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The Association between Skin Characteristics and Skin Cancer Prevention Behaviors

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Abstract

Background: **Behaviors such as sunscreen use and wearing sun-protective clothing are thought to prevent certain types of skin cancer and precancerous lesions, but few studies have examined differences in these prevention behaviors by skin type.**

Methods: **We carried out a cross-sectional study (n = 6,858) nested within a community-based prospective cohort in Washington County, Maryland. We measured the associations between skin type, complexion, freckling, and eye color, and sunscreen and sun-protective clothing use.**

Results: **The prevalence of regular sunscreen use was 23% and regular sun-protective clothing use was 21%. There were consistent trends indicating those with the most sun-sensitive skin type were most likely to engage in prevention behaviors. For example, compared with those who tan without burning, those who develop blistering sunburns were more likely to use sunscreen [odds ratio (OR), 6.04; 95% confidence interval (95% CI), 2.82-12.95 men; OR, 4.89; 95% CI, 3.34-7.16 women] and sun-protective clothing (OR, 2.87; 95% CI, 1.71-4.80 men; OR, 4.44; 95% CI, 2.88-6.85 women). Health-related characteristics such as body mass index and cigarette smoking were also significantly inversely associated with prevention behaviors.**

Conclusion: **The overall prevalence of prevention behaviors was low. Those with phenotypic risk factors for skin cancer were most likely to use sunscreen and sun-protective clothing. Those with high-risk skin cancer phenotypes may also be those who are most receptive to skin cancer prevention educational interventions.** (Cancer Epidemiol Biomarkers Prev 2009;18(10):2613–9)

Introduction

Nonmelanoma skin cancer (NMSC), comprised mainly of basal cell carcinoma and squamous cell carcinoma, is the most common malignancy in the United States, with well more than one million cases estimated for 2008 (1). The high prevalence of NMSC translates into substantial medical care costs, as NMSC ranks as the fifth costliest malignancy among Medicare patients (2). Although most NMSCs are highly curable, the high incidence and cost of treatment accentuate the need for improved prevention.

The most common environmental risk factor for NMSC is ultraviolet radiation (UVR; ref. 3). Skin cancer risk can be reduced by behaviors that protect against UVR exposure, such as sunscreen use, wearing sun-protective clothing, and avoiding midday sun (4). Individual susceptibility to UVR, and thus risk for skin cancer, varies by phenotypic characteristics, such as Fitzpatrick skin type. These are defined by skin reaction to sunlight, complexion, freckling, and eye and hair color (3, 5-11). Despite the fact that both UVR exposure and individual susceptibility are important determinants of skin cancer risk, the relationship between skin cancer risk and prevention behaviors remains to be fully understood. Preliminary results suggest that this topic merits further investigation to address possible associations of skin cancer prevention behaviors not only with phenotypic risk factors for skin cancer but also individual-level factors, such as age, gender, and lifestyle characteristics that may be associated with prevention behaviors (12-18).

Advancing our understanding of skin cancer prevention behaviors according to phenotypic risk factors for skin cancer, such as skin type, freckling, and eye color, and other personal characteristics will potentially lead to refined strategies for targeting those at greatest need for preventive intervention. We therefore carried out the present study to assess the associations between phenotypic risk factors for skin cancer and skin cancer prevention behaviors.

Materials and Methods

Study Design. This research was carried out with approval of the Institutional Review Boards at the Medical University of South Carolina and the Johns Hopkins University Bloomberg School of Public Health. This cross-sectional study was nested within a larger parent study, the Give Us a Clue to Cancer and Heart Disease

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II cohort (CLUE II), a community-based prospective cohort study. At baseline in 1989, the Give Us a Clue to Cancer and Heart Disease II cohort consisted of 28,594 participants in Washington County, Maryland, which is in western Maryland. In May 2007, a follow-up survey was mailed to cohort members who had responded to at least one of the four previous follow-up surveys (n = 14,779). From a longer questionnaire, we focus only on the items used in this report.

The two primary variables used to assess the study outcome of skin cancer prevention behaviors were the use of sunscreen and sun-protective clothing. Use of sun-protective clothing was based on a single item that used the examples of wearing a hat, long sleeves, or long pants, or using an umbrella. The items used to measure these variables had a four-point scale ranging from "Never" to "Often/Always". In our analyses, responses of "Often/Always" were considered regular users, and all other categories together were considered nonregular users.

The primary independent variables were measures of skin cancer susceptibility: skin reaction to sunlight, complexion, amount of facial freckling, and eye color. The item used to assess skin reaction to sunlight asked, "If you spent an hour in the midday sun for the first time without sunscreen, which of these reactions best describes what would happen to your skin?" The five possible responses were: blistering sunburn, sunburn without blisters, mild sunburn that becomes a tan, tan or darken with no sunburn, or no change in skin color. Complexion was measured on a seven-point scale ranging from "very fair" to "dark brown" with an option for "don't know". The "dark brown" and "medium brown" categories were collapsed due to a small number of participants (n = 22) in the "dark brown" category. For this same reason, we collapsed the "large amount" and "almost all" categories for amount of facial freckling. Light eye color, often classified as blue or green eyes, has been associated with an increased risk of skin cancer compared with other colors (3, 5, 6, 19, 20). We therefore classified eye color into two categories: (*a*) blue plus green and (*b*) hazel, light brown, dark brown, and "other color".

A series of questions was used to measure sun exposure history. One item asked the number of days per week in the summer with at least 60 min of direct sun exposure using a five-point scale, from never to 6-7 days per week. Another determined whether the respondent ever had a blistering sunburn. Two items asked about the number of hours of midday sun exposure (0-6 h) on both weekdays and weekends during the past decade. Lastly, a series of questions was used to determine both personal and family history of skin cancer.

In addition to these sun exposure and skin cancer variables, other covariates integrated into our analysis include gender, age, years of education, race, body mass index (BMI), and cigarette smoking status (never/former/current). Age was calculated from birthdate to September 1, 2007, the midpoint of the data collection interval. Height and weight were used to calculate BMI.

Study Population. Of the total 8,128 Caucasian participants in the 2007 survey, 1,270 had missing data for any of the following variables: sunscreen use, sun-protective clothing use, skin reaction to sunlight, complexion, amount of facial freckling, eye color, days of sun exposure, midday sun exposure on both weekdays and weekends during the past decade, and personal history of skin cancer. There were complete data for 6,858 individuals. As ignoring those with incomplete data can introduce bias, we used multiple imputations to account for missing values. As described below, we did our analyses on both the subset with complete data (n = 6,858) and on the full population after using multiple imputations to estimate missing values (n = 8,128).

Data Analyses. Compared with those with complete data, those without complete data had a significantly higher ($P < 0.005$) proportion of females (66.2% versus 60.6%, incomplete versus complete) and nonsmokers (95.8% versus 93.2%), and were significantly ($P < 0.005$) more likely to be older (72.1 versus 63.8 mean y), less educated (12.2 versus 13.6 mean y), and leaner (BMI 27.9 versus 28.5 mean kg/m^2; data not shown).

As described in the results, initial analyses revealed notable differences between men and women across most of the key study characteristics (Table 1). Consequently, all analyses were stratified by sex. Bivariate comparisons of skin cancer prevention behavior prevalence with phenotypic, demographic, and skin cancer history variables were done, with P-values estimated from the χ^2 test for categorical variables and the t-test for continuous variables. The Cochran-Armitage trend test was used to calculate P-values for multi-level variables.

We calculated Spearman's rank correlation coefficients between skin type, complexion, freckling, and eye color. All four phenotype variables were statistically significantly correlated with each other ($P \leq 0.0001$ for each). By far the strongest correlation was between the two characteristics that later emerged as most important in our analyses: skin type and complexion (r = 0.45). In contrast, the correlations between skin type and freckling (r = 0.19) and eye color (r = 0.16) were considerably weaker. Based upon this observation, we opted to model each phenotypic variable separately.

Sunscreen use and sun-protective clothing use were both modeled using logistic regression with each of the four skin cancer susceptibility variables individually, then adjusting for additional covariates. The primary results presented in the tables are from the analyses using only those with complete data (n = 6,858). To account for the impact on the associations that the 1,270 individuals with missing data may have had, we carried out the same analyses on all 8,128 participants using multiple imputations to estimate values for the missing items. As described in the Results section, these two separate analyses yielded results that were mostly very similar. Thus, we emphasize the results from the sample with complete data (n = 6,858), noting any differences between the analyses. All statistical tests and data analyses were done using SAS 9.1 (SAS Institute). Multiple imputations for missing values were conducted using the tree-based imputation approach described in Dai et al. (21), implemented in R version 2.6.0 (the R Project for Statistical Computing, http://www.r-project.org/). A two-sided P-value of 0.05 was considered to be statistically significant.

Results

Sample Characteristics. Men (n = 2,701) and women (n = 4,157) differed significantly across many of the key study factors (Table 1). On average, males were 2 years

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Table 1. Descriptive characteristics of study participants, Washington County, Maryland, 2007

	Males (*n* = 2,701)	Females (*n* = 4,157)	*P*-value*
Age	65.2 ± 12.0	63.0 ± 12.8	<0.0001
30-39 (%)	2.0	4.3	
40-49	8.8	11.9	
50-59	22.6	25.4	
60-69	30.0	27.9	
70-79	24.8	20.7	
>80	11.8	9.8	
Years of education	13.7 ± 3.0	13.5 ± 2.7	0.10
Cigarette Smoking (% never)	40.0	63.0	<0.0001
BMI	28.6 ± 5.1	28.5 ± 6.6	0.45
Use sunscreen often/always (%)	13.2	29.0	<0.0001
Wear sun-protective clothing often/always (%)	27.0	16.9	<0.0001
Skin reaction to sunlight (%)			
Blistering sunburn	4.0	6.7	<0.0001
Sunburn without blisters	28.5	34.0	
Mild sunburn that becomes a tan	48.9	46.3	
Tan or darken with no sunburn	16.7	10.8	
No change in skin color	1.9	2.2	
Complexion (%)†			
Very fair	1.8	5.2	<0.0001
Fair	28.1	40.9	
Medium	53.1	45.7	
Light brown	7.3	3.6	
Medium/dark brown	9.7	4.7	
Facial freckling (%)			
None	70.9	55.6	<0.0001
Small amount	26.8	39.9	
Large amount/almost all	2.3	4.5	
Eye color (%)†			
Blue or green	46.4	44.4	0.10
Other eye color	53.7	55.6	
≤1 day per week of 1 h sun exposure (%)	23.6	49.0	<0.0001
Blistering sunburn (% yes)	59.8	61.3	0.19
Weekday h in the midday sun	2.3 ± 1.7	1.3 ± 1.3	<0.0001
Weekend h in the midday sun	2.6 ± 1.6	1.6 ± 1.5	<0.0001
Skin cancer (% yes)			
Personal history	23.2	17.1	<0.0001
Family history	24.9	31.2	<0.0001

*t-test for continuous variables, χ^2 test for categorical variables.
†Percentages may not sum to exactly 100 due to rounding.

older than females (65.2 versus 63.0 years). The proportion of males who were never smokers was less than that of females (40.0% versus 63.0%). Compared with females, males reported lower prevalence of burning after exposure to sunlight, fair complexion, and facial freckling. Males, in comparison with females, self-reported more hours per day in sunlight and a higher prevalence of a personal history of skin cancer (23.2% versus 17.1%). With respect to the study outcomes, the prevalence of regular sunscreen use was less in males than females (13.2% versus 29.0%, $P < 0.0001$), but the prevalence of regularly wearing sun-protective clothing was greater in males than females (27.0% versus 16.9%, $P < 0.0001$).

Skin Cancer Prevention Behaviors by Skin Cancer Risk Factors. When skin cancer prevention behaviors were evaluated by age group, regular use of sun-protective clothing increased steeply with age among both males and females, whereas regular sunscreen use decreased with age among females (Table 2). These associations also held true in multiple regression models adjusted for all the variables shown in Table 2, plus skin type. In both sexes, years of education was positively associated with both sunscreen and sun-protective clothing use. Compared with never smokers, male current smokers were less likely to engage in both prevention behaviors (sunscreen use: OR, 0.33; 95% CI, 0.13-0.84; sun-protective clothing use: OR, 0.46; 95% CI, 0.28-0.77) and female current smokers were less likely to use sunscreen regularly (OR, 0.69; 95% CI, 0.51-0.95). BMI was significantly inversely associated with sunscreen use, but not protective clothing use, in both genders.

The likelihood of wearing sun-protective clothing was inversely associated with the numbers of days with sun exposure and hours of weekend sun exposure (Table 2). For example, compared with those who spent 1 day or fewer per week with an hour of sun exposure, those who spent at least 2 days per week with sun exposure were less likely to wear sun-protective clothing (males: OR, 0.77; 95% CI, 0.63-0.95; females: OR, 0.72; 95% CI, 0.58-0.89). Sun-protective clothing use was not associated with increasing hours of sun exposure on weekdays for either males or females. Regular sunscreen use was not associated with duration or frequency of sun exposures in the adjusted models. Sunscreen use and wearing sun-protective clothing were both positively associated with personal history of skin cancer among men and women whereas a family history of skin cancer was associated with only an increased use of sunscreen among males.

In general, there were trends of increasing skin cancer prevention behaviors by increasing skin cancer susceptibility based on phenotypic characteristics among both males (Table 3) and females (Table 4). For example, those

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who develop a blistering sunburn were much more likely to use sunscreen regularly than those who tan or darken without burning in both men (24% versus 4%; OR, 7.71; 95% CI, 3.88-15.30) and women (45% versus 16%; OR, 4.30; 95% CI, 3.04-6.08). After adjustment for age, years of education, race, smoking, BMI, days of sun exposure, history of blistering sunburns, hours of midday exposure, and personal and family history of skin cancer, these associations remained strong (males: OR, 6.04; 95% CI, 2.82-12.95; females: OR, 4.89; 95% CI, 3.34-7.16). Using multiple imputations to estimate missing data further attenuated this association, although it remained robust among both males (OR, 4.85; 95% CI, 2.56-9.21) and females (OR, 3.98; 95% CI, 2.82-5.62). Gradients were also noted in skin reaction to sunlight for the use of sun-protective clothing compared with those who tan or darken without burning, those who develop blistering sunburns were more likely to cover up (males: 49% versus 20%; adjusted OR, 2.87; 95% CI, 1.71-4.80; females: 40% versus 10%; adjusted OR, 4.44; 95% CI, 2.88-6.85). A similar pattern of associations was observed for complexion in both sexes with the prevalence of prevention behaviors increasing as phenotypic susceptibility also increases.

With respect to freckling and eye color, the tendency was for individuals with more facial freckling or lighter colored eyes to more frequently use sunscreen, but this did not hold true for sun-protective clothing. In males, the analyses using multiple imputations yielded positive associations between blue or green eye color and sunscreen use, and freckling and both sunscreen and sun-protective clothing use. Among females, in the analyses based on imputed data, facial freckling was associated with increased regular sunscreen use and blue or green eye color was associated with increased sun-protective clothing use.

Discussion

The primary findings of the present study are: (*a*) the overall prevalence of skin cancer prevention behaviors was low; (*b*) the likelihood of engaging in these behaviors is strongly associated with phenotypic risk factors, such as propensity to burn and complexion; and (*c*) the likelihood of engaging in these behaviors is negatively correlated with cigarette smoking and elevated BMI.

Randomized trials have shown daily sunscreen use is effective at preventing squamous cell carcinoma and its precursors, so we used our "often/always" category to estimate this standard of sun protection (4). Based on this distinction, less than one fourth of the total study population regularly uses sunscreen (23%), or wears sun-protective clothing (21%). These results are consistent with data from the National Health Interview Survey,

Table 2. Prevalence and OR (and 95% CI) for the associations among demographic factors, health-related characteristics, sun exposure and sunburn history, and skin cancer history according to skin cancer prevention behaviors among males and females, Washington County, Maryland, 2007

	Males				Females			
	Regular sunscreen use		Regular sun-protective clothing use		Regular sunscreen use		Regular sun-protective clothing use	
	%	OR (95% CI)*	%	OR (95% CI)*	%	OR (95% CI)*	%	OR (95% CI)*
Age								
30-39	9.3	1.0 (referent)	11.1†	1.0 (referent)	41.1†	1.0 (referent)	7.2†	1.0 (referent)
40-49	14.3	2.50 (0.69-9.00)	16.0	2.69 (0.77-9.36)	28.4	0.66 (0.45-0.97)	9.3	1.15 (0.59-2.22)
50-59	15.2	2.34 (0.68-8.08)	22.1	3.36 (1.00-11.24)	34.1	0.81 (0.57-1.16)	13.7	1.67 (0.91-3.07)
60-69	12.1	1.59 (0.46-5.50)	26.8	4.35 (1.30-14.54)	28.6	0.63 (0.44-0.90)	18.8	2.21 (1.21-4.06)
70-79	13.7	1.73 (0.49-6.06)	30.8	4.73 (1.41-15.92)	26.4	0.58 (0.40-0.85)	20.8	2.34 (1.27-4.38)
≥80	11.0	1.08 (0.29-3.98)	39.5	5.66 (1.65-19.40)	17.7	0.30 (0.19-0.47)	24.6	2.43 (1.27-4.66)
Years of education	—‡	1.09 (1.05-1.14)	—‡	1.04 (1.01-1.08)	—‡	1.13 (1.10-1.16)	—‡	1.05 (1.02-1.09)
Cigarette Smoking								
Never	13.2	1.0 (referent)	28.5	1.0 (referent)	28.9	1.0 (referent)	17.3	1.0 (referent)
Former	13.4	1.13 (0.86-1.49)	27	0.77 (0.63-0.95)	31.2	1.17 (1.00-1.37)	17.4	0.99 (0.82-1.20)
Current	3.8	0.33 (0.13-0.84)	12.7†	0.46 (0.28-0.77)	21.6	0.69 (0.51-0.95)	10.8	0.73 (0.48-1.10)
BMI	—‡	0.94 (0.92-0.97)	—‡	0.99 (0.97-1.01)	—‡	0.97 (0.96-0.98)	—‡	1.00 (0.99-1.01)
Days of 1 h sun exposure								
≤1 d/w	16.0	1.0 (referent)	35.4†	1.0 (referent)	27.8	1.0 (referent)	21.9†	1.0 (referent)
>1 d/w	12.3	0.78 (0.56-1.08)	24.3	0.77 (0.63-0.95)	30.1	1.09 (0.92-1.30)	12.0	0.72 (0.58-0.89)
Ever blistering sunburn								
No	10.3	1.0 (referent)	28.2	1.0 (referent)	31.8	1.0 (referent)	18.5	1.0 (referent)
Yes	15.2	1.12 (0.84-1.50)	24.8	1.08 (0.88-1.33)	24.8†	0.99 (0.85-1.16)	14.3†	1.22 (1.00-1.49)
Weekday hours in the midday sun	—‡	0.99 (0.88-1.12)	—‡	1.09 (0.99-1.19)	—‡	0.98 (0.90-1.06)	—‡	1.09 (0.97-1.22)
Weekend hours in the midday sun	—‡	1.04 (0.92-1.18)	—‡	0.88 (0.80-0.97)	—‡	1.04 (0.96-1.12)	—‡	0.81 (0.73-0.90)
Personal history of skin cancer								
No	10.7	1.0 (referent)	22.4	1.0 (referent)	26.2	1.0 (referent)	14.8	1.0 (referent)
Yes	21.5	2.07 (1.54-2.78)	41.8†	1.84 (1.46-2.30)	42.5†	2.21 (1.83-2.67)	27.0†	1.71 (1.39-2.11)
Family history of skin cancer								
No	11.6	1.0 (referent)	26.0	1.0 (referent)	27.6	1.0 (referent)	16.6	1.0 (referent)
Yes	18.7	1.41 (1.07-1.86)	29.9	1.00 (0.80-1.25)	32.5†	1.00 (0.85-1.17)	17.6	0.96 (0.79-1.16)

*OR with 95% CI. Adjusted for all covariates listed in table plus skin reaction to sunlight.
†*P* for trend <0.05.
‡Measured continuously.

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Table 3. Prevalence and OR (and 95% CI) for the associations between phenotypic skin cancer risk factors and skin cancer prevention behaviors among males, Washington County, Maryland, 2007

Phenotypic factor	Regular sunscreen use				Regular sun-protective clothing use			
	%	OR (95% CI)	OR (95% CI)*	OR (95% CI)*,†	%	OR (95% CI)	OR (95% CI)*	OR (95% CI)*,†
Skin reaction to sunlight								
Blistering sunburn	23.9‡	7.71 (3.88-15.30)	6.04 (2.82-12.95)	4.85 (2.56-9.21)	48.6‡	4.09 (2.55-6.58)	2.87 (1.71-4.80)	2.44 (1.59-3.73)
Sunburn without blisters	22.5	6.95 (4.09-11.81)	5.73 (3.21-10.23)	4.23 (2.61-6.86)	36.6	2.50 (1.87-3.36)	2.00 (1.46-2.75)	1.75 (1.34-2.29)
Mild sunburn that becomes a tan	10.1	2.44 (1.43-4.18)	2.35 (1.32-4.19)	2.25 (1.40-3.64)	22.1	1.24 (0.93-1.65)	1.18 (0.88-1.59)	1.14 (0.88-1.47)
Tan or darken with no sunburn	4.3	1.0 (referent)	1.0 (referent)	1.0 (referent)	20.0	1.0 (referent)	1.0 (referent)	1.0 (referent)
No change in skin color	11.3	2.81 (0.98-8.04)	2.61 (0.81-8.45)	2.27 (0.83-6.19)	20.8	1.15 (0.55-2.41)	0.67 (0.28-1.59)	0.94 (0.49-1.80)
Complexion								
Very fair	40.8‡	13.25 (5.91-29.7)	11.06 (4.64-26.35)	8.67 (4.11-18.31)	36.7‡	2.55 (1.27-5.10)	2.20 (1.06-4.55)	2.27 (1.24-4.14)
Fair	20.1	3.99 (2.21-7.21)	3.04 (1.62-5.70)	2.92 (1.71-4.97)	36.6	2.83 (1.95-4.10)	2.36 (1.59-3.48)	1.97 (1.42-2.71)
Medium	10.8	2.03 (1.13-3.66)	1.78 (0.96-3.30)	1.79 (1.06-3.04)	24.1	1.50 (1.05-2.15)	1.38 (0.95-2.01)	1.29 (0.95-1.77)
Light brown	7.5	1.26 (0.56-2.83)	1.03 (0.43-2.48)	1.18 (0.57-2.44)	18.4	0.98 (0.59-1.65)	1.02 (0.60-1.75)	1.06 (0.67-1.65)
Medium/dark brown	6.0	1.0 (referent)	1.0 (referent)	1.0 (referent)	18.6	1.0 (referent)	1.0 (referent)	1.0 (referent)
Facial freckling								
None	11.6‡	1.0 (referent)	1.0 (referent)	1.0 (referent)	26.0	1.0 (referent)	1.0 (referent)	1.0 (referent)
Small amount	16.6	1.55 (1.20-2.00)	1.32 (1.00-1.74)	1.42 (1.12-1.80)	29.0	1.17 (0.96-1.43)	1.17 (0.94-1.45)	1.21 (1.01-1.46)
Large amount/ almost all	22.2	2.17 (1.13-4.18)	1.38 (0.69-2.76)	1.21 (0.64-2.26)	30.2	1.15 (0.64-2.07)	1.00 (0.54-1.85)	1.04 (0.67-1.59)
Eye color								
Blue or green	15.3	1.38 (1.09-1.75)	1.27 (0.98-1.63)	1.25 (1.01-1.56)	27.5	1.11 (0.92-1.32)	1.03 (0.85-1.24)	0.96 (0.81-1.13)
Other color	11.5	1.0 (referent)	1.0 (referent)	1.0 (referent)	26.5	1.0 (referent)	1.0 (referent)	1.0 (referent)

*OR with 95% CI. Adjusted for age, years of education, race, smoking, BMI, days of exposure, history of blistering sunburns, hours of midday exposure, and personal and family history of skin cancer.
†Multiple imputations used to estimate missing data values.
‡P for trend <0.05.

in which 30% reported they were "very likely" to use sunscreen and 23% were "very likely" to wear sun-protective clothing (12).

In the present study, we examined the relationship of skin cancer risk factors with personal skin cancer prevention behaviors. In general, our findings indicate that the likelihood of engaging in skin cancer prevention behaviors increases in a graded fashion as personal susceptibility to skin cancer, based on phenotypic characteristics, increases. These trends remained strong even after adjusting for gender, age, education, race, smoking, BMI, sun exposures, and skin cancer history.

The associations observed in the present study are likely to hold true in general based on the consistency of similar findings observed in six different studies carried out in Israel (13), Denmark (14), the United Kingdom (15), and different regions of the United States (16-18) that all reported an association between skin type and other phenotypic markers of skin cancer risk and skin cancer prevention behaviors. Three of these investigations may have had limited generalizability because the populations studied were selected to be at increased risk for skin cancer based on family history (15), skin cancer risk behaviors (17), or phenotype (16). Most of these studies only reported whether or not the findings were statistically significant (14, 15) or only reported the prevalence (13, 16, 17).

In the study most comparable with ours, Coups et al. also observed that skin reaction to sunlight was inversely associated with multiple skin cancer risk behaviors, including sunscreen and sun-protective clothing, among adults ages 50 and older (18). Our investigation adds several important points to the substantial evidence presented in this important earlier study. We used a more comprehensive assessment of skin cancer susceptibility phenotypic characteristics, as well as examined the associations with sunscreen and sun-protective clothing use individually rather than grouped. We also used a narrower definition of "regular use" that we feel better reflects the level of protection shown to be efficacious (4). Lastly, we present measures of association adjusted for numerous confounders to isolate the effects of phenotypic skin cancer risk factors on sunscreen and sun-protective clothing use.

Women were significantly more likely than men to rate their complexion as very fair or fair (Table 1). This puzzling finding has been also observed in other studies (16). To evaluate the potential impact of misclassification on the associations between complexion and sunscreen and sun-protective clothing use, we applied the male distribution of sunscreen use by complexion to the female distribution of complexions. The associations were weakened, but nevertheless the associations still mirrored the trend of increasing prevention behaviors

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according to fairer complexion that was seen in the observed data. Based on these findings, gender differences in misclassification of complexion likely were not present to the degree that they would have overturned the study inferences, but could have affected the strength of the associations.

In the present study, sunscreen and sun-protective clothing use varied with age. An increase in the prevalence of sun-protective clothing among those of older ages has been observed in some (12, 18) but not all (13, 14) previous studies. Sunscreen use has previously been observed to have a peak prevalence in 50 to 70 year-olds (12), or no pattern by age (18). Among males, we saw a similar peak in the 50 to 59 age group, although sunscreen use in this age group was low (15.2%). Among females, as age increased the prevalence of sunscreen use decreased, a drop in prevalence that was not completely offset by a greater prevalence of sun-protective clothing use (Table 2). These patterns of skin cancer prevention behaviors by age and gender warrant further investigation, and could potentially provide clues for focused prevention strategies.

In contrast to most previous reports (reviewed in ref. 22), a family history of skin cancer was not strongly associated with use of sunscreen or sun-protective clothing (Table 2) in the present study. As our study population was weighted toward elderly ages for a study of skin cancer prevention behaviors, we examined if these null associations varied by age. Even in the youngest age group (30-39 years) family history was not strongly associated with sun-protective clothing use among males and females, or sunscreen use among females. A positive family history of skin cancer is a known risk factor for skin cancer, making it important that these high-risk individuals engage in prevention behaviors.

We also found that a lower BMI and not smoking cigarettes were associated with a higher prevalence of skin cancer prevention behaviors. The observations for BMI (18) and cigarette smoking (12, 18, 23) corroborate previous findings. Due to this constellation of health-related characteristics, counseling patients on smoking cessation and weight management could also present an opportunity to discuss sun protection with high-risk patients (23).

Our study had several limitations. The cross-sectional study design would typically limit inferences because the information is collected at a single point in time, but in this instance our main independent variables, skin cancer susceptibility, are genetically predetermined and thus necessarily precede the behavioral outcomes. The generalizability of the study may be limited as the study population was not a random sample of a population but rather was composed of cohort members who provided complete information in a long-term follow-up. The study

Table 4. Prevalence and OR (and 95% CI) for the associations between phenotypic skin cancer risk factors and skin cancer prevention behaviors among females, Washington County, Maryland, 2007

Phenotypic factor	Regular sunscreen use				Regular sun-protective clothing use			
	%	OR (95% CI)	OR (95% CI)*	OR (95% CI)*,†	%	OR (95% CI)	OR (95% CI)*	OR (95% CI)*,†
Skin reaction to sunlight								
Blistering sunburn	45.3‡	4.30 (3.04-6.08)	4.89 (3.34-7.16)	3.98 (2.82-5.62)	39.9‡	5.69 (3.85-8.39)	4.44 (2.88-6.85)	3.51 (2.43-5.09)
Sunburn without blisters	35.0	2.80 (2.13-3.69)	2.79 (2.08-3.76)	2.47 (1.89-3.24)	20.3	2.20 (1.58-3.06)	1.93 (1.34-2.78)	1.63 (1.20-2.22)
Mild sunburn that becomes a tan	26.0	1.81 (1.38-2.37)	1.73 (1.30-2.30)	1.77 (1.36-2.30)	12.6	1.23 (0.88-1.72)	1.29 (0.90-1.85)	1.27 (0.94-1.73)
Tan or darken with no sunburn	16.3	1.0 (referent)	1.0 (referent)	1.0 (referent)	10.4	1.0 (referent)	1.0 (referent)	1.0 (referent)
No change in skin color	12.5	0.80 (0.42-1.55)	0.91 (0.45-1.83)	0.95 (0.52-1.72)	15.6	1.74 (0.93-3.30)	1.54 (0.79-3.03)	1.15 (0.65-2.05)
Complexion								
Very fair	46.3‡	4.28 (2.69-6.81)	3.87 (2.37-6.33)	3.86 (2.46-6.06)	39.8‡	7.35 (4.11-13.13)	5.51 (2.94-10.35)	4.58 (2.68-7.82)
Fair	34.4	2.63 (1.77-3.89)	2.34 (1.56-3.53)	2.22 (1.52-3.23)	21.0	2.88 (1.71-4.87)	2.51 (1.42-4.44)	2.13 (1.32-3.44)
Medium	24.1	1.58 (1.07-2.34)	1.45 (0.97-2.19)	1.60 (1.10-2.33)	11.8	1.47 (0.86-2.49)	1.41 (0.80-2.50)	1.38 (0.86-2.23)
Light brown	22.2	1.36 (0.79-2.34)	1.32 (0.75-2.30)	1.36 (0.81-2.27)	12.4	1.50 (0.74-3.06)	1.61 (0.76-3.42)	1.77 (0.95-3.30)
Medium/dark brown	16.2	1.0 (referent)	1.0 (referent)	1.0 (referent)	8.8	1.0 (referent)	1.0 (referent)	1.0 (referent)
Facial freckling								
None	25.4‡	1.0 (referent)	1.0 (referent)	1.0 (referent)	16.4	1.0 (referent)	1.0 (referent)	1.0 (referent)
Small amount	32.8	1.40 (1.22-1.61)	1.20 (1.03-1.39)	1.24 (1.08-1.42)	17.1	1.03 (0.87-1.22)	1.11 (0.92-1.33)	1.10 (0.93-1.29)
Large amount/ almost all	38.8	1.82 (1.34-2.48)	1.51 (1.09-2.10)	1.49 (1.17-1.90)	20.2	1.30 (0.89-1.89)	1.39 (0.94-2.06)	1.30 (0.97-1.73)
Eye color								
Blue or green	30.5	1.14 (1.00-1.31)	1.18 (1.02-1.36)	1.12 (0.98-1.27)	18.4	1.20 (1.02-1.41)	1.18 (0.99-1.40)	1.18 (1.01-1.37)
Other color	27.8	1.0 (referent)	1.0 (referent)	1.0 (referent)	15.7	1.0 (referent)	1.0 (referent)	1.0 (referent)

*OR with 95% CI. Adjusted for age, years of education, race, smoking, BMI, days of exposure, history of blistering sunburns, hours of midday exposure, and personal and family history of skin cancer.
†Multiple imputations used to estimate missing data values.
‡P for trend <0.05.

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took place in Washington County, an area in western Maryland. Populations living in areas where sun exposure is typically higher, such as coastal regions, may have different patterns of skin cancer prevention behaviors in general that would affect the associations we observed. The fact that our findings were consistent with previous studies, specifically those from the National Health Interview Survey, likely indicates that geographic region did not have a significant impact. Among our participants, those with missing data differed significantly from those with complete data by gender, age, years of education, cigarette smoking, BMI, both prevention behaviors, and all four phenotype risk factors (data not shown). We addressed this issue by using statistically rigorous multiple imputation procedures, and found that the observed associations were attenuated but the primary study inferences remained robust. Lastly, our study was based on self-reported information; the most recent evidence, however, suggests self-reported information about skin characteristics, sun exposures, and sun protection behaviors may be reliable (24-26).

The present study has distinct methodologic advantages that help to solidify the existing evidence on factors associated with skin cancer prevention behaviors. These include a substantial sample size in combination with a more complete set of skin cancer related and lifestyle characteristics than previously reported. When the results of the present study are added to previous evidence on this topic, clear-cut patterns emerge. When viewed as a whole, the population prevalence of skin cancer prevention behaviors is low. These behaviors are not distributed uniformly in populations, but are more heavily concentrated among those who most need to protect their skin from the sun based on phenotypic risk factors, and also among nonsmokers and those with a lower BMI. However, even in the population subgroups with the highest prevalence of skin cancer prevention behaviors, less than one half engage in regular use of sunscreen or sun-protective clothing. These findings provide optimism that the highest risk population based on phenotype is the audience most receptive to messages about skin cancer prevention. The fact that even within this group a substantial proportion are not adopting optimal prevention behaviors provides a sobering reminder of the further need for interventions targeted to this group.

Disclosure of Potential Conflicts of Interest

No potential conflicts of interest were disclosed.

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