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Pigmentary traits and use of indoor tanning beds in a cohort of women

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DEAR EDITOR

Frequent use of indoor tanning with artificial UV radiation likely contributes to the rising incidence of skin cancer^{1,2}. Despite known risks, indoor tanning is very common, with a prevalence of 36% among adults in Western countries¹. Reasons for individuals' use of indoor tanning include perceived aesthetic benefits, improved mood, and socialization^{3,4}. Several cross-sectional studies have examined the association between pigmentary traits, such as hair color, skin color, Fitzpatrick phototype and freckles, and use of indoor tanning, with conflicting results^{3–7}. These studies have been limited by modest sample sizes and failure to assess the factors associated with the frequency of indoor tanning.

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Study concept and design: Li, Qureshi. *Acquisition of data:* Li, Qureshi.

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Elucidating the associations between pigmentary traits and indoor tanning may provide insights to guide intervention strategies to curb indoor tanning and prevent skin cancer. We investigated the association between major pigmentary traits and frequency of indoor tanning based on the Nurses' Health Study II. Details of the cohort have been published previously⁸. Natural hair color in early adulthood (age 18 years) was asked in 1991 in the following categories: red, blonde, light brown, dark brown, and black. Other pigmentary traits, including number of nevi on the lower legs (none, 1–2, 3–4, 5–9, 10–14, 15–20, or 21), childhood or adolescent susceptibility to sunburn after 2 hours in the sun (practically none, some redness only, burn, painful burn, or burn with blisters), and number of teenage severe sunburns (0, 1–2, 3–4, or 5) were asked in 1989 (The questionnaire did not specifically define 'childhood', 'adolescent', and 'teenage'). In 2005, we collected information on the frequency of tanning bed usage during high school/college and ages 25–35 years in six categories: none, 1–2, 3–5, 6–11, 12–23, or 24 times/year⁸. We used methods applied in our prior study⁸ to calculate the average use of indoor tanning for each participant by summing up the frequency of indoor tanning during these two time periods, based on the median value of the reported category, and dividing the sum by 2. We then categorized average use of indoor tanning as follows: none, 1–2, 3–5, or 6 times/year. Among 93,497 eligible women, we excluded those with missing data on indoor tanning or any pigmentary trait and all non-Caucasians (n=24,736), 68,761 remained in the analysis (Table 1).

A total of 1981 participants (2.9%) reported frequent indoor tanning (≥ 6 times/year) during high school/college, and 5141 (7.5%) reported frequent indoor tanning at age 25–35 years. To calculate the odds ratios (ORs) and 95% confidence intervals (CIs) for the association between each pigmentary trait and indoor tanning at high school/college, age 25–35 years, and average indoor tanning, both univariate and multivariate-adjusted multinomial logistic regression analyses were conducted. Based on the data distribution, each pigmentary trait was classified into categories as shown in Table 2. Other statistical analysis methods are shown in the Supplementary File.

Frequency of indoor tanning varied according to pigmentary trait categories (Table 1). Light hair color, number of nevi, and number of teenage severe sunburns were significantly associated with increased indoor tanning at high school/college, age 25–35 years, and average indoor tanning (Table 2). For average indoor tanning ≥ 6 times/year, the multivariate-adjusted OR (95% CI) was 1.20 (1.10–1.32) among participants with red/blonde hair relative to participants with black/dark-brown hair, 1.27 (1.16–1.40) among those with ≥ 10 nevi relative to those without nevi, and 1.25 (1.11–1.40) among those with ≥ 5 teenage severe sunburns relative to those with none (Table 2). In generalized linear regression models, there was a trend towards increased usage of indoor tanning from darker to lighter hair color, by increasing number of cutaneous nevi, and by increasing number of teenage severe sunburns (all $P_{\text{trend}} < 0.001$, Supplementary Table 1). As hair color and sunburn sensitivity are correlated, we conducted a sensitivity analysis for hair color without adjusting for sunburn susceptibility, which slightly increased the effect estimates but did not materially change our findings (data not shown). We found an inverse association between childhood/adolescent burning susceptibility and indoor tanning. Those with painful or blistering sunburn susceptibility had a 39% lower chance of being frequent indoor tanners (OR=0.61,

95%CI=0.55–0.69) (Table 2). We further examined the association with outdoor sun exposure and found that women with childhood/adolescent sunburn susceptibility reported significantly lower outdoor sun exposure at high school/college and age 25–35 years (data not shown).

Analyses for the association between each pigmentary trait and frequency of indoor tanning stratified by the remaining three pigmentary traits did not find appreciable differences in effect estimates across different strata (data not shown). For example, the association between hair color and indoor tanning frequency did not differ by childhood/adolescent burning susceptibility (Supplementary Table 2). The P-values for interaction between burning susceptibility and hair color were 0.36 for indoor tanning at high school/college, 0.73 for indoor tanning at age 25–35, and 0.49 for average indoor tanning.

The mechanisms underlying the associations between pigmentary traits and indoor tanning may be complex. It would be interesting to examine whether people with different pigmentary traits have different motivations for indoor tanning. Previous studies have shown consistent positive associations of female gender, young adulthood and middle-age, location of residence, and unhealthy lifestyles with indoor tanning^{3–7}. It is likely that the associations we found in the present study are partly mediated by these factors as well.

As frequent indoor tanning may be determined by host genetic predisposition⁹, potentially shared genetic predisposition between pigmentary traits and indoor tanning may play an important role. Fell et al showed that the opioid peptide β -endorphin may mediate primordial UV seeking behaviors^{2,10}. β -endorphin shares a precursor (POMC) with melanocortin ligands, such as α -MSH¹¹, which activates MC1R and is essential for cutaneous pigmentation¹². Therefore, MC1R and β -endorphin linked by POMC could be one possible explanation, which requires further biological studies to classify. Recently, tanning addiction (dependence) has been proposed to contribute to the popularity of indoor tanning^{2,13}. A large proportion of indoor tanners meet criteria for substance abuse with respect to UV radiation, and frequent usage of indoor tanning may be a surrogate for tanning addiction^{14,15}. Interestingly, those with more severe sunburns as teenagers had increased rates of frequent indoor tanning at age 25–35 in our study, which may support the centrally rewarding (reinforcing) properties of indoor tanning¹⁴. However, reverse causation may also partly explain the association between number of teenage sunburns and indoor tanning use, as the association was particularly notable for indoor tanning bed use in high school/college.

In contrast to other pigmentary traits, individuals with increased burning susceptibility in childhood used indoor tanning less frequently, which may reflect a “phenotype-behavior feedback”. Consistent with the findings for indoor tanning use, we also found that those with burning susceptibility have less outdoor summer time sun exposure.

In conclusion, our findings from a large, prospective, well-established cohort study suggest that women with naturally lighter hair color, more nevi and severe sunburns as teenagers tended to use indoor tanning more frequently. In contrast, individuals with susceptibility to sunburn in childhood or adolescence used indoor tanning less frequently later in life. As all

participants were White women, extrapolation of our findings requires caution. Further studies are needed to confirm our findings and to investigate any underlying mechanisms.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1

Characteristics of the participants according to average indoor tanning: the Nurses' Health Study II ^a

	None	1–2 times/year	3–5 times/year	6 times/year	<i>P</i> ^b
n=68,761	52,062	9,811	3,163	3,725	
Age in 1989, years, mean (SD)	35.1 (4.5)	33.3 (4.7)	32.6 (4.7)	32.0 (4.7)	<0.0001
Body mass index in 1989, kg/m ² , mean (SD)	24.1 (5.1)	23.2 (4.4)	23.1 (4.3)	23.5 (4.7)	<0.0001
Body mass index at age 18, kg/m ² , mean (SD)	21.3 (3.3)	21.0 (3.1)	21.0 (3.1)	21.3 (3.5)	<0.0001
Physical activity in 1989, metabolic equivalent hours/week, mean (SD)	25.5 (60.7)	30.1 (65.1)	32.4 (72.7)	33.8 (62.9)	<0.0001
Alcohol intake in 1991, g/d, mean (SD)	3.0 (6.1)	3.8 (6.6)	3.7 (6.2)	3.8 (6.3)	<0.0001
Current smoking in 1989, %	11.1	13.0	15.3	17.6	<0.0001
History of major chronic diseases in 1989 ^c , %	7.4	6.3	6.4	7.1	0.0003
Family history of melanoma	8.2	8.8	7.6	8.7	0.10
Outdoor sun exposure 5 hours/wk, %					
At high school/college	58.7	64.9	70.6	74.7	<0.0001
Between ages 25 and 35 years	48.6	54.1	60.0	66.3	<0.0001
UV index in the state of residence 7, %					
At birth	18.0	20.0	22.6	22.6	<0.0001
At age 15 years	18.4	19.8	22.0	22.8	<0.0001
At age 30 years	25.0	25.4	26.4	26.6	0.10
Pigmentary traits					
Red or blonde hair, %	20.2	21.9	22.0	22.5	<0.0001
Cutaneous nevi 5 on lower legs, %	22.0	23.9	25.1	24.0	<0.0001
Childhood or adolescent sunburns or blistering susceptibility after continuous sun exposure, %	50.5	44.9	42.6	40.9	<0.0001
Number of teenage severe sunburns, 5, %	10.1	10.4	11.0	11.4	0.03

^a Average indoor tanning was calculated based on the indoor tanning at high school/college and at age 25–35 years.

^b *P* values were calculated by using one-way ANOVA (for continuous variables) or chi-square test (for categorical variables).

^c Major chronic diseases include hypertension, cardiovascular disease, cancer, diabetes, and common autoimmune diseases (rheumatoid arthritis, systemic lupus erythematosus, psoriatic arthritis, Crohn's disease, ulcerative colitis, and multiple sclerosis).

The multivariable-adjusted odds ratios (95% confidence intervals) for the association between pigmentation traits and frequency of indoor tanning^a

Table 2

		None		1–2 times/year		3–5 times/year		6 times/year	
		n	n	OR (95% CI)	n	OR (95% CI)	n	OR (95% CI)	n
<i>Indoor tanning bed use at high school or college^b</i>									
Hair color									
Black/dark-brown		24,769	1094	1.00	556	1.00	715	1.00	
Light brown		24,902	1,175	1.05 (0.96–1.14)	520	0.90 (0.80–1.01)	809	1.09 (0.99–1.21)	
Blonde/red		12,785	646	1.08 (0.98–1.20)	333	1.06 (0.92–1.21)	457	1.12 (0.99–1.26)	
Number of cutaneous nevi									
0		30,397	1,367	1.00	641	1.00	993	1.00	
1–4		18,147	830	1.03 (0.95–1.13)	417	1.11 (0.98–1.25)	593	1.14 (1.03–1.27)	
5–9		4,357	216	1.10 (0.95–1.26)	118	1.27 (1.05–1.55)	139	1.11 (0.93–1.32)	
10		9,555	502	1.14 (1.03–1.26)	233	1.14 (0.98–1.32)	357	1.26 (1.11–1.43)	
Number of teenage severe sunburns									
0		20,943	778	1.00	397	1.00	551	1.00	
1–2		24,498	1,245	1.37 (1.25–1.49)	605	1.33 (1.17–1.50)	803	1.22 (1.10–1.36)	
3–4		10,739	566	1.46 (1.31–1.62)	235	1.25 (1.07–1.46)	352	1.24 (1.09–1.42)	
5		6,276	326	1.45 (1.28–1.65)	172	1.51 (1.26–1.80)	275	1.68 (1.46–1.94)	
Childhood/adolescent sunburn susceptibility									
Practically none		8,997	432	1.00	198	1.00	303	1.00	
Redness only		22,720	1,144	1.01 (0.91–1.13)	574	1.09 (0.93–1.28)	823	1.00 (0.88–1.13)	
Burn		15,138	733	0.98 (0.87–1.11)	369	1.07 (0.90–1.26)	494	0.91 (0.79–1.04)	
Painful/blistering burn		15,601	606	0.83 (0.73–0.94)	268	0.79 (0.66–0.95)	361	0.66 (0.57–0.77)	
<i>Indoor tanning bed use at age 25–35^c</i>									
Hair color									
Black/dark-brown		22,190	2,052	1.00	1,045	1.00	1,847	1.00	
Light brown		21,904	2,191	1.07 (1.01–1.14)	1,144	1.12 (1.02–1.22)	2,167	1.19 (1.11–1.27)	
Blonde/red		11,262	1,180	1.09 (1.01–1.18)	652	1.20 (1.09–1.33)	1,127	1.17 (1.08–1.27)	

	None			1–2 times/year			3–5 times/year			6 times/year		
	n	n	OR (95% CI)	n	n	OR (95% CI)	n	n	OR (95% CI)	n	n	OR (95% CI)
Number of cutaneous nevi												
0	27,026	2,562	1.00	1,321	1.00	1.00	2,388	1.00	1.00	1.00	1.00	1.00
1–4	16,026	1,567	1.05 (0.98–1.12)	867	1.14 (1.04–1.24)	1.12 (1.03–1.18)	1,527	1.10 (1.03–1.18)	1.10 (0.98–1.23)	1.10 (0.98–1.23)	1.10 (0.98–1.23)	1.10 (0.98–1.23)
5–9	3,836	411	1.12 (1.01–1.25)	215	1.12 (1.01–1.25)	1.12 (1.01–1.25)	368	1.10 (0.98–1.23)	1.10 (0.98–1.23)	1.10 (0.98–1.23)	1.10 (0.98–1.23)	1.10 (0.98–1.23)
10	8,468	883	1.10 (1.02–1.19)	438	1.07 (0.96–1.19)	1.07 (0.96–1.19)	858	1.20 (1.11–1.30)	1.20 (1.11–1.30)	1.20 (1.11–1.30)	1.20 (1.11–1.30)	1.20 (1.11–1.30)
Number of teenage severe sunburns												
0	18,621	1,706	1.00	801	1.00	1.00	1,541	1.00	1.00	1.00	1.00	1.00
1–2	21,557	2,237	1.12 (1.05–1.20)	1,216	1.27 (1.17–1.39)	1.15 (1.08–1.23)	2,141	1.15 (1.08–1.23)	1.15 (1.08–1.23)	1.15 (1.08–1.23)	1.15 (1.08–1.23)	1.15 (1.08–1.23)
3–4	9,508	950	1.11 (1.02–1.20)	515	1.25 (1.12–1.39)	1.13 (1.04–1.23)	919	1.13 (1.04–1.23)	1.13 (1.04–1.23)	1.13 (1.04–1.23)	1.13 (1.04–1.23)	1.13 (1.04–1.23)
5	5,670	530	1.03 (0.93–1.14)	309	1.21 (1.06–1.38)	1.10 (1.00–1.22)	540	1.10 (1.00–1.22)	1.10 (1.00–1.22)	1.10 (1.00–1.22)	1.10 (1.00–1.22)	1.10 (1.00–1.22)
Childhood/adolescent sunburn susceptibility												
Practically none	7,849	836	1.00	442	1.00	1.00	803	1.00	1.00	1.00	1.00	1.00
Redness only	19,608	2,189	1.01 (0.93–1.10)	1,209	1.05 (0.95–1.17)	1.07 (0.98–1.16)	2,255	1.07 (0.98–1.16)	1.07 (0.98–1.16)	1.07 (0.98–1.16)	1.07 (0.98–1.16)	1.07 (0.98–1.16)
Burn	13,582	1,290	0.86 (0.79–0.94)	660	0.84 (0.74–0.95)	0.82 (0.75–0.90)	1,202	0.82 (0.75–0.90)	0.82 (0.75–0.90)	0.82 (0.75–0.90)	0.82 (0.75–0.90)	0.82 (0.75–0.90)
Painful burn/blistering	14,317	1,108	0.74 (0.67–0.81)	530	0.67 (0.59–0.76)	0.60 (0.55–0.66)	881	0.60 (0.55–0.66)	0.60 (0.55–0.66)	0.60 (0.55–0.66)	0.60 (0.55–0.66)	0.60 (0.55–0.66)
<i>Average indoor tanning of the two periods.c.d</i>												
Hair color												
Black/dark-brown	20,918	3,720	1.00	1,178	1.00	1.00	1,318	1.00	1.00	1.00	1.00	1.00
Light brown	20,606	3,944	1.06 (1.01–1.12)	1,288	1.10 (1.01–1.19)	1.20 (1.11–1.30)	1,568	1.20 (1.11–1.30)	1.20 (1.11–1.30)	1.20 (1.11–1.30)	1.20 (1.11–1.30)	1.20 (1.11–1.30)
Blonde/red	10,538	2,147	1.10 (1.03–1.17)	697	1.11 (1.01–1.23)	1.20 (1.10–1.32)	839	1.20 (1.10–1.32)	1.20 (1.10–1.32)	1.20 (1.10–1.32)	1.20 (1.10–1.32)	1.20 (1.10–1.32)
Number of cutaneous nevi												
0	25,541	4,594	1.00	1,440	1.00	1.00	1,722	1.00	1.00	1.00	1.00	1.00
1–4	15,076	2,874	1.07 (1.02–1.13)	928	1.12 (1.03–1.22)	1.12 (1.03–1.21)	1,109	1.12 (1.03–1.21)	1.12 (1.03–1.21)	1.12 (1.03–1.21)	1.12 (1.03–1.21)	1.12 (1.03–1.21)
5–9	3,579	747	1.14 (1.05–1.25)	253	1.24 (1.08–1.42)	1.08 (0.95–1.24)	251	1.08 (0.95–1.24)	1.08 (0.95–1.24)	1.08 (0.95–1.24)	1.08 (0.95–1.24)	1.08 (0.95–1.24)
10	7,866	1,596	1.12 (1.06–1.19)	542	1.25 (1.13–1.38)	1.27 (1.16–1.40)	643	1.27 (1.16–1.40)	1.27 (1.16–1.40)	1.27 (1.16–1.40)	1.27 (1.16–1.40)	1.27 (1.16–1.40)
Number of teenage severe sunburns												
0	17,702	2,957	1.00	898	1.00	1.00	1,112	1.00	1.00	1.00	1.00	1.00
1–2	20,221	4,056	1.19 (1.13–1.25)	1,348	1.28 (1.17–1.39)	1.16 (1.08–1.26)	1,526	1.16 (1.08–1.26)	1.16 (1.08–1.26)	1.16 (1.08–1.26)	1.16 (1.08–1.26)	1.16 (1.08–1.26)
3–4	8,883	1,779	1.21 (1.14–1.29)	568	1.24 (1.12–1.38)	1.15 (1.05–1.27)	662	1.15 (1.05–1.27)	1.15 (1.05–1.27)	1.15 (1.05–1.27)	1.15 (1.05–1.27)	1.15 (1.05–1.27)

	None			1–2 times/year			3–5 times/year			6 times/year		
	n	OR	(95% CI)	n	OR	(95% CI)	n	OR	(95% CI)	n	OR	(95% CI)
5	5,256	1,019	1.16 (1.07–1.25)	349	1.27	(1.12–1.43)	425	1.25	(1.11–1.40)			
Childhood/adolescent sunburn susceptibility												
Practically none	7,394	1,468	1.00	488	1.00		580	1.00				
Redness only	18,372	3,938	1.04 (0.97–1.11)	1,329	1.04	(0.94–1.15)	1,622	1.06	(0.96–1.17)			
Burn	12,695	2,387	0.92 (0.86–0.99)	789	0.91	(0.81–1.02)	863	0.81	(0.73–0.91)			
Painful burn/blistering	13,601	2,018	0.76 (0.71–0.82)	557	0.62	(0.55–0.70)	660	0.61	(0.55–0.69)			

^aThe results from univariate models are not shown but appeared very similar with the results from multivariable-adjusted models. Because the age at cohort baseline (1989) was between 25 and 42 years, we primarily used covariate information collected in 1989.

^bAdjusted for age, physical activity, BMI at age 18, family history of melanoma, UV index at age 15, and other pigmentation traits. To avoid over-adjustment, for the analysis of hair color and cutaneous nevi, we adjusted for sunburn sensitivity but not number of severe sunburns. For the analysis of sunburn sensitivity (or number of severe sunburns), we did not adjust for number of severe sunburns (or sunburn sensitivity).

^cAdjusted for age, physical activity, BMI, smoking, alcohol intake, family history of melanoma, UV index at age 15, and age 30 years, personal history of major chronic diseases and autoimmune diseases, and other pigmentation traits. To avoid over-adjustment, for the analysis of hair color and cutaneous nevi, we adjusted for sunburn sensitivity but not number of severe sunburns. For the analysis of sunburn sensitivity (or number of severe sunburns), we did not adjust for number of severe sunburns (or sunburn sensitivity).

^dWe calculated the average indoor tanning for each participant by summing up the frequency of indoor tanning at high school/college and at age 25–35 years and dividing the sum by 2.