Indoor tanning in businesses and homes and risk of melanoma and nonmelanoma skin cancer in 2 US case-control studies

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Background: Indoor tanning increases skin cancer risk. Beyond early research describing melanoma and sun lamps, few recent reports describe where individuals indoor tan and whether skin cancer risk varies by location (business, home-based).

Objective: We sought to assess where individuals tanned indoors and skin cancer risk by tanning device location.

Methods: Multivariate logistic regression was conducted in 2 US case-control studies of melanoma (1161 cases, 1083 controls, ages 25-59 years) and early-onset basal cell carcinoma (375 cases, 382 controls, age <40 years) conducted between 2004 and 2010.

Results: Most indoor tanners (86.4%-95.1%), especially younger individuals, tanned exclusively in businesses. Persons who used indoor tanning exclusively in businesses were at increased risk of melanoma (odds ratio 1.82, 95% confidence interval 1.47-2.26) and basal cell carcinoma (odds ratio 1.69, 95% confidence interval 1.15-2.48) compared with non-users. Melanoma risk was also increased in the small number who reported tanning indoors only at home relative to non-users (odds ratio 4.14, 95% confidence interval 1.75-9.78); 67.6% used sun lamps.

Limitations: Self-reported tanning and potential recall bias are limitations.

Conclusion: Business-only tanning, despite claims of "safe" tanning, was positively associated with a significant risk of melanoma and basal cell carcinoma. Home tanning was uncommon and mostly from sun lamps, which were rarely used by younger participants. Regardless of location, indoor tanning was associated with increased risk of skin cancer. (J Am Acad Dermatol 2014;71:882-7.)

Key words: basal cell carcinoma; epidemiology; indoor tanning; melanoma; nonmelanoma skin cancer; skin cancer.

In 2009, the International Agency for Research on Cancer classified ultraviolet (UV)-emitting tanning devices as carcinogenic to human beings, akin to tobacco smoke and asbestos,[1] and recent meta-analyses concluded indoor tanning was a risk factor for nonmelanoma skin cancer and

Abbreviations used:

BCC:	basal cell carcinoma
CI:	confidence interval
MC1R:	melanocortin 1 receptor gene
OR:	odds ratio
UV:	ultraviolet

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melanoma.[2,3] Despite the scientific evidence on the dangers of indoor tanning, it continues to be popular, especially among young people.[4] In 2012, indoor tanning salons in the United States had more than $4.9 billion in revenue; 58.7% was generated directly from UV indoor tanning.[5] These industry data suggest that in the United States approximately 22,145 tanning salons are frequented by 28 million people each year,[5] of which 2.3 million are teenagers.[6]

From this industry information, it is clear that a substantial amount of recent indoor tanning in the United States has taken place in business locations, yet published epidemiologic data have seldom delineated where individuals use indoor tanning devices. Although all indoor tanning devices emit UV radiation, the actual UV exposure may vary substantially by setting because of different device types, exposure time, and safety practices. Thus, location of indoor tanning may be a potential determinant of skin cancer risk.

CAPSULE SUMMARY

- Indoor tanning increases risk of skin cancer; variation in risk by tanning device location (home, business) is understudied.
- Indoor tanning occurs predominantly in businesses. All indoor tanning, regardless of location, is associated with increased risk of skin cancer.
- Tanning device proliferation in commercial and private settings should be discouraged.

To better understand the risks of skin cancer associated with where individuals use indoor tanning devices (ie, in business, home, other, or mixed locations), we analyzed data from 2 recent US case-control studies: (1) melanoma among individuals ages 25 to 59 years; and (2) early-onset basal cell carcinoma (BCC) among individuals younger than 40 years. With a younger study population than prior studies of indoor tanning and study recruitment from 2004 through 2010, these data provide a relatively current picture of patterns and associated risks of indoor tanning in the United States.

METHODS

Skin Health Study: Melanoma

Methods for the Skin Health Study, a case-control study of melanoma, have been published elsewhere.[7] In brief, persons in Minnesota given the diagnosis of invasive cutaneous melanoma from 2004 to 2007 between ages 25 and 59 years were ascertained through the state cancer registry. Persons without melanoma were frequency matched to cases on age and gender, and were randomly selected from the state driver license list (including persons with state identification cards). A total of 1167 melanoma cases and 1101 controls (84.6% and 69.2% of eligible, respectively) completed a self-administered questionnaire and computer-assisted telephone interview. Detailed measures of sun exposure, sunscreen use, education, income, and family history of melanoma were collected via telephone interview and information on skin, hair and eye color, and presence and pattern of freckles and moles were collected via self-administered questionnaire. The Skin Health Study was approved by the institutional review board at the University of Minnesota (protocol number 0403M58561; approved August 24, 2004) and informed consent was obtained from the participants.

Yale Study of Skin Health in Young People: BCC

The Yale Study of Skin Health in Young People was a case-control study of early-onset BCC conducted in Connecticut, described in detail elsewhere.[8,9] BCC cases and controls with minor benign skin conditions (both evaluated by skin biopsy) diagnosed between July 2006 and September 2010 were identified through Yale University's dermatopathology database, as BCC is not collected in the state cancer registry. Eligible participants had to be younger than 40 years at the time of skin biopsy, reside in Connecticut, speak English, and be capable of completing all study components. A total of 389 BCC cases enrolled (participation rate 72.8%). Randomly sampled controls were frequency matched to BCC cases on age at biopsy, gender, and biopsy site, with a total of 458 controls enrolling (participation rate 60.7%). The most common conditions among controls were cyst (16.4%), seborrheic keratosis (16.2%), and wart (11.4%). All other conditions were present among less than 10% of control subjects. Analyses are restricted to the non-Hispanic white participants: 96.9% of cases and 85.2% of controls. Participants completed an in-person interview and self-administered questionnaires. The structured in-person interview assessed numerous characteristics, including sociodemographics, sun exposure, sunscreen, family history, medical history; self-reported skin, hair, and eye color; and skin reaction to UV exposure. Yale University's Institutional Review Board approved the study (protocol number 0612002107; approved February 2, 2007) and study participants (or guardians) provided informed consent.

Assessment of indoor tanning and tanning device location

Indoor tanning exposure data were obtained in both studies using a questionnaire developed for the Skin Health Study; details are published elsewhere.[7,9] Briefly, participants were asked about their indoor tanning history and had color photographs of different tanning devices as visual aids. Both studies queried ever use of indoor tanning, which included regular tanning beds/booths, high-speed/high-intensity tanning beds/booths, and high-pressure tanning beds/booths. Data were collected across 5-year periods between ages 11 and 59 years in the Skin Health Study and across 4 age periods starting at age 11 years (ages 11-15, 16-20, 21-30, and 31-40 years) in the Yale Study of Skin Health. In both studies, participants reported the location of the tanning devices (home, business, or other) during each time period; no additional descriptions/definitions were given for the location descriptions and participants were not asked to report a specific type of business. With the older age of the Skin Health Study population, sun lamp use was also assessed in this manner. In the Yale Study of Skin Health population, participants reported ever use of sun lamps on a self-administered mailed questionnaire; home use was assumed.

Statistical analysis

Analyses were limited to individuals included in the primary indoor tanning multivariate analyses published previously[7,9]: melanoma (1167 cases and 1101 controls) and BCC (375 cases and 382 controls). Twenty four (1.1%) individuals in the Skin Health Study with missing tanning device location information were excluded from the melanoma sample leaving 1161 cases and 1083 controls.

Descriptive analyses of controls were conducted to characterize the locations where indoor tanning occurred. We classified indoor tanning location into 3 categories: exclusively in businesses, exclusively in the home, and other only or mixed location (reported at least 2 of the 3 locations). In the Yale Study of Skin Health, sun lamp use was extremely uncommon and was not included in our original analysis of tanning beds and booths[9]; for this analysis of indoor tanning location we included sun lamp use, which resulted in 1 control being reclassified from unexposed to exposed to home-based indoor tanning.

Using multiple unconditional logistic regression, odds ratios (OR) and 95% confidence intervals (CI) were calculated for the association of indoor tanning by location. In these analyses, individuals reporting indoor tanning not exclusive to the location under evaluation were excluded and persons who never tanned indoors served as the reference group. Multivariate models were adjusted for characteristics previously evaluated and reported as potential confounders in the primary indoor tanning analyses (regardless of device location) in the respective study populations.[7,9] The Skin Health Study models were adjusted for gender, age at reference date, eye color, hair color, skin color, freckles, moles, income, education, family history of melanoma, lifetime routine sun exposure, lifetime sun exposure from outdoor activities, lifetime sun exposure from outdoor jobs, lifetime sunburns, and lifetime sunscreen use. These potential confounders were defined a priori and included in the final models regardless of statistical significance. Models for the Yale Study of Skin Health were adjusted for age at diagnosis, body site, gender, skin color, family history of melanoma and/or nonmelanoma skin cancer, first exposure of the season to 1 hour of summer sun, prolonged exposure to the sun, and melanocortin 1 receptor gene (*MC1R*) nonsynonymous variants. These variables were study frequency matching variables, altered risk estimates by at least 10%, or were significantly associated with BCC. Analyses were conducted using SAS software (Version 9.3, SAS Institute Inc, Cary, NC) and statistical tests were 2-sided.

RESULTS

Characteristics of the melanoma and BCC case-control study populations have been previously reported.[7,9] Among the controls, 50.3% in the Skin Health Study and 64.4% in the Yale Study of Skin Health reported a history of indoor tanning. The overwhelming majority (86.4%-95.1%) of control indoor tanners reported using indoor tanning devices in business locations only in both populations (Table I). This was especially true for younger indoor tanners, as all (100%) of the youngest control indoor tanners age 12 to 29 years in the Yale Study of Skin Health and 98.1% of the Skin Health Study control indoor tanners aged 25 to 29 years tanned indoors exclusively in businesses. Although business-only tanning declined with increasing age in the Skin Health Study (*P* value Fisher exact = .001 across 4 age groups: 25-29, 30-39, 40-49, and 50-59 years), it was still the most common location among the oldest (ages 50-59 years) control indoor tanners, with 79.6% reporting business-only use.

In contrast, 1.5% of control indoor tanners in the Skin Health Study and 0.8% of indoor tanners in the Yale Study of Skin Health reported indoor tanning only in the home (Table I). The remainder of controls who tanned indoors indicated using devices in other locations only or multiple locations.

Table I. Location of indoor tanning devices among control subjects who reported a history of indoor tanning in 2 US case-control studies

Location of indoor tanning device	Skin Health Study Control subjects N = 545 N (%)	Yale Study of Skin Health Control subjects N = 246 N (%)
Business only	471 (86.4)	234 (95.1)
Home only	8 (1.5)	2 (0.8)
Other only or mixed location	66 (12.1)	10 (4.1)

We observed statistically significant increased risks of melanoma (OR 1.82, 95% CI 1.47-2.26) and BCC (OR 1.69, 95% CI 1.15-2.48) among individuals who reported tanning indoors exclusively in business locations compared with those who never tanned indoors (Table II). The association between business-only indoor tanning and BCC was unchanged (OR 1.74, 95% CI 1.17-2.58) when we removed 28 individuals (19 reported business-only indoor tanning) who reported any UV light therapy for medical conditions (eg, acne, psoriasis); this information was not queried in the Skin Health Study.

Because of infrequent home tanning, the risk of skin cancer associated with indoor tanning exclusively in the home could only be examined in the Skin Health Study. The majority (67.6%) of the 34 home-only indoor tanners reported using only sun lamps. For individuals who reported exposure to any tanning device only at home, the risk of melanoma was 4.14 (95% CI 1.75-9.78).

Among indoor tanners who reported other locations only or a combination of any 2 locations, we observed a statistically significant increased risk of melanoma (OR 1.63, 95% CI 1.08-2.46). There was no clear association with BCC (OR 1.24, 95% CI 0.38-4.04), although the sample size was limited.

DISCUSSION

In 2 recent US skin cancer case-control studies, we observed a high prevalence of prior indoor tanning. Indoor tanning was more common in the Yale Study of Skin Health than in the Skin Health Study, which was expected given the younger participants. Among those who tanned indoors, nearly all tanning occurred in business settings, with exclusive indoor tanning in businesses most common among younger individuals in both studies. Given the low prevalence of indoor tanning outside of business locations, the associations we observed with business-based indoor tanning and skin cancer were very similar or identical to those we previously reported in these populations for all indoor tanning, regardless of location.[7,9] In addition, despite infrequent exclusive home indoor tanning, a strong association with melanoma was observed, although the CIs were wide.

Our analysis represents a detailed assessment of the skin cancer risk associated with recent indoor tanning patterns and our results provide data to refute a claim made by the indoor tanning industry that the risk of skin cancer associated with indoor tanning in recent studies is "misleading because researchers often included tanning beds used in homes and doctors' offices in addition to those at salons."[10] Although the location prevalence data among controls from our 2 studies are most generalizable to the general US population, the pattern of locations was mirrored in the cases.

In older melanoma studies that reported on location, indoor tanning devices in homes do appear to have been more common than in our current analysis[11-14] and is in line with our finding that older individuals were more likely to report home-based indoor tanning. However, our data in tandem with contemporary economic data on tanning salons indicate that business-based tanning accounts for the vast majority of recent indoor tanning. A pooled analysis cited by the indoor tanning industry on tanning salon use being harmless in relation to skin cancer relied on data from study populations composed of older individuals and is outdated given the rapidly changing pattern of indoor tanning in the United States.[15,16] Furthermore, only a subset of studies from a large meta-analysis[17] were included in the pooled study and the authors conducted only a univariate pooled analysis without adjustment for potential confounders.[15,16] An additional limitation of the older data is that most studies did not evaluate exclusive use in each location[11-13] and 1 only evaluated location among frequent tanners.[13]

Medical phototherapy is prescribed for select conditions, particularly skin-related conditions, such as psoriasis. Even in our BCC population, who sought care from a dermatologist, less than 5% of individuals reported prescribed medical phototherapy, so it is likely exposure to UV for medical reasons would compose a small percentage of total exposure to artificial UV in the United States. In addition, the indoor tanning industry risk estimate for melanoma associated with medical phototherapy is based on 1 study from 1990 in which 27 individuals reported such use,[11] resulting in a nonsignificant univariate association (OR 1.96, 95% CI 0.89-4.33).[15,16] Importantly, in a sensitivity analysis in our BCC population that removed persons who reported medical phototherapy, the risk estimate for business-only indoor tanning did not appreciably change.

Table II. Odds ratios and 95% confidence intervals for the association between indoor tanning by location and basal cell carcinoma (age <40 years) and melanoma (ages 25-59 years)

	Skin Health Study		Yale Study of Skin Health	
Characteristics	Melanoma Cases/controls	Multivariate OR* (95% CI)	BCC Cases/controls	Multivariate OR† (95% CI)
Indoor tanning in businesses only				
Never	433/538	1.00	129/136	1.00
Ever	622/471	1.82 (1.47-2.26)	238/234	1.69 (1.15-2.48)
Indoor tanning at home only				
Never	433/538	1.00	129/136	-
Ever	26/8	4.14 (1.75-9.78)	0/2	-
Indoor tanning in other locations only or mixed locations				
Never	433/538	1.00	129/136	1.00
Ever	80/66	1.63 (1.08-2.46)	8/10	1.24 (0.38-4.04)

BCC, Basal cell carcinoma; *CI*, confidence interval; *OR*, odds ratio.

*Adjusted for gender, age at reference date (in years), eye color (gray/blue, green, hazel, or brown), hair color (red, blond, light brown, or dark brown/black), skin color (very fair, fair, light olive, versus dark olive, brown, very dark brown or black), freckles (none, very few, few, some/many), moles (none, very few, few, some/many), annual income ($\leq$ $60,000, >$60,000, missing), education (completed college, did not complete college), family history of melanoma (yes, no, missing), lifetime routine sun exposure (continuous), lifetime sun exposure from outdoor activities (continuous), lifetime sun exposure from outdoor jobs (continuous), lifetime sunburns (continuous), and lifetime sunscreen use (continuous).

†Adjusted for age at diagnosis (continuous), body site (head/neck, trunk, extremity), gender, skin color (olive, fair, very fair), family history of melanoma and/or nonmelanoma skin cancer (yes, no), first exposure of the season to 1 hour of summer sun (turn brown with no sunburn, mild sunburn followed by some degree of tanning, painful sunburn for a few days followed by peeling, severe sunburn with blistering), prolonged exposure to the sun (very brown and deeply tanned, moderately tanned, only mildly tanned because of tendency to peel, only freckled or no suntan at all), and *MC1R* nonsynonymous variants (0, 1, $\geq$ 2 variants).

Larger studies are needed to clarify if differences exist between home-based versus business-based use of tanning devices in relation to skin cancer risk. For home-based tanning, older devices emitting higher levels of UVB compared with normal solar UV radiation[7] may still be in use or use may be more frequent if a device is located in one's home. Nearly two thirds of the home indoor tanners reported using only sun lamps and overall sun lamp use was more common in older study participants. Sun lamps have largely become obsolete, so are unlikely to contribute to skin cancer risk in future cohorts. Because the risk of skin cancer with use of newer tanning beds, located primarily in business locations, is high,[18] it is reasonable to assume similar or even higher risks if these devices proliferate in homes, suggesting a possible regulatory need.

Although these 2 case-control studies capture the indoor tanning patterns of respondents over the past few decades, it should be recognized that very recently, tanning beds/booths have become fixtures in fitness centers, hair salons, spas, and apartment complexes. Unfortunately, we did not collect this level of detail on tanning location, as tanning outside of salons is a more recent phenomenon. Many of these newer indoor tanning locations are likely to have less supervision than a tanning salon and introduce additional safety risks. To our knowledge, data on health risks associated with indoor tanning in these locations are not available and these other types of businesses are likely to represent a very small percentage of business-only tanning in our populations. Also, although unlikely, it is possible some participants reported medical phototherapy as business-related tanning. However, phototherapy as assessed by a separate question in our BCC population was very rare. Finally, the control groups were different in these 2 studies, each of which may be subject to potential selection bias, but, importantly, risk estimates and prevalence figures were similar despite the differing control populations (skin biopsy and driver license controls).

Our findings indicate that indoor tanning is associated with an increased risk of skin cancer regardless of location. As states and countries around the world enact legislation to restrict minors from commercial indoor tanning,[19-21] regulatory and policy efforts should consider all indoor tanning venues, including the home, as some may allow indoor tanning access to minors otherwise restricted from tanning salons.

In conclusion, indoor tanning in businesses has accounted for the majority of recent indoor tanning exposure in young and middle-aged people alike. In addition, despite federal and some state-level provisions requiring indoor tanning salons to adhere

to exposure limits, indoor tanning in businesses was associated with increased risk of melanoma and nonmelanoma skin cancer. This risk, combined with the prevalence data on business-based indoor tanning, indicates that indoor tanning in businesses accounts for a large percentage of the current total indoor tanning attributable risk for skin cancer in the United States. Indoor tanning, regardless of location, is harmful to health, and proliferation of indoor tanning devices in all locations should be discouraged.

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