Published OnlineFirst March 2, 2017; DOI: 10.1158/1055-9965.EPI-16-0854

Research Article

Cancer Epidemiology, Biomarkers & Prevention

Sun Exposure and Protection Behaviors among Long-term Melanoma Survivors and Population Controls

Rachel Isaksson Vogel[1,2], Lori G. Strayer[2], Leah Engelman[3], Heather H. Nelson[2,3], Anne H. Blaes[2,4], Kristin E. Anderson[2,3], and DeAnn Lazovich[2,3]

Abstract

Introduction: Melanoma is considered a generally preventable cancer, with excessive ultraviolet radiation (UVR) exposure being a strong causal factor. UVR exposure following a melanoma diagnosis can be modified to reduce risk of second primary melanomas. The goal of this study was to compare measures of UVR exposure and protection behaviors between long-term melanoma survivors and controls.

Methods: Participants from a previously conducted case–control study were recruited for a cross-sectional survey. Melanoma cases were 25 to 59 years old at diagnosis; controls were age and sex matched. Participants were asked about UVR exposure and protection measures used in the past year, and comparisons between melanoma survivors and controls were conducted using logistic regression models, adjusting for potential confounders.

Results: A total of 724 (62.0%) long-term melanoma survivors and 660 (59.9%) controls completed the follow-up survey. Melanoma survivors were significantly less likely to report high sun exposure on a typical weekday [OR, 0.72 (0.55–0.94)], sunburns [OR, 0.40 (0.30–0.53)], or indoor tanning [OR, 0.20 (0.09–0.44)] than controls; however, high sun exposure on a typical weekend day was similar. Report of optimal sun protection behaviors was higher in melanoma survivors compared with controls. However, a few melanoma survivors reported indoor tanning, 10% reported intentionally seeking sun to tan, and 20% reported sunburns.

Conclusions: Although long-term melanoma survivors reported healthier UVR exposure and protection behaviors compared with controls, a sizeable proportion still reported elevated sun exposure, sunburns, and suboptimal UVR protection behaviors.

Impact: Opportunities remain for improving sun protection to reduce future melanoma risk among melanoma survivors. *Cancer Epidemiol Biomarkers Prev; 1–7. ©2017 AACR.*

Introduction

Melanoma is considered a generally preventable cancer, with excessive ultraviolet radiation (UVR) exposure being one of the strongest risk factors for the disease (1, 2). Additional risk factors include a large number of moles and/or freckles, fair skin, light hair or eye color, family history of melanoma, and immune suppression (3). Patients diagnosed with melanoma experience high rates of recurrence with an approximately 9-fold increased risk of developing another melanoma (4). Excess risk of recurrence remains 20 years after the initial diagnosis (4, 5). For melanomas that develop as a consequence of UVR exposure, the damage done to the skin prior to the first melanoma cannot be ameliorated, and this damage may increase risk of a subsequent melanoma. Importantly, however, UVR exposure following a melanoma diagnosis can be modified to reduce risk of a new melanoma diagnosis (6).

It has been suggested that cancer may be a "teachable moment" for health behavior change (7). Unfortunately, while some cancer survivors initiate positive health behaviors, others do not (8). In the case of melanoma, reduction of sun exposure is paramount. Individuals are advised to limit time in the sun during peak hours, seek shade, wear protective clothing, use sunscreen, and avoid indoor tanning devices (9).

The young age at diagnosis of melanoma for some suggests ample opportunity to engage in improved sun protection behaviors following diagnosis. Little research has documented UVR exposure among melanoma survivors. Results from studies to date on sun protection behaviors among melanoma survivors have been mixed, though most suggest that if an improvement in sun behaviors among melanoma survivors is present, it is moderate (10, 11). Further clarification of these behaviors in long-term melanoma survivors is needed to help devise effective interventions for this group. In particular, data are lacking on sun exposure patterns and specific sun protection behaviors compared with an appropriately matched control group with measured potential confounders. The objective of this study was to compare measures of UVR exposure and protection behaviors between long-term melanoma survivors and controls.

[1]Division of Gynecologic Oncology, Department of Obstetrics, Gynecology and Women's Health, University of Minnesota, Minneapolis, Minnesota. [2]Masonic Cancer Center, University of Minnesota, Minneapolis, Minnesota. [3]Division of Epidemiology and Community Health, University of Minnesota, Minneapolis, Minnesota. [4]Division of Hematology and Oncology, Department of Medicine, University of Minnesota, Minneapolis, Minnesota.

Corresponding Author: Rachel Isaksson Vogel, University of Minnesota, 420 Delaware Street SE, MMC 395, Minneapolis, MN 55455. Phone: 612-624-6928; Fax: 612-626-0665; E-mail: isak0023@umn.edu

doi: 10.1158/1055-9965.EPI-16-0854

Published OnlineFirst March 2, 2017; DOI: 10.1158/1055-9965.EPI-16-0854

Materials and Methods

Study design and population

Approval for this study was granted by the University of Minnesota Institutional Review Board and the Minnesota Cancer Surveillance System. We recruited participants from the Skin Health Study, a population-based case–control study conducted from 2004 to 2009 designed to assess indoor tanning use and risk of melanoma. The Skin Health Study is described elsewhere (12). Briefly, cases in the Skin Health Study were ascertained by the Minnesota Cancer Surveillance System, a population-based, statewide cancer registry. Individuals with invasive cutaneous melanoma diagnosed between July 2004 and December 2007, between the ages of 25 and 59, with a state driver's license or state identification card, were eligible to participate. Controls were randomly selected from the Minnesota state driver's license list (which included persons with state identification cards) and frequency-matched to cases in a 1:1 ratio on age (in 5-year age groups) and sex. Eligible cases and controls were required to be English-speaking and to have a telephone number. A total of 1,167 cases (84.6% among eligible) and 1,101 controls (69.2% among eligible) participated in the original study.

Recruitment and data collection

All Skin Health Study participants who were alive at the time of the survey administration were identified for this follow-up study. Deaths among cases and controls were identified using the Minnesota Death Index and the Minnesota Cancer Surveillance System. Cause of death was ascertained whenever possible. The Minnesota Cancer Surveillance System required updated permission from the physician of record in the registry before re-contacting each person with melanoma (case).

Participants were recruited by mail to complete an online or paper survey using methods outlined by Dillman to maximize response (13). We recruited potential participants by sending an initial letter with a link to the online survey, programmed using REDCap (14), along with an incentive (two $2 bills). Three additional reminder letters and a paper copy of the survey were sent to nonresponders.

Survey measures

The primary outcomes for this follow-up study were self-reported sun exposure and protection measures. The validated questionnaire included nine items related to sun exposure and protection practices (15, 16). All items had categorical responses. Two questions asked about number of hours outside per day between 10 am and 4 pm in the summer separately for weekdays and weekend days using the following categories: 0 to 30 minutes, 31 minutes to 1 hour, 2, hours, 3 hours, 4 hours, 5 hours, or 6 hours. Participants were also asked to report the number of red or painful sunburns that lasted a day or more in the past year: 0, 1, 2, 3, 4, or 5 or more. Sun protection methods utilized during the summer on a warm sunny day, including wearing sunscreen, a shirt with sleeves, or a hat with a wide brim, staying in the shade, and spending time in the sun in order to get a tan (intentional tanning), were collected using the following categories: never, rarely, sometimes, often, or always. The final question asked whether the participant had used a tanning bed or booth in the past 12 months (yes, no). For the purposes of this analysis and ease of interpretation, all measures were dichotomized into "optimal" and "suboptimal" categories. The following were considered optimal: weekday sun exposure in the summer of 1 hour or less, weekend day sun exposure in the summer of 1 hour or less, no sunburns in the past year, no indoor tanning in the past year, and reporting often or always using sunscreen, often or always wearing a shirt with sleeves, often or always wearing a hat, often or always staying in the shade, and rarely or never intentionally tanning.

Potential confounders collected at the time of the original study included self-report of skin, hair, and eye color, and presence and pattern of freckles and moles. Indoor tanning and sun exposure, history and number of painful sunburns before and after age 18, and sun protection behaviors, including sunscreen use, were collected during a telephone interview. A phenotypic risk score was calculated based on hair and eye color, and tanning ability using a previously reported measure (17). Potential confounders collected at the time of the follow-up survey included education, income, smoking status, personal history of other skin cancer, and family history of melanoma.

Statistical methods

To assess how death and nonresponse may have biased the results, comparisons were made between those eligible and ineligible for the study and between those who did and did not participate in the follow-up survey using data from the original Skin Health Study.

Demographic, general health characteristics, and prediagnosis sun exposure and protection behaviors were compared between melanoma survivors and population controls that completed the survey using χ^2 tests for categorical data and *t* tests and Wilcoxon Rank Sum tests as appropriate for continuous data.

Primary analyses compared optimal UVR exposure and protection behaviors between melanoma survivors and population controls. Controls who reported a personal history of melanoma at the time of the follow-up study ($N = 21$) were excluded from the analysis. Initial comparisons between melanoma survivors and population controls for all categories were conducted using χ^2 tests. Multivariate logistic regression models, both sex and age-adjusted, and fully-adjusted, were conducted, and ORs and 95% confidence intervals (CI) for each outcome are presented. Confounding variables were defined *a priori* and included age (continuous), sex, education (high school, vocation/associates, some college, college graduate, graduate/professional degree), income (<$50,000, $50,000–$74,999, $75,000–$149,999, $150,000+, prefer not to say), current smoking status, phenotypic risk score (low, intermediate, high), freckles (none/few/some/many), moles (none/few/some/many), personal history of other skin cancer, family history of melanoma, and sun exposure data reported prior to diagnosis (lifetime sun exposure, outdoor activity sun exposure, mean sunscreen use, and number of sunburns).

To explore whether differences in optimal UVR exposure and sun protection behaviors between melanoma survivors and controls differed according to age or sex, stratified analyses were conducted within age groups (30–49, 50–59, 60–72 years) and by sex. Analyses were fully adjusted for all confounders, as previously described, and an interaction effect was included to examine whether a statistically significant interaction between melanoma status and age or sex was present. *P* values <0.05 were considered statistically significant.

Published OnlineFirst March 2, 2017; DOI: 10.1158/1055-9965.EPI-16-0854

Results

Among cases and controls from the Skin Health Study, 724 (62.0%) melanoma survivors and 660 (59.9%) controls completed the follow-up survey (Table 1). A total of 80 cases died during the follow-up period; the cause of death was available for 73, and 54 died of melanoma. A total of 15 controls died during the follow-up period; the cause of death was available for 10 and none died of melanoma. Those who completed the survey were generally similar to those who did not respond, though they were older, more likely to have completed college, and less likely to have ever used indoor tanning. When examined separately for melanoma survivors and controls, these differences were similar. Melanoma survivors and controls were not statistically significantly different across the demographic and health characteristics with the exceptions of race and smoking status (Table 2). However, melanoma survivors were more likely than controls to have a high phenotypic risk score ($P < 0.0001$), some to many freckles ($P < 0.0001$), some to many moles ($P < 0.0001$), use indoor tanning before their diagnosis ($P < 0.0001$), and report more lifetime sunburns prior to their diagnosis ($P < 0.0001$).

Melanoma survivors were diagnosed an average of 9.6 ± 1.0 years prior to completing the survey; the majority (85.6%) had stage I disease, 6.4% had stage II disease, 6.6% had stage III disease, and 1.4% had stage IV disease. The most common site was the trunk (35.0%), followed by legs (26.9%), arms (26.4%), and head/neck (11.7%). Almost all (99.3%) had surgery and about one-third had lymph node dissection (34.8%).

Compared with controls, survivors were statistically significantly more likely to report optimal exposure behaviors with the exception of sun exposure on weekend days in the summer (Table 3). Specifically, survivors were less likely to spend more than 1 hour outside on weekdays during the summer (34.3% vs. 44.4%, $P = 0.01$), less likely to report a sunburn in the past year (19.5% vs. 36.5%, $P < 0.0001$), less likely to have indoor tanned in the past year (1.7% vs. 6.8%, $P < 0.0001$), and less likely to intentionally tan (10.4% vs. 23.2%, $P < 0.0001$) than controls. Of note, however, the proportion of melanoma survivors who reported spending more than 1 hour in the sun on a typical weekend day in the summer was similar to controls.

In addition, melanoma survivors compared with controls were more likely to report often or always engaging in sun protection behaviors, including wearing sunscreen (61.9% vs. 38.4%, $P < 0.0001$), a shirt with sleeves (77.0% vs. 65.9%, $P < 0.0001$), and a hat (33.2% vs. 22.6%, $P = 0.01$); survivors were also more likely to stay in the shade in the summer (48.1% vs. 28.7%, $P < 0.0001$; Table 4). These comparisons were similar when stratified by weekday and weekend sun exposure (data not shown).

Results from the comparison of optimal UVR exposure and sun protection behaviors between melanoma survivors and controls by age group were similar to the overall comparison with the exception of hours spent in the sun on weekend days. The oldest melanoma survivors were more likely to avoid sun exposure on weekend days compared with controls, whereas those 30 to 49 and 50 to 59 years old reported similar sun exposure on weekend days compared with controls. While males and females differed in their sun exposure and protection behaviors, the stratified comparisons by sex between melanoma survivors and controls were similar to the overall comparisons in direction and magnitude of the associations.

Table 1. Final study recruitment

	Cases ($N = 1,167$) N (%)	Controls ($N = 1,101$) N (%)
Not eligible		
Previous refusal for future contact	0 (0.0)	7 (0.6)
Physician refusal	17 (1.5)	0 (0.0)
Deceased	80 (6.8)	15 (1.4)
Eligible		
Unable to locate	59 (5.1)	87 (7.9)
Refusal	8 (0.7)	18 (1.6)
Nonresponse	279 (23.9)	314 (28.5)
Survey complete	724 (62.0)	660[a] (59.9)

[a]21 controls with personal history of melanoma excluded from analyses.

Discussion

This follow-up study of participants in a case-control of melanoma is the largest to date to report UVR exposure and protection behaviors of long-term melanoma survivors compared with a control group. Our study provides a more complete picture of the UVR exposure and protection habits of melanoma survivors as compared with a similarly recruited population control group than previous research. Consistent with other health behaviors reported by cancer survivors (18) and a recent meta-analysis of the limited available literature among melanoma survivors (19), our study indicates long-term melanoma survivors report healthier UVR exposure and protection behaviors compared with controls. Despite this, opportunities remain to reduce future melanoma risk among melanoma survivors as a significant proportion still report elevated sun exposure, sunburns, and suboptimal sun protection behaviors.

Exposure to UVR is a significant and modifiable risk factor for melanoma, with intermittent exposure and sunburns identified as the main causes (20). While debate continues about the best sun protection methods for skin cancer prevention (21), UVR avoidance, including from sun and artificial sources, is crucial. Few studies report UVR exposure among melanoma survivors, with most focusing on frequency of sunbathing or indoor tanning as opposed to time spent in the sun. Consistent with our results, a recent qualitative study reported many melanoma survivors are more conscious of sun exposure and protection (22). However, melanoma survivors in our study reported being outside more than 1 hour on weekend days during peak hours in the summer at similar levels as controls. One possible explanation for this is that this study included long-term melanoma survivors. A small prospective study of melanoma survivors and controls found that UVR exposure was initially lower among survivors compared with controls but then converged over the 3-year study (23, 24).

We found that few melanoma survivors and controls reported indoor tanning in the past year. This may be explained by the fact that this study population is now older and therefore less likely to use indoor tanning, and prevalence of indoor tanning has declined over time (25). While long-term melanoma survivors were less likely to report indoor tanning in the past year than controls, a small number of survivors reported still engaging in this behavior. This phenomenon has been reported elsewhere (26, 27) and indicates a small proportion of individuals will continue this high-risk behavior despite a melanoma diagnosis.

Published OnlineFirst March 2, 2017; DOI: 10.1158/1055-9965.EPI-16-0854

Table 2. Demographic and general health characteristics among melanoma survivors and population controls that completed the follow-up survey

Variable	Melanoma survivors (*N* = 724) *N* (%)	Population controls (*N* = 639) *N* (%)	*P* value
Age at survey			0.98
30–39	49 (6.8)	46 (7.2)	
40–49	117 (16.2)	100 (15.7)	
50–59	263 (36.3)	234 (36.6)	
60–72	295 (40.8)	259 (40.5)	
Sex			0.91
Female	433 (59.8)	384 (60.1)	
Male	291 (40.2)	255 (39.9)	
Race			0.0001
White, non-Hispanic	718 (99.2)	614 (96.1)	
Other	6 (0.8)	25 (3.9)	
Education			0.34
High school	92 (13.2)	78 (12.4)	
Vocational/associates	127 (18.3)	141 (22.4)	
Some college	116 (16.7)	90 (14.3)	
College graduate	215 (30.9)	185 (29.3)	
Graduate/professional degree	146 (21.0)	137 (21.7)	
Missing	*28*	*8*	
Marital status			0.81
Never married	38 (5.5)	37 (5.9)	
Married/partnered	578 (83.4)	516 (81.5)	
Widowed	15 (2.2)	14 (2.2)	
Divorced	62 (9.0)	66 (10.4)	
Missing	*31*	*6*	
Income			0.34
<$50,000	102 (14.7)	104 (16.5)	
$50,000–$74,999	126 (18.2)	118 (18.7)	
$75,000–$149,999	278 (40.1)	235 (37.2)	
$150,000+	129 (18.6)	104 (16.5)	
Prefer not to say	59 (8.5)	70 (11.1)	
Missing	*30*	*8*	
Body mass index			0.95
Underweight (<18.5 kg/m^2)	4 (0.6)	3 (0.5)	
Normal (18.5–24.9 kg/m^2)	267 (36.9)	242 (37.9)	
Overweight (25.0–29.9 kg/m^2)	244 (33.7)	218 (34.1)	
Obese (30.0+ kg/m^2)	209 (28.9)	176 (27.5)	
Current smoker			0.04
No	680 (94.4)	582 (91.7)	
Yes	40 (5.6)	53 (8.4)	
Missing	*4*	*4*	
Phenotypic risk index			<0.0001
Low	196 (27.3)	236 (37.1)	
Intermediate	308 (42.9)	279 (43.9)	
High	214 (29.8)	121 (19.0)	
Missing	*6*	*3*	
Freckles			<0.0001
None	340 (47.2)	363 (57.0)	
Very few	193 (26.8)	171 (27.3)	
Few	131 (18.2)	70 (11.0)	
Some	47 (6.5)	22 (3.5)	
Many	9 (1.3)	8 (1.3)	
Missing	*4*	*2*	
Moles			<0.0001
None	107 (14.9)	243 (38.2)	
Few	405 (56.5)	336 (52.8)	
Some	157 (21.9)	51 (8.0)	
Many	48 (6.7)	6 (0.9)	
Missing	*7*		
Personal history of nonmelanoma skin cancer			0.77
No	674 (95.2)	600 (95.5)	
Yes	34 (4.8)	28 (4.5)	
Missing	*16*	*11*	
Family history of melanoma			0.59
No	506 (69.9)	438 (68.5)	
Yes	218 (30.1)	201 (31.5)	

(Continued on the following page)

Published OnlineFirst March 2, 2017; DOI: 10.1158/1055-9965.EPI-16-0854

Table 2. Demographic and general health characteristics among melanoma survivors and population controls that completed the follow-up survey (Cont'd)

Variable	Melanoma survivors (*N* = 724) *N* (%)	Population controls (*N* = 639) *N* (%)	*P* value
Measures from Original Study			
Indoor tanning use prior to diagnosis/reference			<0.0001
No	277 (38.3)	313 (49.0)	
Yes	447 (61.7)	326 (51.0)	
Sun exposure—before diagnosis, mean ± SD	723 (2,589 ± 1,739)	637 (2,749 ± 1,739)	0.09
Outdoor activity exposure—before diagnosis, mean ± SD	723 (2,076 ± 2,495)	639 (2,097 ± 1,701)	0.85
Mean sunscreen use—before diagnosis, mean ± SD	724 (1.37±1.01)	639 (1.32±1.03)	0.30
Lifetime sunburns—before diagnosis, median (min, max)	722 [9 (0–400)]	637 [6 (0–250)]	<0.0001

Sunburn is a critical measure of excessive sun exposure. A meta-analysis found increased risk of melanoma with increasing sunburns throughout the lifetime, not just sunburns obtained during childhood (28), emphasizing the importance of continued and improved sunburn prevention among melanoma survivors. Few studies have reported sunburn occurrence among melanoma survivors, however. A large international online survey had a subgroup of participants who reported a previous melanoma diagnosis, and 27% of those cases reported at least one severe sunburn in the past year (29); that percentage is similar to our result of 20%. While our study indicates melanoma survivors are about half as likely to report sunburn in the previous year compared with controls, a significant minority engage in behaviors that result in sunburns.

A number of studies have reported sunscreen use among melanoma survivors (10, 11, 27, 30–33); however, a review found that general population estimates of regular sunscreen use vary greatly in the literature (7%–90%; ref. 34); therefore, it is critical to simultaneously collect data on population controls for comparison. Few studies have included a control group (23, 24, 26, 35); the largest to date compared 156 melanoma survivors with 11,408 respondents without cancer who participated in 2005 and 2007 National Cancer Institute Health Information National Trends Surveys (HINTS; 26). Notably, the results were similar to our study, though HINTS respondents reported slightly lower frequencies of sunscreen use.

Wearing UVR protective clothing and staying in the shade during peak hours are recommended as important components of proper sun protection. A few studies have reported increases in sun-protection behaviors among melanoma patients following diagnosis (30, 32, 36). Studies of melanoma survivors alone, one of which included longer-term survivors, found modest sun protection behaviors similar to our results (10, 11). In comparison to non-cancer controls, two studies found that melanoma survivors use sunscreen and seek shade more frequently than controls (26, 29), whereas another study found sun protection behaviors were similar to general population estimates (10). As found previously, these differences were modest, however, with more than half reporting they do not wear a hat or stay in the shade during peak hours.

While this study has many strengths, including the large sample size, population-based sample, and inclusion of a control group with measured confounding factors, we note important limitations. As with other self-reported measures, participants may have over-reported behaviors due to social desirability, particularly among melanoma survivors, resulting in an overestimate of sun protection behaviors leading to potential bias. The self-report measures used have been previously shown to compare well with direct observation measures, however (16). We were unable to make comparisons with the sun exposure and protection data prior to the diagnosis due to differences in measures. Another limitation is that survivors who responded to our survey may be more likely to practice health behaviors, or those who are still alive may be those who frequently use optimal sun protection behaviors. Further, unfortunately, we do not have access to the information on second primary melanomas for all participants and therefore were unable to address that outcome.

Table 3. Sun exposure compared between melanoma survivors and nonmelanoma controls

	Melanoma survivors *N* (%)	Nonmelanoma controls *N* (%)	Sex- and age-adjusted OR (95% CI)	Sex- and age-adjusted *P* value	Fully adjusted[a] OR (95% CI)	Fully adjusted[a] *P* value
Hours outside in summer on weekdays				<0.0001		0.01
1 hour or less	473 (65.7)	350 (55.6)	1.00		1.00	
2 hours or more	247 (34.3)	280 (44.4)	0.63 (0.51–0.80)		0.72 (0.55–0.94)	
Hours outside in summer on weekend days				0.04		0.37
1 hour or less	181 (25.2)	128 (20.3)	1.00		1.00	
2 hours or more	538 (74.8)	502 (79.7)	0.76 (0.58–0.99)		0.87 (0.65–1.18)	
Number of sunburns in past 12 months				<0.0001		<0.0001
None	581 (80.5)	401 (63.6)	1.00		1.00	
1 or more	141 (19.5)	230 (36.5)	0.40 (0.31–0.52)		0.40 (0.30–0.53)	
Use of tanning bed in past 12 months				<0.0001		<0.0001
No	709 (98.3)	593 (93.2)	1.00		1.00	
Yes	12 (1.7)	43 (6.8)	0.23 (0.12–0.45)		0.20 (0.09–0.44)	
Spend time in the sun to get a tan				<0.0001		<0.0001
Sometimes/often/always	75 (10.4)	147 (23.2)	1.00		1.00	
Rarely/never	645 (89.6)	488 (76.9)	2.81 (2.05–3.86)		2.88 (2.00–4.13)	

[a]Adjusted for sex, age, education, income, smoking status, phenotypic risk group, freckles, moles, personal history of other skin cancer, family history of melanoma, and lifetime sun exposure, outdoor activities, mean sunscreen, and sunburns reported prior to diagnosis or reference date.

Published OnlineFirst March 2, 2017; DOI: 10.1158/1055-9965.EPI-16-0854

Table 4. Sun protection behaviors compared between melanoma survivors and nonmelanoma controls

	Melanoma survivors	Nonmelanoma controls	Sex- and age-adjusted		Fully adjusted[a]	
	N (%)	*N* (%)	OR (95% CI)	*P* value	OR (95% CI)	*P* value
When outside in the summer on a warm sunny day, how often do you...						
Wear sunscreen				<0.0001		<0.0001
Never/rarely/sometimes	275 (38.1)	391 (61.6)	1.00		1.00	
Often/always	446 (61.9)	244 (38.4)	2.89 (2.29–3.65)		3.31 (2.48–4.41)	
Wear a shirt with sleeves				<0.0001		<0.0001
Never/rarely/sometimes	165 (23.0)	216 (34.1)	1.00		1.00	
Often/always	553 (77.0)	418 (65.9)	1.83 (1.41–2.37)		1.87 (1.40–2.51)	
Wear a hat with brim				<0.0001		0.01
Never/rarely/sometimes	480 (66.8)	489 (77.4)	1.00		1.00	
Often/always	239 (33.2)	143 (22.6)	1.72 (1.34–2.21)		1.44 (1.09–1.90)	
Stay in the shade				<0.0001		<0.0001
Never/rarely/sometimes	372 (51.9)	453 (71.3)	1.00		1.00	
Often/always	345 (48.1)	182 (28.7)	2.38 (1.89–3.00)		1.99 (1.54–2.57)	

[a]Adjusted for sex, age, education, income, smoking status, phenotypic risk group, freckles, moles, personal history of other skin cancer, family history of melanoma, and lifetime sun exposure, outdoor activities, mean sunscreen, and sunburns reported prior to diagnosis or reference date.

Despite limitations, this study contributes to the field as the largest to date to examine the sun exposure and protection behaviors of long-term melanoma survivors as compared with similarly recruited controls. While a melanoma diagnosis may serve as a trigger for behavior change for many, resulting in better sun protection among survivors compared with controls, one-fifth of survivors experienced sunburn in the past year and many reported engaging in suboptimal sun protection behaviors. These data suggest that interventions are needed to further improve sun behaviors and reduce future risk of skin cancer in this population.

Disclosure of Potential Conflicts of Interest

No potential conflicts of interest were disclosed.

Authors' Contributions

Conception and design: R.I. Vogel, A.H. Blaes, D. Lazovich
Development of methodology: R.I. Vogel, L.G. Strayer, K.E. Anderson, D. Lazovich
Acquisition of data (provided animals, acquired and managed patients, provided facilities, etc.): R.I. Vogel, L.G. Strayer, L. Engelman, K.E. Anderson, D. Lazovich
Analysis and interpretation of data (e.g., statistical analysis, biostatistics, computational analysis): R.I. Vogel, A.H. Blaes, K.E. Anderson, D. Lazovich
Writing, review, and/or revision of the manuscript: R.I. Vogel, L.G. Strayer, L. Engelman, H.H. Nelson, A.H. Blaes, K.E. Anderson, D. Lazovich
Administrative, technical, or material support (i.e., reporting or organizing data, constructing databases): L.G. Strayer, D. Lazovich
Study supervision: D. Lazovich

Grant Support

This study was funded by a grant from the Masonic Cancer Center of the University of Minnesota's Internal Grants Program to D. Lazovich, National Cancer Institute NIH grant P30 CA77598 (Principal Investigator: D. Yee) utilizing the Biostatistics and Bioinformatics Core shared resource of the Masonic Cancer Center to R.I. Vogel, and University of Minnesota and Award Number UL1TR000114 (Principal Investigator: B. Blazar) from the National Center for Advancing Translational Sciences (NCATS) of the NIH to R.I. Vogel.

The costs of publication of this article were defrayed in part by the payment of page charges. This article must therefore be hereby marked *advertisement* in accordance with 18 U.S.C. Section 1734 solely to indicate this fact.

Received October 27, 2016; revised November 30, 2016; accepted November 30, 2016; published OnlineFirst March 2, 2017.

References

1. Gilchrest BA, Eller MS, Geller AC, Yaar M. The pathogenesis of melanoma induced by ultraviolet radiation. N Engl J Med 1999;340:1341–8.
2. Narayanan DL, Saladi RN, Fox JL. Ultraviolet radiation and skin cancer. Int J Dermatol 2010;49:978–86.
3. National Cancer Institute (U.S.). What You Need to Know About Melanoma and Other Skin Cancers. Bethesda, MD: U.S. Department of Health and Human Services, National Institutes of Health, National Cancer Institute, 2010. Available at http://www.cancer.gov/cancertopics/wyntk/skin.pdf.
4. Bradford PT, Freedman DM, Goldstein AM, Tucker MA. Increased risk of second primary cancers after a diagnosis of melanoma. Arch Dermatol 2010;146:265–72.
5. Freedman M, Miller BA, Tucker MA. New malignancies following melanoma of the skin, eye melanoma, and non-melanoma eye cancer. In: Curtis RE, Freedman DM, Ron E, et al. editors. New malignancies among cancer survivors: SEER Cancer Registries, 1973–2000. Bethesda, MD: National Cancer Institute; 2006.
6. Kricker A, Armstrong BK, Goumas C, Litchfield M, Begg CB, Hummer AJ, et al. Ambient UV, personal sun exposure and risk of multiple primary melanomas. Cancer Causes Control 2007;18:295–304.
7. Pinto BM, Eakin E, Maruyama NC. Health behavior changes after a cancer diagnosis: what do we know and where do we go from here? Ann Behav Med 2000;22:38–52.
8. Demark-Wahnefried W, Aziz NM, Rowland JH, Pinto BM. Riding the crest of the teachable moment: promoting long-term health after the diagnosis of cancer. J Clin Oncol 2005;23:5814–30.
9. American Cancer Society. Cancer facts & figures 2012. Atlanta, GA: American Cancer Society; 2012.
10. Mujumdar UJ, Hay JL, Monroe-Hinds YC, Hummer AJ, Begg CB, Wilcox HB, Oliveria SA, Berwick M. Sun protection and skin self-examination in melanoma survivors. Psychooncology 2009;18:1106–15.
11. Bowen D, Jabson J, Haddock N, Hay J, Edwards K. Skin care behaviors among melanoma survivors. Psycho-Oncology 2012;21:1285–91.
12. Lazovich D, Vogel RI, Berwick M, Weinstock MA, Anderson KE, Warshaw EM. Indoor tanning and risk of melanoma: a case-control study in a highly exposed population. Cancer Epidemiol Biomarkers Prev 2010;19:1557–68.
13. Dillman D, Smith J, Christian L. Internet, phone, mail, mixed-mode surveys: the tailored design method. Hoboken, NJ. Wiley; 2014.

Published OnlineFirst March 2, 2017; DOI: 10.1158/1055-9965.EPI-16-0854

14. Harris PA, Taylor R, Thielke R, Payne J, Gonzalez N, Conde JG. Research electronic data capture (REDCap) - A metadata-driven methology and workflow process for providing translational research informatics support. J Biomed Inform 2009;42:377–81.
15. Glanz K, Yaroch AL, Dancel M, Saraiya M, Crane LA, Buller DB, et al. Measures of sun exposure and sun protection practices for behavioral and epidemiologic research. Arch Dermatol 2008;144: 217–22.
16. Glanz K, McCarty F, Nehl EJ, O'Riordan DL, Gies P, Bundy L, et al. Validity of self-reported sunscreen use by parents, children, and lifeguards. Am J Prev Med 2009;36:63–9.
17. Thomas NE, Kanetsky PA, Edmiston SN, Alexander A, Begg CB, Groben PA, et al. Relationship between germline MC1R variants and BRAF-mutant melanoma in a North Carolina population-based study. J Invest Dermatol 2010;130:1463–5.
18. Rock CL, Doyle C, Demark-Wahnefried W, Meyerhardt J, Courneya KS, Schwartz AL, et al. Nutrition and physical activity guidelines for cancer survivors. CA Cancer J Clin 2012;62:243–74.
19. Nahar VK, Ford MA, Jacks SK, Thielen SP, Johnson AK, Brodell RT, et al. Sun-related behaviors among individuals previously diagnosed with non-melanoma skin cancer. Indian J Dermatol Venereol Leprol 2015; 81:568–75.
20. Gandini S, Sera F, Cattaruzza MS, Pasquini P, Picconi O, Boyle P, et al. Meta-analysis of risk factors for cutaneous melanoma: II. Sun exposure. Eur J Cancer 2005;41:45–60.
21. Lazovich D, Choi K, Vogel RI. Time to get serious about skin cancer prevention. Cancer Epidemiol Biomarkers Prev 2012;21:1893–901.
22. Oliveria SA, Shuk E, Hay JL, Heneghan M, Goulart JM, Panageas K, et al. Melanoma survivors: health behaviors, surveillance, psychosocial factors, and family concerns. Psychooncology 2013;22:106–16.
23. Idorn LW, Datta P, Heydenreich J, Philipsen PA, Wulf HC. A 3-year follow-up of sun behavior in patients with cutaneous malignant melanoma. JAMA Dermatol 2014;150:163–8.
24. Idorn LW, Datta P, Heydenreich J, Philipsen PA, Wulf HC. Sun behaviour after cutaneous malignant melanoma: a study based on ultraviolet radiation measurements and sun diary data. Br J Dermatol 2013;168: 367–73.
25. Guy GP Jr., Berkowitz Z, Holman DM, Hartman AM. Recent changes in the prevalence of and factors associated with frequency of indoor tanning among US adults. JAMA Dermatol 2015;151:1256–9.
26. Mayer D, Layman A, Carlson J. Sun-protection behaviors of melanoma survivors. J Am Acad Dermatol 2012;66:e9–10.
27. Palesh O, Aldridge-Gerry A, Bugos K, Pickham D, Chen JJ, Greco R, et al. Health behaviors and needs of melanoma survivors. Support Care Cancer 2014;22:2973–80.
28. Dennis LK, Vanbeek MJ, Beane Freeman LE, Smith BJ, Dawson DV, Coughlin JA. Sunburns and risk of cutaneous melanoma: does age matter? A comprehensive meta-analysis. Ann Epidemiol 2008;18:614–27.
29. Branstrom R, Kasparian NA, Chang YM, Affleck P, Tibben A, Aspinwall LG, et al. Predictors of sun protection behaviors and severe sunburn in an international online study. Cancer Epidemiol Biomarkers Prev 2010;19: 2199–210.
30. Freiman A, Yu J, Loutfi A, Wang B. Impact of melanoma diagnosis on sun-awareness and protection: efficacy of education campaigns in a high-risk population. J Cutaneous Med Surg 2004;8:303–9.
31. Manne S, Lessin S. Prevalence and correlates of sun protection and skin self-examination practices among cutaneous malignant melanoma survivors. J Behav Med 2006;29:419–34.
32. Soto E, Lee H, Saladi R, Gerson Y, Manginani S, Lam K, et al. Behavioral factors of patients before and after diagnosis with melanoma: a cohort study - are sun-protection measures being implemented?. Melanoma Res 2010;20:147–52.
33. McMeniman E, De'Ambrosis K, De'Ambrosis B. Risk factors in a cohort of patients with multiple primary melanoma. Australas J Dermatol 2010;51: 254–7.
34. Kasparian NA, McLoone JK, Butow PN. Psychological responses and coping strategies among patients with malignant melanoma: a systematic review of the literature. Arch Dermatol 2009;145:1415–27.
35. Zivkovic M, Dediol I, Ljubicic I, Situm M. Sun behaviour patterns and perception of illness among melanoma patients. J Eur Acad Dermatol Venereol 2012;26:724–9.
36. Novak CB, Young DS, Lipa JE, Neligan PC. Evaluation of sun protection behaviour in patients following excision of a skin lesion. Can J Plast Surg 2007;15:38–40.

Cancer Epidemiology, Biomarkers & Prevention

AACR American Association for Cancer Research

Sun Exposure and Protection Behaviors among Long-term Melanoma Survivors and Population Controls

Rachel Isaksson Vogel, Lori G. Strayer, Leah Engelman, et al.

Cancer Epidemiol Biomarkers Prev Published OnlineFirst March 2, 2017.