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RESEARCH ARTICLE

Tanning Salons and Melanoma Risk

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ABSTRACT

There has been considerable debate concerning melanoma risk associated with the use of commercial tanning salons. In this review we examine the current state of the scientific evidence on this subject as well as whether use of tanning salons confers any health benefit. We conclude that there is no persuasive evidence that use of commercial tanning salons is associated with increased risk of melanoma, that there is significant evidence that use of commercial tanning salons is associated with decreased risk of melanoma, and that use of commercial tanning salons confers a significant health benefit.

Introduction

In June 2009, 20 scientists from nine countries (the Committee) met at the International Agency for Research on Cancer (IARC) to reassess the carcinogenicity of various types of radiation.[1] The author was one of those 20 scientists. At the time, UV radiation from the sun was classified in Group 1 (carcinogenic to humans) but UV radiation from artificial devices was classified in Group 2A (probably carcinogenic to humans). The term "carcinogenic to humans" was defined as "an agent that is capable of causing cancer." Capable of causing cancer means that in some amount the substance is capable of causing cancer. Wine, beer, liquor, processed meats, sawdust and sunlight are all Group 1 carcinogens because in some amount they are capable of causing cancer. For example, sunlight has been found to be a carcinogen because it is capable of causing sunburn and sunburns have been found to be capable of causing melanoma. Inclusion in Group 1 requires "sufficient evidence of carcinogenicity in humans" and Group 2A required only "limited evidence of carcinogenicity in humans." [2] It had been previously determined that there was "sufficient evidence of carcinogenicity in humans" of UV radiation from the sun, but no such determination had been made for UV radiation from artificial devices. One of the tasks of the Committee was to reassess whether such determination could be made at the time of their 2009 meeting. The Committee cited a 2006 meta-analysis (the "2006 IARC Study") [3] as containing sufficient evidence of carcinogenicity in humans, and therefore raised the classification of UV radiation from artificial radiation from Group 2A to Group 1. Artificial UV radiation was found to be no different than sunlight.[2]

The 2006 IARC Study

The 2006 IARC Study's meta-analysis was based on 19 studies that investigated the association between use of artificial UV devices for tanning purposes and risk of melanoma. Two of the members of the working group that authored the 2006 IARC Study (Peter Boyle, then the Director of IARC, and Sara Gandini) one year before had been co-authors of a definitive 3-part study of all the risk factors for melanoma [4-6] which concluded that the only environmental risk factor for melanoma was sun exposure, but the relationship between sun exposure and melanoma risk was not straightforward. The authors found that while sunburns doubled the risk of melanoma (RR = 2.03, 95% Confidence Interval, 1.73-2.37), chronic sun exposure had a null effect or *reduced* the risk of melanoma (RR = 0.95, 95% CI, 0.87-1.04).[5] They also concluded that intermittent sun exposure increased the risk of melanoma by 61% (RR = 1.61, 95% CI, 1.31-1.99).[5] As used in the meta-analysis, the term intermittent sun exposure meant sun intensive activities such as sunbathing, outdoor recreations and holidays in sunny climates, a likely marker for sunburn.[5]

An examination of the 19 constituent studies in the IARC Study's meta-analysis of the association between use of artificial UV devices for tanning purposes and melanoma reveals that only one of such studies [7] contains any data or other information on whether any of the users of artificial UV devices in such studies did or did not receive UV burns. This made it impossible for the authors to adjust risk assessments for this important confounder. Without such an adjustment, their finding that ever-use of artificial UV devices for tanning purposes was associated with a 15% increased risk of melanoma (OR 1.15, 95% CI, 1.00-1.31) could easily have meant only that a significant number of users received UV burns from use of the artificial UV devices for tanning purposes, not that the use of artificial UV devices for tanning purposes was in itself an independent risk factor for melanoma. Supporting the foregoing, the one study with burn data [7] found no significant increased risk *for* melanoma for users who did not burn and a 56% increased risk for those who did burn (OR 1.56, 95% CI, 1.13-2.15). There was no evidence that the use of artificial UV devices for tanning purposes was in itself a risk factor for melanoma independent of UV burns.

Also, only one study contained data on place of use [8], and that study found a 21% reduced risk of melanoma for commercial tanning salon use of artificial UV for tanning purposes (OR 0.79, 95% CI, 0.49-1.26) and a 40% increased risk of melanoma for home use of artificial UV for tanning purposes (OR 1.40, 95% CI, 0.97-2.04).[8]

The 2006 IARC Study[3] also found in a meta-analysis of data from 7 constituent studies that ever-use of sunbeds before 35 years of age was associated with a 75% increased risk of melanoma (RR = 1.75, 95% CI, 1.35-2.26), again without any data in the constituent studies on UV burns and with data from only one study on place of use.[8] That study found a 37% reduced risk of melanoma for commercial tanning salon use of artificial UV devices by persons under the age of 25 (OR 0.63, 95% CI, 0.29-1.36) and a 79% increased risk of melanoma for home use of artificial UV devices by persons under the age of 25 (OR 1.79, 95% CI, 1.07-2.97).[8]

The Misinterpretation of the IARC Study

The lack of burn data in the IARC Study was irrelevant to the Committee because the IARC Study clearly showed that artificial UV, like sunlight, was capable in some amount (in this case, an amount sufficient to cause a UV burn) of causing melanoma in humans, which is why the Committee cited the IARC Study in raising the classification of UV radiation from artificial radiation from Group 2A to Group 1. The problem arose from the wording of the IARC Study's conclusion that "Based on 19 informative studies, ever-use of sunbeds [defined to include any type of artificial UV device] was positively associated with melanoma (summary relative risk, 1.15; 95% CI, 1.00-1.31)." This led many people to believe that use of artificial UV devices caused melanoma whether or not such use resulted in UV burns.

The Follow-Up Studies

In 2012 the authors Boniol et al. (which included Peter Boyle and Sara Gandini) [9] updated the 2006 IARC Study in a new meta-analysis with data from additional studies, which repeated the mistakes of the 2006 IARC Study and contained no new data on UV burns or place of use except for one additional study [10] which had place of use data. That study found no significant increased risk of melanoma for commercial tanning salon use of artificial UV devices for tanning purposes and a 39% increased risk of melanoma for home use of artificial UV devices for tanning purposes (OR 1.39, 95% CI, 1.00-1.96).[10] Boniol et al. concluded that ever-use of UV devices for tanning purposes was associated with a 25% increased risk of melanoma (RR = 1.25, 95% CI, 1.09-1.43) and ever-use of UV devices for tanning purposes before age 35 was associated with an 87% increased risk of melanoma (RR = 1.87, 95% CI, 1.41-2.48).[9] However, after an error in Boniol et al. was discovered, the authors were required to publish a correction which lowered the risk associated with ever-use of UV devices for tanning purposes before age 35 from 87% to 59% (RR = 1.59, 95% CI, 1.36-1.85).[11] It is noted that no attempt was made in Boniol et al. to clarify the misinterpretation of the 2006 IARC Study, which had already caused the State of California to ban the use of commercial tanning salons by persons under the age of 18.

Finally, in 2014 the authors Colantonio et al.,[12] in another meta-analysis on the same subject, criticized errors made in both Boniol et al. and the 2006 IARC Study and found that there was no statistically significant increased risk of melanoma for ever-use of artificial UV devices for tanning purposes before age 25 compared to after age 25.[12]

Commercial Tanning Salons in the United States

In the United States, sunlamp products including sunbeds are regulated by the FDA pursuant to 21 CFR 1040.20 [13] and the FDA's Policy Letter on Maximum Timer Interval and Exposure Schedule for Sunlamp Products dated August 21, 1986).[14] The Policy Letter requires all manufacturers of sunbeds to place prominent labels on sunbeds specifying the permitted exposure times for persons of each skin type using the Fitzpatrick Scale of skin typing.[15] These exposure times have been calculated by FDA scientists to assure avoidance of UV burns by all users regardless of their skin color or tendency to burn. A 2017 meta-analysis found that use of tanning beds in commercial tanning salons was not associated with increased risk of melanoma, but use of tanning beds in user's homes was associated with a 53% increased risk of melanoma.[16] The conclusion is that UV burns were common in the use of tanning beds in the home but insignificant or non-existent in commercial tanning salons.

In 2018 Burgard et al. published a meta-analysis of 41 observational studies which investigated the

use of artificial UV devices for tanning purposes and the risk of melanoma.[17] They discussed the poor quality of many of the studies and concluded "At present, there is no convincing evidence that moderate/responsible solarium use increases melanoma risk."

In 2019 Sara Gandini attempted to resurrect the notion that use of artificial UV devices for tanning purposes was associated with increased risk of melanoma regardless of the place of use and regardless of UV burns by publishing another paper on the subject titled "Sunbeds and melanoma risk: time to close the debate." [18] In this paper, the authors cite two studies that were published after Boniol et al. which they claim are supportive of their assertion that use of artificial UV devices causes melanoma regardless of whether or not the user receives UV burns, and that users under the age of 25 are especially at risk.

They first cite Lazovich et al. 2016,[19] which concluded that "Women younger than 30 years were 6 times more likely to be in the case rather than the control group if they tanned indoors." This statement is demonstrably incorrect as the data upon which it is based are set forth in Table 1 of the study and show it to be incorrect (61 of 63 female cases were under the age of 30 years and tanned indoors and 51 of 61 female controls were under the age of 30 years and tanned indoors, thus women younger than 30 years were 1.16 times more likely to be in the case rather than the control group if they tanned indoors, not 6 times more likely). The entire data set used in Lazovich et al. 2016 was collected in Minnesota in 2004-2007 in connection with a prior study, Lazovich et al. 2010 [20] and assumedly was taken into account in Colantonio et al.'s 2014 meta-analysis. Lazovich 2010 concluded that there was no difference in risk associated with age of first use and stated that "We did not confirm the IARC report's emphasis on an increased risk of melanoma with first exposure to indoor tanning "in youth", defined as use before the age of 36." Then, six years later, Lazovich et al. 2016 reversed this conclusion with respect to a subset of cases with no additional data beyond that included in Lazovich et al. 2010. Additionally, Lazovich et al. 2010 found that a family history of melanoma *reduced* the risk of melanoma by 13%. Lazovich et al. 2010 and Lazovich 2016 must have used this finding to adjust their odds ratios for this important confounder, casting doubt on all their findings of risk of melanoma from use of artificial UV devices for tanning purposes. Table 1 of Lazovich et al. 2016 indicates that 24.6% of melanoma cases under the age of 30 had a family history of melanoma (compared to 8% of melanoma cases nationwide [21], so misadjustment for this confounder would have a large impact on the findings of Lazovich et al. 2016 and Lazovich et al. 2010.

In light of the foregoing, there is no basis for using Lazovich et al 2016 to overturn or alter the results of Colantonio et al. 2014 showing that there is no statistically significant increased risk of melanoma for ever-use of artificial UV devices for tanning purposes before age 25 compared to after age 25, or to support Suppa and Gandini's incorrect assertion that use of artificial UV devices for tanning purposes is associated with increased risk of melanoma regardless of the place of use and regardless of UV burns.

The second study cited by Suppa and Gandini 2019 as having been published subsequent to Boniol et al. 2012 is Ghiasvand et al. 2017. [22] Ghiasvand et al. 2017 created 5 variables to describe exposure to indoor tanning: cumulative number of sessions, ever/never use of artificial UV devices, duration of use, current use and age at initiation of use. Notably, the authors did not include either UV burns or place of use as variables, and thus made the same errors as Boniol et al. 2012 and added nothing to the debate over whether use of artificial UV devices for tanning purposes without getting burned increases or decreases the risk of melanoma.

It is noted that Suppa and Gandini include in their Table 1 an incorrect statistic for risk of melanoma associated with first exposure in youth (first exposure under age 35).[18] They show a relative risk factor of 1.87 (1.41-2.48) for Boniol et al. 2012 rather than the corrected figures of 1.59 (1.36-1.85) in the Boniol Correction.[11] Boniol et al. 2012 lists Sara Gandini as one of the two authors responsible for the statistical analysis.[9]

Subsequently, in 2020 Reichrath et al. published "Sunbeds and Melanoma Risk: Many Open Questions, Not Yet Time to Close the Debate" and also Burgard and Reichrath published "Solarium Use and Risk for Malignant Melanoma: Many Open Questions, Not the Time to Close the Debate".[23,24] The 103 detailed articles considered by Reichrath et al. stated: "Conclusion: Current scientific knowledge does not demonstrate a causal relationship between moderate solarium use and melanoma risk."[23] Although Suppa and Gandini used the Hill criteria in their report, Reichrath et al. went through the detailed Hill criteria and concluded that the Hill criteria did not establish causality. They also found no studies that demonstrated a causal relationship between moderate solarium use and melanoma risk.

A recent international study by Alfredsson et al. has further clarified the relationship between UV exposure and melanoma. They noted that five sunburns per decade vs. no sunburns showed a relative risk of 3.24 (95% CI, 2.19-4.66), indicating higher risk for melanoma with increasing number of sunburns, and that sunburn or other trauma is needed to stimulate replication of normally non-replicating melanocyte cells.[25] They further noted that cancer is not possible without cell replication. With respect to non-burning UV exposure, they stated that "More continuous (chronic) sun exposure, on the other hand, appears to have a null or an inverse association with melanoma". This suggests that nonburning UVR exposure in commercial tanning salons may reduce rather than increase the risk of melanoma.

Health Benefit

Alfredsson et al. also found that insufficient UV sun exposure has become a real public health problem and may be responsible for 340,000 deaths in the United States and 480,000 deaths in Europe per year, and an increased incidence of breast cancer, colorectal cancer, hypertension, cardiovascular disease, metabolic syndrome, multiple sclerosis, Alzheimer's disease, autism, asthma, type 1 diabetes and myopia. They explain that UV exposure to the skin besides increasing vitamin D levels also reacts with stores of nitric oxide precursors (NO_3, NO_2) in the skin to produce nitric oxide (NO) which lowers blood pressure, and that hypertension is the leading risk factor for cardiovascular disease and underlies 18% of all deathsworldwide.[25]

As Feelisch et al. hypothesized, these chemical species in the skin are mobilized by sunlight and delivered to the systemic circulation to act as a vasodilator to reduce blood pressure.[26] Also see Mowbray et al. about NO in the skin and the effects on it by UV.[2]

Alfredsson et al. notes that vitamin D concentrations (measured as 25-hydroxy vitamin D [25(OH)D]) are considered to be a proxy for sun exposure, and the studies cited in Alfredsson et al. show that a 25(OH)D level of less than 30 ng/mL is indicative of insufficient UV exposure.[25] Studies indicate that 70-90% of 25(OH)D is produced in the human body by sun exposure. [28-30] Liu at al. al.[31] found that 70% of all U.S. adults have less than 30 ng/mL and Kumar et al.[32] found that 70% of all U.S. children and adolescents also have less than 30 ng/mL. Correcting insufficient UV exposure is a public health imperative.

Conclusions

In conclusion, there is no significant evidence that use of commercial tanning salons in the United States increases the risk of melanoma for persons of any age. To the contrary, there is significant evidence that they do not, and may even reduce the risk of melanoma. Additionally, commercial tanning salons provide a very important benefit of increasing UV exposure for persons suffering from the ill effects of insufficient UV exposure and persons of all age groups are currently suffering from the ill effects of insufficient UV exposure. Under-18 tanning bans enacted in some states in reliance on Boniol et al. 2012 [9] are likely harmful to public health and should be rescinded.

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Conflicts of Interest The author has done consulting for the American Suntanning Association

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