Behavioral Medicine issued a position statement calling for a ban on indoor tanning in minors in 2014, and the American Academies of Dermatology and Pediatrics also released recent reports in support of a total ban on indoor tanning in individuals under the age of 18 (Pagoto et al., 2014).

Despite these and other efforts to reduce indoor tanning, melanoma incidence is rising in the United States and worldwide, over and above the effects of screening (Purdue et al., 2008; Garbe and Leiter, 2009). It is the goal of this paper to explore current evidence supporting the relationship between indoor tanning and melanoma risk, and to promote novel efforts to reduce melanoma incidence by identifying and targeting the populations most at risk of negative consequences from tanning indoors.

Methods

References for this review were collected via a "PubMed" search from years 1970 to 2015, English language only, and the review of the literature cited in selected papers. Search terms used included "indoor tanning", "tanning bed(s)", "sunbed(s)", "artificial tanning", "UV tanning", "ultraviolet light tanning", and "melanoma(s)". No restrictions were made regarding study design or type of paper. Review of the literature noted the critical pieces of information that went into (1) establishing the health risks of tanning; (2) efforts to prevent tanning; and (3) shortcomings of those efforts to date.

Results and discussion

The health risks of UV radiation obtained from indoor tanning

A common misconception among indoor tanners is that artificial UVR produces a "safer" tan than outdoor sunlight (CDC, 2014). This belief is contradicted by scientific evidence, and must be addressed in order to effectively reduce the burden of indoor tanning on health outcomes worldwide. Exposure to UVR from indoor tanning devices has been shown to cause DNA damage in skin cells, and is associated with an increased risk of developing melanoma, and squamous and basal cell carcinomas (Whitmore et al., 2001; The International Agency for Research on Cancer Working Group on Artificial Ultraviolet I SC, 2006; Karagas et al., 2002). Indoor tanning has also been associated with accelerated skin aging, ocular melanoma, immune suppression, and skin burns (Whitmore et al., 2001; Piepkorn, 2000; Vajdic et al., 2004; Walters and Kelley, 1987; Clingen et al., 2001; Cokkinides et al., 2009). Due to variation in the intensity and UV wavelength emitted by indoor tanning devices, consistent regulation of their use is paramount.

Indoor tanning devices exert their effect through the emission of both UVA and UVB radiation. While UVB is associated with direct DNA damage through cyclobutane pyrimidine dimer formation and the production of DNA damaging photoproducts, UVA exposure is associated with indirect DNA damage through the production of reactive oxygen species (Matsumura and Ananthaswamy, 2004; Walter et al., 1999; Autier et al., 1994; Bataille et al., 2004; Petersen et al., 2000). Solar UVR reaching the earth's surface is composed of roughly 95% UVA and 5% UVB radiation (El Ghissassi et al., 2009). UVB radiation induces burning of the skin at a much lower dose than UVA, which requires emissions 500 to 1000 times that of UVB to evoke a response (Gies et al., 1986; Parrish et al., 1982; Ying et al., 1974; Kaidbey and Kligman, 1979). Although UVB produces a delayed erythema (sunburn) or tan more efficiently than UVA, UVA alone is sufficient to cause a reaction (Parrish et al., 1982; *Praeger*, 1986). Indoor tanning devices can emit UVR in amounts 10 to 15 times higher than the sun at its most direct exposure (The International Agency for Research on Cancer Working Group on Artificial Ultraviolet I SC, 2006). In the 1990s UVB-exclusive high intensity tanning devices were developed, as well as high pressure UVA-only devices. Lazovich et al. examined the individual effect of these devices on melanoma risk (Lazovich et al., 2010). The authors found users of high intensity devices, high pressure devices, and traditional sunlamps to have an increased likelihood of developing melanoma compared to respondents who had never tanned indoors. Lazovich et al. could not identify one type of tanning equipment as more associated with melanoma than another, replicating the findings of previous research on risk according to indoor tanning device type (Bataille et al., 2004; Veierod et al., 2003; Clough-Gorr et al., 2008; Chen et al., 1998).

To address the association between indoor tanning and melanoma incidence, Lazovich et al. examined cases of invasive cutaneous melanoma diagnosed in individuals between the ages of 25 and 59 in Minnesota from 2004 to 2007 (Lazovich et al., 2010). The authors concluded that the use of UVB and UVA indoor tanning devices conferred an elevated risk of melanoma that increased with use by years, hours, and sessions. Risks were seen across all device types, and regardless of the age of at which the individual first tanned. The likelihood of melanoma having ever tanned indoors was 1.74 (95% CI 1.42, 2.14), while the adjusted odds ratio ranged from 2.5 to 3.0 in the category of greatest use (more than 50 h, more than 100 session, 10 or more years). When taking anatomic site of melanoma into account, by gender the dose response pattern remained significant for both men and women for truncal melanomas, among men with head and neck melanomas, and women with melanoma of the upper or lower limbs. It was also noted that melanoma cases were more likely to have been burned when indoor tanning and reported a greater number of painful sunburns than controls.

While Lazovich et al. adjusted for outdoor sun exposure, Vogel et al. assessed melanoma risk in the absence of sunburn from outdoor UVR. Vogel reported that melanoma patients who had never experienced sunburn were four times as likely to have tanned indoors than melanoma patients who had never tanned indoors, including those who reported zero lifetime sunburns (odds ratio, 3.87; $P = 0.002$) (Vogel et al., 2014). In patients with a history of sunburn, melanoma patients reported a greater number of years and sessions of indoor tanning, and having started tanning indoors at an earlier age than controls (Vogel et al., 2014).

A 2005 meta analysis reported an odds ratio of 1.25 (1.05–1.49) of having a melanoma if having ever used an indoor tanning bed (Gallagher et al., 2005). The risk was reported to increase to 1.69 (1.32–2.18) if the first exposure was as a young adult (Lazovich et al., 2010). These results were replicated by the International Agency for Research on Cancer, and supported by a 2005 meta analysis finding a 75% increase in risk of melanoma when indoor tanning began during adolescence or early adulthood (The International Agency for Research on Cancer Working Group on Artificial Ultraviolet I SC, 2006; Boniol et al., 2012). Sunbed use in adolescence was also noted to confer an additional risk of melanoma development by Cust et al. 2011, who reported the risk of melanoma attributed to sunbed use before age 35 as 75% (Cust et al., 2011).

A review of 27 observational studies associating use of sunbeds with skin cancers (BCC, SCC, and cutaneous melanoma) across western Europe found a summary relative risk of 1.20 (1.08–1.34) (Boniol et al., 2012). When examining only cohort and population based studies, the summary relative risk was found to be 1.25 (1.09 to 1.43). Dose–response calculations highlighted a 1.8% increase in melanoma risk for every additional indoor tanning session per year, and that use of sunbeds before age 35 allowed a summary relative risk of 1.59 (1.36–1.85). Overall the authors reported that from 27 observational