

Title: Indoor tanning use among white female students aged 18-30 years in the U.S. State of Indiana, 2016.

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Indoor tanning refers to using sunlamps or tanning beds/booths in place of natural sunlight to achieve a tan. Though excessive exposure to ultraviolet (UV) radiation from the sun is a well-known risk factor for premature skin aging and skin cancers, indoor tanning devices also expose users to UV radiation. Previous research found that among women younger than 30 years at melanoma diagnosis or reference age, those who reported tanning indoors were six times more likely to fall into the case group rather than the control group [1]. Thus, reducing artificial UV radiation exposure is crucial for melanoma prevention. However, indoor tanning is quite prevalent in the United States. For example, in 2011, 29.3% of non-Hispanic white female high-school students used indoor tanning [2]. In 2013, 14.2% of women aged 18-29 tanned indoors, and the prevalence was highest in the Midwest [3], a region that includes Indiana. To provide an epidemiological basis for the control of tanning device use in Indiana, we investigated the prevalence of indoor tanning among a cohort of white female students aged 18-30 in that state.

A self-administrated questionnaire survey was conducted among female undergraduates and graduate students at Indiana University in 2016 (Supplementary methods). Information about indoor tanning habits, demographic characteristics, socio-behavioral features, pigmentary traits, and attitudes towards tanning was collected. Women who tanned indoors at least once during the past year were classified as current tanners. Past users were those who had ever used indoor tanning but had not tanned indoors during the past year. Non-current users included both past and never users. Grouping current and past tanners together as the “ever used” group and designating the “never used” group as the control, we conducted simple and multivariable logistic

regression analyses to investigate factors influencing people to choose indoor tanning. Data analysis was performed using SAS software (9.4). Level of significance was 0.05.

A total of 629 white females aged 18-30 responded, among whom 21.3% were current indoor tanners, 33.9% were past tanners, and 44.8% had never used indoor tanning. Approximately 80% of current users were frequent tanners who had tanned indoors ≥ 10 times during the past year [2] (Table S1). Compared to current users, a higher proportion of the past users reported that they always or often experienced sunburn after tanning indoors (5.3% vs. 15.5%, $P=0.01$) (Table S2).

The median age of the ever users was slightly higher than that of the never users (22 vs. 20 years, $P<0.0001$); compared to non-current users, current users were slightly younger (21 vs. 20 years, $P<0.0001$). Those more likely to use indoor tanning were women who had families/friends regularly tanned indoors, had friends who tanned outdoors in summer, or rarely/never used sunscreen in summer (All $P<0.05$). Never users were more likely to be those with fair skin and/or red hair, those who tanned less easily, and those more prone to sunburn (All $P<0.05$). Indoor tanners were more likely to have positive attitudes towards tanning in general (Table 1). Multivariable analysis identified the following independent predictors for choosing indoor tanning: having families/friends who used tanning devices, tanning easily, viewing a tan as attractive, believing tanning can stimulate healthy vitamin D production, and still seeking to get a tan despite knowing its ill effects. Disagreeing with the contention that indoor tanning is safe or safer than outdoor tanning made people less likely to tan indoors (All $P<0.05$, See Table 2).

We found that current indoor tanning prevalence was 21.3% among our cohort of white female students 18-30 years old in Indiana. Indoor tanning is associated with

elevated skin cancer risk and is particularly dangerous for younger and more frequent indoor tanners. One meta-analysis showed those who had ever used sunbeds had a 25% higher risk of melanoma, and those who first used sunbeds before the age of 35 years had an 87% higher risk of melanoma compared to those who had never used sunbeds [4]. Finally, compared to never users, tanning bed users had a 67% and 29% higher risk of squamous and basal cell carcinoma, respectively [5].

It has been established that people with fair skin, red hair, and susceptibility to sunburn are at elevated risk of skin cancer. In our cohort, white females with these traits were less likely to seek indoor tanning. As these pigimentary traits are highly correlated, it is understandable that women with fair skin and/or red hair—who are more susceptible to sunburn — are less willing to use tanning devices. In addition, attitudes towards tanning greatly influenced women's indoor tanning behavior, especially the preference for a tanned appearance. In addition, women who agreed they still liked to tan (including outdoor and indoor tanning) despite its known harms were 2.3-fold more likely to use tanning devices, compared to those who disagreed ($P=0.003$). Moreover, compared to never users, a higher proportion of ever users reported that they felt more relaxed and pleasant during tanning (22.2% vs. 83.0%, $P<0.0001$). These results suggested a role for addictive behaviors in affecting tanning use and frequency. In fact, excessive indoor tanning is a complicated phenomenon and has only recently been recognized as having a possible relation to certain psychiatric disorders. People with excessive tanning behaviors may show some addictive manifestations such as spending excessive time and money in tanning, failing to resist the urge to tan repeatedly[6].

In 2015, U.S Food and Drug Administration proposed new safety measures of

tanning devices and banning its use among minors [7]. Our study provided some very recent epidemiologic evidence on indoor tanning behaviors. We acknowledge several limitations of this study. First, our sample size was relatively small, and all participants were white females. Generalizing our findings to males and other racial/ethnic groups should be approached with caution. Second, because our analysis was based on self-reported information, we cannot rule out misclassifications and unmeasured confounders. Future research could focus more on tanning addiction, and ongoing surveillance would provide monitoring of the impact of current policies on reducing tanning device use and skin cancer prevention.

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Table 1. Simple logistic regression analysis of demographic and socio-behavioral features, pigmentary traits, and attitudes towards tanning between the “ever used” and the “never used” groups

Variables		Ever used (n=347)	Never used (n=282)	OR (95%CI)	P value
Demographic and socio-behavioral features [n (%)]					
Age [median (Q1-Q3)]		22 (20-25)	20 (19-22)	1.13 (1.08-1.19)	<0.0001
Education level	Undergraduate	230 (66.3)	221 (78.4)	1	
	Graduate	117 (33.7)	61 (21.6)	1.84 (1.29-2.64)	0.0009
Health-related major/work	No	206 (59.4)	207 (73.4)	1	
	Yes	141 (40.6)	75 (26.6)	1.89 (1.34-2.65)	0.0002
Skin cancer family history	No	299 (86.2)	248 (87.9)	1	
	Yes	48 (13.8)	34 (12.1)	1.17 (0.73-1.87)	0.51
Family/Friends regularly use indoor tanning	None	102 (29.4)	128 (45.4)	1	
	Some/A few	232 (66.9)	149 (52.8)	1.95 (1.40-2.72)	<0.0001
	All/Most	13 (3.7)	5 (1.8)	3.26 (1.13-9.44)	0.03
Friends got tan in summer or after going to the beach	All/Most	282 (81.3)	197 (69.9)	1	
	Some/A few	57 (16.4)	71 (25.2)	0.56 (0.38-0.83)	0.004
	None	8 (2.3)	14 (4.9)	0.40 (0.16-0.97)	0.04
Sunscreen use in summer	Always/Often	218 (62.8)	202 (71.6)	1	
	Sometimes	82 (23.6)	55 (19.5)	1.38 (0.93-2.04)	0.11
	Rarely/Never	47 (13.6)	25 (8.9)	1.74 (1.03-2.94)	0.04
Pigmentary traits [n (%)]					
Natural skin color	Fair	177 (51.0)	200 (70.9)	1	
	Medium/Olive	170 (49.0)	82 (29.1)	2.34 (1.68-3.27)	<0.0001
Natural hair color	Dark brown/Black	108 (31.1)	97 (34.4)	1	
	Light brown	148 (42.7)	98 (34.8)	1.36 (0.93-1.97)	0.11
	Blonde	83 (23.9)	66 (23.4)	1.13 (0.74-1.73)	0.57
	Red	8 (2.3)	21 (7.4)	0.34 (0.15-0.81)	0.01
Eye color	Brown/dark	146 (42.1)	107 (37.9)	1	
	Hazel/green/medium	89 (25.6)	86 (30.5)	1.32 (0.90-1.94)	0.16
	Blue/light	112 (31.3)	89 (31.6)	1.22 (0.81-1.83)	0.35
Tanning ability [#]	Deep tan	109 (31.4)	47 (16.7)	1	
	Average tan	159 (45.8)	91 (32.3)	0.75 (0.49-1.16)	0.19
	Light tan	63 (18.2)	90 (31.9)	0.30 (0.19-0.48)	<0.0001
	Practically none	16 (4.6)	54 (19.1)	0.13 (0.07-0.25)	<0.0001
Sunburn susceptibility ^Δ	Practically none	81 (23.3)	43 (15.2)	1	
	Some redness only	160 (46.1)	93 (33.0)	0.91 (0.58-1.43)	0.69
	Burn	80 (23.1)	84 (29.8)	0.51 (0.31-0.82)	0.005
	Painful Burn/Blistering	26 (7.5)	62 (22.0)	0.22 (0.12-0.40)	<0.0001
Mole counts on left arm	None	140 (40.3)	133 (47.1)	1	
	1-9 moles	164 (47.3)	113 (40.1)	1.38 (0.98-1.93)	0.06
	≥10 moles	43 (12.4)	36 (12.8)	1.14 (0.69-1.88)	0.62
Attitudes about tanning [n (%)] (Tanning includes both indoor and outdoor tanning)					
A tan makes me feel more	Agree	290 (83.6)	164 (58.1)	1	

attractive	No Opinion	35 (10.1)	56 (19.9)	0.35 (0.22-0.56)	<0.0001
	Disagree	22 (6.3)	62 (22.0)	0.20 (0.12-0.34)	<0.0001
A tan represents a healthy appearance	Disagree	68 (19.6)	97 (34.4)	1	
	No Opinion	153 (44.1)	124 (44.0)	1.76 (1.19-2.60)	0.005
	Agree	126 (36.3)	61 (21.6)	2.95 (1.91-4.55)	<0.0001
Tanning can stimulate vitamin D production in my body which can be good for my health	Agree	204 (58.8)	111 (39.4)	1	
	No Opinion	104 (30.0)	118 (41.8)	0.48 (0.34-0.68)	<0.0001
	Disagree	39 (11.2)	53 (18.8)	0.40 (0.25-0.64)	0.0002
Tanning can cause skin problems such as premature aging and skin cancer	Agree	345 (99.4)	278 (98.6)	-	0.14
	No Opinion	2 (0.6)	1 (0.4)	-	
	Disagree	0 (0.0)	3 (1.0)	-	
Indoor tanning is safe (or at least safer than outdoor tanning)	Disagree	273 (78.7)	262 (92.9)	1	
	No Opinion	67 (19.3)	16 (5.7)	4.02 (2.27-7.11)	<0.0001
	Agree	7 (2.0)	4 (1.4)	1.68 (0.49-5.80)	0.41
I still like to get a tan even though I know tanning may be bad for my skin	Agree	240 (69.1)	108 (38.3)	1	
	No Opinion	45 (13.0)	58 (20.6)	0.35 (0.22-0.55)	<0.0001
	Disagree	62 (17.9)	116 (41.1)	0.24 (0.16-0.35)	<0.0001
113 responses were collected for the following statement *		Ever used (n=59)	Never used (n=54)	OR (95%CI)	P value
Compared to how I feel before tanning, I feel more relaxed/pleasant during tanning	Agree	49 (83.0)	12 (22.2)	1	
	No Opinion	7 (11.9)	28 (51.9)	0.06 (0.02-0.17)	<0.0001
	Disagree	3 (5.1)	14 (25.9)	0.05 (0.01-0.21)	<0.0001

Note: Abbreviations: Q1: lower quartile; Q3: upper quartile; OR: odds ratio; 95% CI: 95% confidence interval; *: This variable was not included in the multivariable analysis; #: Tanning ability was evaluated by asking, "As a child or adolescent, after repeated sun exposure, e.g., a 2-week vacation outdoors, what kind of tan would you get?"; [^]: Burn tendency was evaluated by asking "As a child or adolescent, once you had been exposed to the sun several times, what kind of reaction would your skin have after two or more hours in the sun on a bright sunny day?"

Table 2. Multivariable logistic regression analysis of factors related to indoor tanning use

Parameter		β	S.E	P-value	OR (95%CI)
(Intercept)		-4.61	0.74	<0.0001	---
Age		0.23	0.03	<0.0001	1.26 (1.19-1.34)
Health-related majors	Yes vs. No	0.70	0.21	0.0007	2.01 (1.35-3.01)
Family/Friends indoor tanning use	All/Most vs. None	1.37	0.67	0.04	3.92 (1.05-14.62)
	Some/A few vs. None	0.84	0.21	<0.0001	2.32 (1.54-3.48)
Tanning ability	Practically none/Light tan vs. Deep/Average tan	-0.82	0.21	<0.0001	0.44 (0.29-0.66)
A tan makes me feel more attractive	Disagree vs. Agree	-1.08	0.37	0.003	0.34 (0.17-0.70)
	No opinion vs. Agree	-0.61	0.30	0.04	0.55 (0.30-0.98)
Tanning can stimulate vitamin D production in my body which can be good for my health	Disagree vs. Agree	-0.44	0.30	0.14	0.64 (0.36-1.16)
	No opinion vs. Agree	-0.59	0.21	0.005	0.55 (0.37-0.84)
Indoor tanning is safe (or at least safer than outdoor tanning)	Agree vs. Disagree	0.11	0.74	0.88	1.11 (0.26-4.8)
	No opinion vs. Disagree	1.44	0.35	<0.0001	4.23 (2.14-8.35)
I still like to get a tan even though I know tanning may be bad for my skin	Disagree vs. Agree	-0.81	0.27	0.003	0.44 (0.26-0.76)
	No opinion vs. Agree	-0.88	0.28	0.001	0.41 (0.24-0.71)

Note: Adjusted for all variables listed in Table 1 except “Compared to how I feel before tanning, I feel more relaxed/pleasant during tanning”.

Supplementary material:

Supplementary Methods: A brief description of the study population.

Supplementary Table 1 (Table S1): Prevalence and frequencies of indoor tanning use among white female students aged 18-30 years in Indiana.

Supplementary Table 2 (Table S2): Eye protection use and prevalence of sunburn/other complications after tanning indoors among white female students aged 18-30 years in Indiana.

Description of study population

Our study was conducted among female students currently at the two major campuses of Indiana University in Indiana, United States, namely, Indiana University Bloomington (IUB) and Indiana University Purdue University-Indianapolis (IUPUI). IUPUI is an urban campus at the city of Indianapolis while IUB is located at Bloomington, which is a rural town. Our survey instrument was an online questionnaire sent through Indiana University email system. A total of 740 subjects responded and formed the study cohort. Among the total cohort, 629 participants were white female undergraduate and graduate students aged 18-30 years, who was the study population in this paper.

Supplementary Table 1. Prevalence and frequencies of indoor tanning use among white female students aged 18-30 years in Indiana

	Current users [n (%)]					Past users	Ever users	Never users	
	Total	1-2 times/ week	3-4 times/ week	5-7 times/ week	1-3 times/ month	<1 times/ month	[n (%)] Total	[n (%)] Total	[n (%)] Total
Undergraduate (n=451)	118* (26.2)	51 (43.2)	30 (25.4)	4 (3.4)	12 (10.2)	21 (17.8)	112 ^Δ (24.8)	230 (51.0)	221 (49.0)
Graduate (n=178)	16 (9.0)	4 (25.0)	4 (25.0)	0 (0.0)	1 (6.2)	7 (43.8)	101 (56.7)	117 (65.7)	61 (34.3)
Total (n=629)	134 (21.3)	55 (41.0)	34 (25.4)	4 (3.0)	13 (9.7)	28 (20.9)	213 (33.9)	347 (55.2)	282 (44.8)

* : The proportion of current tanners was higher among undergraduates than graduate students (26.2% vs. 9.0%, $P < 0.0001$); ^Δ: The proportion of past users was much higher among graduate than among undergraduate students (56.7% vs. 24.8%, $P < 0.0001$).

Supplementary Table 2. Eye protection use and prevalence of sunburn/other complications after tanning indoors among white female students aged 18-30 years in Indiana

		Current users (N=134)	Past users (N=213)	Current + Past users (N=347)	P value [*]
Experiencing sunburn after tanning indoors [n (%)]	Always	1 (0.8)	6 (2.8)	7 (2.0)	0.01
	Often	6 (4.5)	27 (12.7)	33 (9.5)	
	Sometimes	55 (41.0)	91 (42.7)	146 (42.1)	
	Rarely	52 (38.8)	54 (25.4)	106 (30.5)	
	Never	20 (14.9)	35 (16.4)	55 (15.9)	
Experiencing complications such as itching, red/painful skin, or eye problems after tanning indoors [n (%)]	Always	0 (0.0)	3 (1.4)	3 (0.9)	0.10
	Often	2 (1.5)	10 (4.7)	12 (3.5)	
	Sometimes	17 (12.7)	40 (18.8)	57 (16.4)	
	Rarely	32 (23.9)	51 (23.9)	83 (23.9)	
	Never	83 (61.9)	109 (51.2)	192 (55.3)	
Wearing protective eyewear/goggles during tanning [n (%)]	Always	62 (46.3)	127 (59.6)	189 (54.5)	0.01
	Often	20 (14.9)	20 (9.4)	40 (11.5)	
	Sometimes	9 (6.7)	24 (11.3)	33 (9.5)	
	Rarely	16 (11.9)	12 (5.6)	28 (8.1)	
	Never	27 (20.2)	30 (14.1)	57 (16.4)	

*: Comparisons between current users and past users;