

Predictors of Sun Protection Behaviors and Severe Sunburn in an International Online Study

Richard Bränström^{1,2}, Nadine A. Kasparian^{3,4}, Yu-mei Chang⁵, Paul Affleck⁵, Aad Tibben⁶, Lisa G. Aspinwall⁸, Esther Azizi¹⁰, Orna Baron-Epel¹¹, Linda Battistuzzi¹², Wilma Bergman⁷, William Bruno¹², May Chan⁵, Francisco Cuellar¹³, Tadeusz Dębniak¹⁴, Dace Pjanova¹⁵, Sławomir Ertmański¹⁴, Adina Figl¹⁶, Melinda Gonzalez¹³, Nicholas K. Hayward¹⁷, Marko Hocevar¹⁸, Peter A. Kanetsky², Sancy A. Leachman⁹, Olita Heisele¹⁵, Jane Palmer¹⁷, Barbara Peric¹⁸, Susana Puig¹³, Dirk Schadendorf¹⁹, Nelleke A. Gruis⁷, Julia Newton-Bishop⁵, and Yvonne Brandberg¹

Abstract

Background: The incidence of melanoma continues to increase in many countries, and primary prevention of melanoma includes avoidance of sunburn as well as adequate sun protection behavior. The aim of this study was to examine the prevalence of self-reported sun protection behaviors and sunburn in users of the Internet, and to identify the demographic, clinical, and attitudinal/motivational correlates of sun protection behaviors.

Methods: Self-report data were gathered on behalf of the GenoMEL consortium using an online survey available in 10 different languages, and 8,178 individuals successfully completed at least 80% of survey items, with 73% of respondents from Europe, 12% from Australia, 7% from the United States, 2% from Israel, and 6% from other countries.

Results: Half of all respondents and 27% of those with a previous melanoma reported at least one severe sunburn during the previous 12 months. The strongest factors associated with sun protection behavior were perceived barriers to protection ($\beta = -0.44/\beta = -0.37$), and respondents who reported a positive attitude toward suntans were less likely to protect ($\beta = -0.16/\beta = -0.14$). Reported use of protective clothing and shade, as well as avoidance of midday sun exposure, were more strongly related to reduced risk of sunburn than sunscreen use.

Conclusions: Despite widespread dissemination of public health messages about the importance of sun protection, a substantial proportion of this international sample, including respondents with a previous melanoma, reported inadequate sun protection behaviors resulting in severe sunburn.

Impact: Future strategies to decrease sunburn should target the practical, social, and psychological barriers associated with nonuptake of sun protection. *Cancer Epidemiol Biomarkers Prev*; 19(9); 2199–210. ©2010 AACR.

Introduction

Over the past several decades, melanoma incidence has increased in many fair-skinned populations (1). This is most likely a result of several factors but in par-

ticular increases in two important risk factors for melanoma, sun exposure, and associated sunburn (2-5). Sun avoidance during periods of peak UV radiation and the adoption of protective measures when exposed are factors influencing sunburn that theoretically could

Authors' Affiliations: ¹Department of Oncology-Pathology, Karolinska Institutet, Stockholm, Sweden; ²Department of Biostatistics and Epidemiology, University of Pennsylvania, Pennsylvania, Philadelphia; ³School of Women's and Children's Health, Faculty of Medicine, University of New South Wales, Kensington, New South Wales, Australia; ⁴Psychosocial Research Group, Department of Medical Oncology, Prince of Wales Hospital, Randwick, New South Wales, Australia; ⁵Section of Epidemiology and Biostatistics, Cancer Research UK Clinical Centre, Leeds Institute of Molecular Medicine, University of Leeds, Leeds, United Kingdom; ⁶Centre for Human and Clinical Genetics, Department of Clinical Genetics, Section Genetic Counseling and ⁷Department of Dermatology, Leiden University Medical Centre, Leiden, the Netherlands; ⁸Department of Psychology and ⁹Huntsman Cancer Institute, University of Utah, Salt Lake City, Utah; ¹⁰Dermatology Department, Sheba Medical Center, Sackler Faculty of Medicine, Tel-Aviv University, Tel-Aviv, Israel; ¹¹Health Promotion Program, School of Public Health, Haifa University, Haifa, Israel; ¹²Department of Oncology, Biology and Genetics, University of

Genoa, Genoa, Italy; ¹³Department of Dermatology, Hospital Clinic Barcelona, Barcelona, Spain; ¹⁴International Hereditary Cancer Center, Pomeranian Medical University, Szczecin, Poland; ¹⁵Latvian Biomedical Research and Study Centre, Riga, Latvia; ¹⁶Skin Cancer Unit, Deutsches Krebsforschungszentrum Stiftung des Öffentlichen Rechts, Heidelberg, Germany; ¹⁷Queensland Institute of Medical Research, Brisbane, Australia; ¹⁸Department of Surgical Oncology, Institute of Oncology Ljubljana, Ljubljana, Slovenia; and ¹⁹Klinik für Dermatologie, Venerologie und Allergologie, Universitätsklinikum Essen, Essen, Germany

Corresponding Author: Richard Bränström, Department of Oncology-Pathology, Karolinska Institutet, Radiumhemmet, Karolinska University Hospital, 171 76 Stockholm, Sweden. Phone: 415-298-44-73; Fax: 415-298-44-73. E-mail: richard.branstrom@ki.se

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reduce melanoma risk. Promotion of these protective health behaviors is therefore essential in skin cancer prevention.

Previous studies have identified several factors associated with sun protective behavior. *Skin sun-sensitivity* is an important factor as those who burn easily are more likely to use sun protection (6, 7). Those with blonde or red hair color are somewhat more likely to engage in protective behavior than people with dark hair. Persons who *downplay the risk* of sunbathing and those who think it is *worth becoming burnt* to obtain a tan tend to use less sunscreen (8, 9). In contrast, individuals with better *knowledge*, higher *skin cancer awareness*, and those who perceive themselves as being at *risk of developing skin cancer* are more inclined to report greater use of sunscreen and other sun protection measures (7). Common reasons not to use sunscreen are that its application is perceived as time consuming and inconvenient, and that sunscreen use reduces the likelihood of getting a desired tan (7, 10).

We report a study that was carried out with the intent of informing the development of an Internet-based prevention tool to increase awareness of personal susceptibility to skin cancer and improve engagement in skin cancer-related behaviors. It is based on theoretical assumptions about predictors of sun protection behavior, as predicated in psychological models of health behavior, that is, the Health Belief Model and the Protection Motivation Theory (11-13). In short, we postulated that individuals would report greater engagement in sun protective behavior if they believed themselves to be susceptible to skin cancer; believed skin cancer to have potentially serious consequences; believed sun protection behavior to be beneficial in reducing either their vulnerability to, or the severity of, skin cancer; and if they believed the anticipated benefits to outweigh any barriers to taking action. Further, we expected perception of the respondents' ability to successfully protect themselves from the sun (that is, self-efficacy) and amount of worry about skin cancer to influence behavior. Severe sunburn due to excessive exposure to UV radiation and sun protection behaviors were measured along with motivational and attitudinal factors relevant to protection behavior in a large international sample. A previous study using this data focusing on intentional tanning has been published previously (14). The aims of the current article were to determine and report on the prevalence of self-reported sun protection behaviors and severe sunburn experiences in users of the Internet; to identify the demographic, clinical, and attitudinal/motivational determinants of sun protection behavior; and to examine the association between sun protection behavior and number of severe sunburn experiences over a 1-year period.

Materials and Method

Study sample and recruitment

The sample was comprised of members of the Internet-using general population recruited between January 2007

and September 2008. Recruiting centers were located in 12 countries (Australia, Germany, Israel, Italy, Latvia, the Netherlands, Poland, Slovenia, Spain, Sweden, the United Kingdom, and the United States) participating in the melanoma genetics consortium, GenoMEL. In each participating country, recruitment was encouraged by use of the Internet through e-mail "cascades" (using personal e-mail address lists, university lists, company lists, etc) and links placed on other health-related Web sites, as well as posted press releases (in conjunction with cancer charities, university press offices, and national authorities responsible for UV radiation and/or public health issues) and paper flyers sent with regular mail. Potential participants were encouraged to visit the GenoMEL Web site (15), in which they could find more information about the study, as well as the study questionnaire. Individuals ages <16 years were advised to discuss their participation with an adult before completing the questionnaire. The study was approved by the relevant ethics institutions in each of the participating countries.

Questionnaire

A Web-based questionnaire was developed for data collection through the GenoMEL Web site. The self-report questionnaire was purposely designed for the study in English, although many of the individual items have been used previously and tested for reliability (16, 17). Questionnaire translation was carried out by two independent bilingual professionals and additionally tested for clarity and readability by several lay people. Efforts were made to ensure that the survey was as user friendly as possible. A list of the questionnaire items can be obtained on request from GenoMEL (15). In addition to questions about age and gender, the questionnaire consisted of three major sections: epidemiologically established objective melanoma risk factors, behavioral risk factors, and motivational/attitudinal factors.

Objective risk factors were assessed through multiple choice items eliciting data on hair color (red/blonde/light brown/dark brown/black), freckling (none/a few/many), eye color (blue/green/gray/green-gray/blue-gray/brown), skin color (based on seven pictures of hands with varying levels of pigmentation), skin type (Fitzpatrick's skin type classification; ref. 18), personal and family history of melanoma (defined as one or more affected first-degree relatives), experience of severe sunburn (with blisters, or redness and pain lasting 2 d or more) before the age of 16 years (childhood sunburn is strongly related to adult sunburn, and a recent pooled meta-analysis of case-control studies showed a stronger association between childhood sunburn and melanoma incidence than adult sunburn; ref. 4), and number of "large moles", defined as moles with a diameter larger than or equal to 6 mm or 1/4 inch (none/1-2/3-5/6-10/>10). These items were used to calculate a risk factor score based on the total number of risk factors ranging from 0 to 9. The strategy of totaling the number of objective risk factors into one score is linked to our ambition to

develop an Internet-based prevention tool in the future, to increase the use of sun protection. Although several of the risk factors both overlap and are not equally large contributors to melanoma risk, the score constitutes a straightforward approach of presenting objective risk factors to laymen. Two alternative ways of calculating a risk score was also explored, e.g., a weighted melanoma risk calculation in line with what has been presented by Glanz et al. (19), and a calculation based on risk ratios derived from a pooled meta-analysis of case-control studies (4). Both these scales were highly correlated with the total number of risk factor score, both 0.76 (Spearman's ρ). All participants were asked to indicate where they currently lived, and based on their response, they were categorized into five regions of residence, based on latitude. The categories were from high latitude to lower: Northern Europe between N55-69° (Sweden, N55-69°; Latvia, N56-58°), Northern/Central Europe between N49-59° (Germany, N50-55°; Poland, N49-55°; the United Kingdom, N50-59°; the Netherlands, N51-53.5°), Southern Europe/North United States between N36-50° (Spain, N36-43.5°; Italy, N38-47°; Slovenia, N46.5-47°; the Northern states in the United States, N40-50°), West Asia/Southern United States/Southern Australia between N30-40° and S29-43° (Israel, N30-35°; the Southern states in the United States, N30-40°; the Southern and West states in Australia, S29-43°), and Northern Australia between S10-29° (the Northern states in Australia, S10-29°).

Behavioral factors were assessed through items about sun exposure, severe sunburn, sun protective behaviors, and skin surveillance (that is, skin self-examination and clinical skin examination). In this article, we report on severe sunburn and sun protective behaviors only. To assess severe sunburn experiences, respondents were asked to indicate how many times (never/once/2-3 times/4-5 times/6-10 times/11 or more) they had experienced a severe sunburn in the past 12 months (defined as a painful redness of the skin caused by sun exposure or sun bed use) in a range of settings, including the following: at the beach, in the mountains, at a sports arena, in the garden/balcony, in the park, at work, at the beach in home country, at the beach abroad in a hot country, or when using a sun bed during the past year. A total score for frequency of severe sunburns was calculated by summing responses to all items. Respondents were also asked to indicate the proportion of time during which they used a range of sun protection measures when outdoors and in the sun, with six response options (never, 0% of the time; rarely, 10-20% of the time; occasionally, 30-40% of the time; about half of the time; regularly, 60-80% of the time; always, 90-100% of the time). Sun protection behaviors assessed were as follows: use of sunscreen with a high sun protection factor (SPF 15 or more), sunscreen with a low SPF (SPF < 15), protective clothing, shade, and avoidance of midday sun. A composite score of total amount of sun protection was also created as an indication of adherence to recommended sun protection. This score was created by summing re-

sponses to all of the above-mentioned items, with the exception of use of sunscreens with an SPF of <15, and dividing the sum by the number of items included (that is, four). In addition to this measure, participants were categorized into three groups based on use of recommended sun protective behavior. When constructing the categorization of sun protection behavior, we examined the association between use of each separate way of protection and sunburn. It became clear that a moderate use of protection was either associated with no or a small reduction in sunburn. Therefore, our categorization included those infrequent or moderately protected, regularly protected, and consistently protected. Regularly protected was defined as those reporting regular (60-80% of the time) use of at least one of the recommended ways to protect from the sun (that is, sunscreen with a SPF of 15+, clothes, shade, or avoidance of midday sun), and consistently protected were defined as those reporting always (90-100%) using at least one of the recommended ways to protect from the sun (that is, sunscreen with a SPF of 15+, clothes, shade, or avoidance of midday sun).

Motivational and attitudinal factors included perceived **severity** of melanoma [three items, Cronbach coefficient α (α) = 0.68], perceived personal **vulnerability** to melanoma (two items, α = 0.72), **worry** about melanoma (three items, α = 0.67), **perceived benefits** of preventive behavior (nine items, α = 0.81), and **self-efficacy** in terms of sun protection (one item). Participants responded to all items using a 5-point scale ranging from 0 to 4. In addition, several questions were asked about difficulties to perform sun related behaviors, in particular, three types of attitudes (that is, barriers of or facilitators to) to sun protection were assessed as follows: perceived inconvenience of sun protection (11 items, α = 0.77), perceived effect of sun protection on ability to achieve a tan (3 items, α = 0.81), and use of sun protection as part of one's daily routine (6 items, α = 0.77). The questions were formulated as a statement, and respondents were to indicate to what degree they agree with this statement on a scale with five response alternatives (strongly disagree, disagree, neither disagree nor agree, agree, strongly agree). A total perceived **barrier** score (α = 0.85) was created by summing all three subscales (with the scale measuring having sun protection as a daily routine reversely coded). Attitudes toward level of tanning were assessed using five pictures of a man and five pictures of a woman with computer-altered level of tan, from very white skin to extreme darkly tanned skin. For both the man and the woman, the participants were asked to indicate which level of tan they perceived as "most attractive" and "most healthy," and responses to these four items were summed to produce a score measuring **attitude toward suntans** from negative to positive (α = 0.88).

Statistical analysis

A dichotomous sunburn variable was constructed as having had at least one severe sunburn versus no severe sunburn during the past 12 months. Logistic regression

analyses were used to assess the association of different types and frequency of sun protection behaviors and sunburn reports. Odds ratio (OR) and 99% confidence intervals (CI) were presented (adjusted for age, gender, and skin type). Interaction effects for age, gender, skin type, and total amount of recommended sun protection behavior were also calculated.

Total sun protection behavior was treated as a continuous outcome variable, and linear regression analyses were used. Regression coefficients (β s) and proportion of variance explained (R^2) were presented for the linear regression models. Analyses were done separately for those with and those without a previous melanoma. In these analyses, the explanatory variables were entered into the model in two steps. In step one, age, gender, latitude of residence, and number of risk factors were entered into the model. At step two, the following attitudinal/motivational correlates of sun protective behavior were entered into the model: perceptions of vulnerability to melanoma, severity of melanoma, worry about developing melanoma, perceived benefits of sun protection, self-efficacy about the performance of protective behavior, perceived barriers to prevention, and attitudes toward suntans.

All analyses were done using SPSS version 16.0.

Results

A total of 11,403 individuals initiated the online questionnaire, with 8,178 (72%) individuals successfully completing at least 80% of survey items. Seventy-three of the respondents were from Europe; 12% were from Australia; 7% were from the United States; 2% were from Israel; and 6% were from other countries. The majority of participants were women (73%, $n = 5,989$), but the proportion varied substantially between countries (between 30% and 80%). Age ranged between 15 and 85 years, and the mean age of participants varied between 30.2 and 42.5 years in different countries. Seven percent of respondents had a personal history of melanoma, and 8% had at least one first-degree relative with a previous melanoma. The mean number of risk factors was 4.2 (SD = 1.8). Demographic characteristics and self-reported objective risk factors are presented in greater detail in Table 1.

Sunburn and sun protection behaviors

Figure 1 shows the estimated mean scores and 99% CIs of total numbers of severe sunburns and total reported use of sun protection (that is, sunscreen with an SPF of 15+, clothes, shade, and/or avoidance of midday sun) among respondents by country, adjusted for age, gender, skin type, hair color, skin color, eye color, experience of severe sunburns before the age of 16 years, family history of melanoma, previous melanoma, degree of freckling, and number of moles. There were statistically significant differences in sunburn frequency among the different countries ($F_{12, 7219} = 16.43$, $P < 0.001$), and pairwise comparisons showed that respondents in Sweden reported significantly more sunburns than in all the other

Table 1. Age, gender, and objective melanoma risk factors distribution among the respondents

	<i>n</i> (%)
Gender	
Men	2,189 (26.8)
Women	5,989 (73.2)
Age (y)	
<25	1,848 (22.6)
25-30	1,322 (16.2)
31-40	2,165 (26.5)
41-50	1,402 (17.1)
>50	1,441 (17.6)
Hair color	
Black/brown	6,034 (73.8)
Blond	1,739 (21.3)
Red	399 (4.9)
Fitzpatrick skin type	
I (%)	405 (5.0)
II (%)	2,302 (28.2)
III (%)	4,914 (60.1)
IV (%)	550 (6.7)
Presence of freckles	
None	3,590 (44.0)
A few	3,449 (42.2)
Many	1,128 (13.8)
No. of large moles (>6 mm)	
None	1,801 (24.0)
1-2	1,231 (16.4)
≥3	4,477 (59.6)
Sunburn before age 16 y	
Never	1,801 (24.0)
1-3 times	4,005 (53.3)
Almost every summer	1,703 (22.7)
Family history of melanoma	656 (8.0)
Previous melanoma	557 (6.8)
Total number of risk factors	
0-3	2,639 (35.3)
4-5	3,088 (41.4)
>5	1,739 (23.3)

countries ($P < 0.001$). Respondents in Latvia reported significantly more sunburns than respondents in the United Kingdom, the Netherlands, Italy, and the United States ($P < 0.001$). Respondents in Poland reported significantly more sunburn than respondents in Italy ($P < 0.001$).

Half of all respondents reported at least one experience of severe sunburn during the past 12 months, and 76% of these reported more than one severe sunburn during the past 12 months. Severe sunburn was reported by more than half of the respondents with no previous history of melanoma (52%), somewhat less commonly by those with a family history of melanoma (47%, $P < 0.01$), and least commonly by those with a previous melanoma (27%, $P < 0.001$). Reported sunburn frequency decreased

with increasing age, with 68% reporting sunburn during the past year among those ages <25 years, 57% among those ages 25 to 30 years, 47% among those ages 31 to 40 years, 42% among those ages 41 to 50 years, and 32% among those over 50 years ($P < 0.001$).

There were significant differences in total sun protection behavior between the different countries ($F_{12, 7472} = 80.15$, $P < 0.001$), and pairwise comparisons showed a significantly lower degree of sun protective behaviors in Sweden and Latvia compared with all other countries ($P < 0.001$). Australians reported the highest use of sun protection. Pairwise comparisons showed significantly greater use of sun protection in Australia compared with all other countries except Slovenia ($P < 0.001$). A similar pattern was evident for the categorization of participants based on total use of recommended sun protection (see Fig. 2). Australia, the United States, and Israel had the highest proportion of participants that reported consistent use of some sun protective behavior. Lower proportion of recommended sun protection was reported from most European countries, and the lowest proportion was reported from Sweden and Latvia.

Sun protective behavior and the likelihood of severe sunburn

Table 2 shows the association between each of the sun protection behaviors and severe sunburn, presented separately for those with and without a pre-

vious melanoma. Overall, reported moderate and regular use of protective clothing, shade, and avoidance of midday sun significantly predicted lower reports of severe sunburn. Regular reported use of sunscreen with a SPF of ≥ 15 was associated with lower likelihood of severe sunburn, compared with infrequent use. Moderate use of sunscreen with a SPF of < 15 was associated with an increased likelihood of severe sunburn for those without or with a personal melanoma history. Participants with a previous melanoma reported a greater frequency of sun protection behavior compared with those without a previous diagnosis ($t = -19.25$, $P < 0.001$); consequently, they were also less likely to have experienced severe sunburn ($t = 7.69$, $P < 0.001$).

Total use of recommended protection showed a strong association with reduced risk of severe sunburn. Those who regularly and consistently protected themselves in the recommended way were much less likely to report getting a severe sunburn. Analyses of interaction effects between protective behavior and age, gender, and skin type on severe sunburn showed no interaction effect for gender and skin type. However, there was an interaction effect of protective behavior and age, showing a reduction of severe sunburn prevalence with age [OR, 0.82 (for each SD increase in age); 99% CI, 0.68-0.99; $P < 0.01$] among those who were consistently protected from the sun.

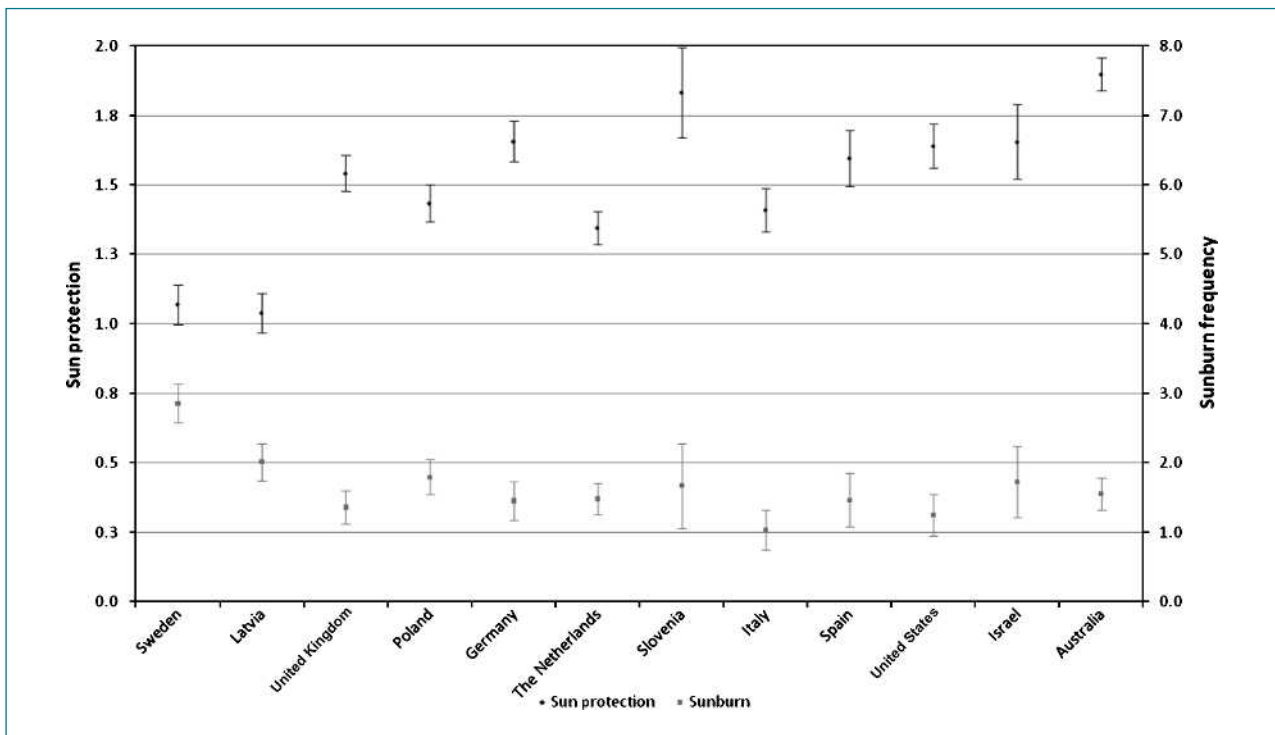


Figure 1. Means with 99% CIs of frequency of severe sunburn (number of severe sunburns during past year) and total recommended sun protection score (min = 0, max = 4) in the different countries (means are corrected for age, gender, skin type, hair color, skin color, eye color, family history of melanoma, own previous melanoma, experience of severe sunburns before the age of 16 y, and number of moles).

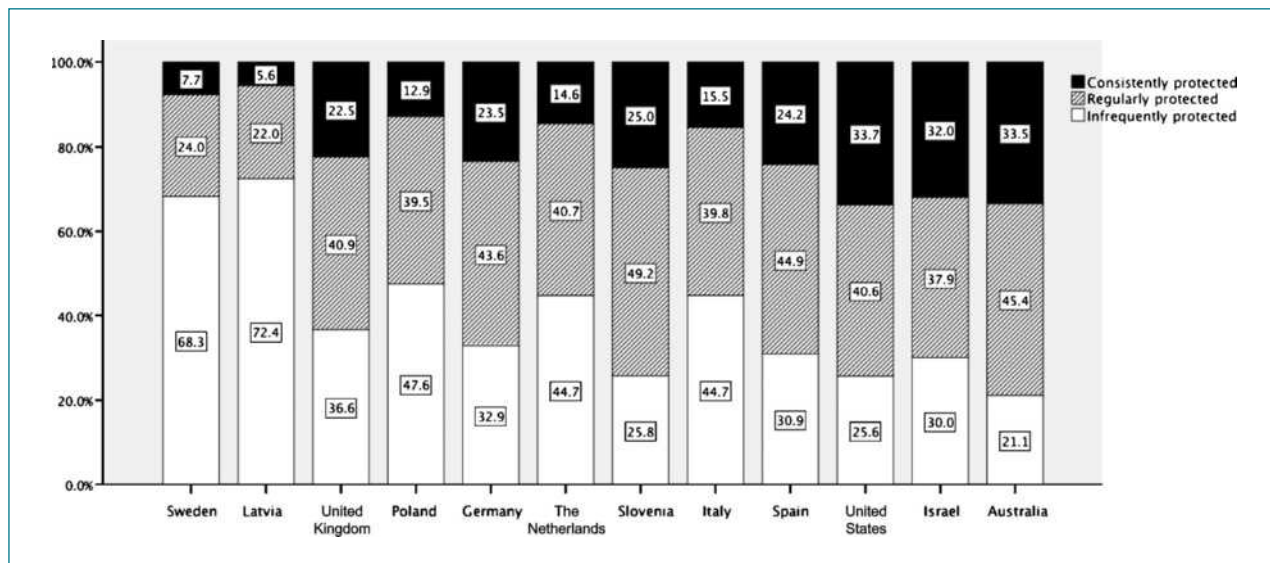


Figure 2. Proportion of respondents in the different countries reporting consistent, regular, and infrequent use of recommended sun protective behavior.

Associations between objective risk factors, sun protection, and attitudinal/motivational factors

Women reported more use of sun protection, greater perceived vulnerability, severity, and worry about melanoma, but also higher perceived benefits of protection behavior and less self-efficacy to protect than men ($P < 0.001$ for all comparisons; see Table 3). Age was related to less sun protection, lower perceived vulnerability, severity, and worry about melanoma, as well as lower perceived benefits with protection behavior. A positive attitude toward suntans was negatively related to age, as were perceived barriers. Many of the objective risk factors were related to motivational/attitudinal factors so that those with a specific risk factor reported more use of sun protection, higher perceived vulnerability, severity, worry, benefits with protection behavior, a less positive attitude toward suntans, and less barriers to sun protection. Self-efficacy to protect was not related to total number of risk factors; however, those with a previous melanoma, those who had not experienced any sunburn before the age of 16 years, and those with no large moles reported lower self-efficacy to protect.

Correlates of sun protection behaviors

Means and SDs for the motivational and attitudinal variables and Spearman's correlation coefficient for pairs of variables are presented in Table 4. Perceived vulnerability to melanoma, perceived melanoma severity, and worry about melanoma showed moderate correlations with sun protection behavior (correlations ranged from 0.16-0.20), and perceived barriers to protection showed a strong negative correlation (-0.56) with total reported sun protection.

Two separate hierarchical linear regression analyses were conducted for those with and those without a previ-

ous melanoma (Table 5). The full model explained 29% of the variance in sun protection behavior among those with a previous melanoma and 45% among those with no previous melanoma. Gender was significantly related to sun protection with women reporting a higher degree of protection than men. For those with no previous melanoma, age was positively associated with sun protection. Latitude and number of risk factors were also associated with sun protection behavior among those without a previous melanoma. People from lower latitudes and those with a higher number of risk factors reported protecting themselves more than those from higher latitudes and those with lower number of risk factors.

The strongest predictor of sun protection behavior was perceived barriers to protection and a positive attitude toward suntans. For respondents with no previous melanoma, perceived benefits of protection behavior and, to a weaker extent, worry about developing a melanoma were also associated with sun protection behavior.

Differences in associations between attitudinal/motivational factors and sun protection in countries of different latitude

Five separate planned regression analyses among participants without a previous melanoma were conducted to examine differences in predictors of sun protection behavior in regions at different latitudes. The pattern of results was similar across regions, and the same variables were significant predictors in all of the regions; however, the regression coefficients varied slightly. The association between perceived barriers and sun protection was strongest in United States and Australia ($\beta = -0.50$), and lowest in Northern Europe ($\beta = -0.42$). The association between a positive attitude toward tans and reduced sun protection was strongest in Northern Europe ($\beta = -0.22$) and lowest

in the United States ($\beta = -0.12$). The association between perceived benefits of sun protection and sun protection behavior was strongest in the United States ($\beta = 0.18$), and lowest in Australia ($\beta = 0.13$) and Northern Europe ($\beta = 0.14$).

Discussion

Internet-based interventions in medical settings have been shown to improve knowledge and minimize distress responses (20). Online information services remove geographic barriers, and there are a growing number of studies supporting the use of Internet resources to promote health behavior change (20, 21). This study focused on a sample of Internet users because this population is the target group for a planned preventative intervention. This study showed that it was possible to target a high proportion of individuals with behavioral risk factors

for melanoma using the Internet. Half of all respondents reported at least one experience of severe sunburn during the past 12 months and thus reported behaviors associated with an increased risk of melanoma. Severe sunburn was common even in melanoma patients as >27% of individuals with a previous melanoma diagnosis reported at least one severe sunburn in the past year. Although participants reported the adoption of sun protection measures, the frequency or thoroughness of protection was evidently insufficient to avoid severe sunburn.

In this study, we analyzed correlates to sun protection behavior, and the study showed that women were more likely to report sun protection behavior than men, and this association was stronger for those with a previous melanoma than for those without such experience. Among respondents with no previous melanoma, age was positively related to reported sun protection behavior. However, this association was not significant when attitudinal/motivational variables were also included in

Table 2. Differences in use of sun protection between participants with or without a previous melanoma, and ORs for severe sunburn associated with use of each sun protection strategy

	No previous melanoma (n = 7,621)			Previous melanoma (n = 557)		
	n (%) [*]	%	OR (99% CI) [†]	n (%) [*]	%	OR (99% CI) [†]
Sunscreen SPF 15+						
Never/rarely	2,924 (38.4)	51.1	1	115 (20.6)	31.3	1
Occasionally/about half of the time	1,943 (25.5)	56.1	1.15 (0.98-1.35)	102 (18.3)	38.1	1.29 (0.59-2.84)
Regularly/always	2,738 (36.0)	48.7	0.83 (0.72-0.97) [‡]	340 (61.0)	22.3	0.50 (0.25-0.97) [‡]
Sunscreen SPF <15						
Never/rarely	5,086 (66.8)	49.1	1	420 (75.4)	24.1	1
Occasionally/about half of the time	1,574 (20.7)	57.7	1.42 (1.21-1.66) [§]	75 (13.5)	45.2	2.74 (1.35-5.54) [§]
Regularly/always	950 (12.5)	53.8	1.18 (0.98-1.43)	62 (11.1)	24.6	1.08 (0.47-2.51)
Clothes						
Never/rarely	4,378 (57.6)	54.7	1	196 (35.3)	35.4	1
Occasionally/about half of the time	2,105 (27.7)	51.9	0.89 (0.77-1.02)	176 (31.7)	32.4	0.86 (0.47-1.55)
Regularly/Always	1,122 (14.8)	38.2	0.55 (0.46-0.67) [§]	184 (33.1)	13.2	0.29 (0.14-0.58) [§]
Shade						
Never/rarely	1,929 (25.3)	61.1	1	60 (10.8)	44.6	1
Occasionally/about half of the time	3,645 (47.9)	53.5	0.69 (0.59-0.81) [‡]	214 (38.6)	34.5	0.54 (0.24-1.24)
Regularly/Always	2,036 (26.8)	38.9	0.37 (0.31-0.44) [‡]	281 (50.6)	17.7	0.21 (0.09-0.49) [‡]
Avoid midday sun						
Never/rarely	3,695 (48.5)	56.3	1	139 (25.0)	42.6	1
Occasionally/about half of the time	2,421 (31.8)	51.1	0.81 (0.70-0.94) [§]	190 (34.1)	25.1	0.40 (0.20-0.77) [§]
Regularly/always	1,498 (19.7)	40.3	0.52 (0.44-0.62) [§]	228 (40.9)	19.6	0.29 (0.15-0.56) [§]
Total use of recommended protection^a						
Infrequent or moderately protected	3,321 (43.6)	58.7	1	101 (18.1)	49.5	1
Regularly protected	2,910 (38.2)	49.7	0.67 (0.58-0.77) [§]	218 (39.1)	28.5	0.38 (0.19-0.76) [§]
Consistently protected	1,389 (18.2)	38.1	0.40 (0.34-0.49) [§]	238 (42.7)	16.4	0.17 (0.08-0.36) [§]

*Number of respondents reporting different level of use of ways to protect in the sun.

[†]OR (99% CI) for having had a severe sunburn during the past year; analysis is controlled for age, gender, and skin type.

[‡]Significant at $P < 0.01$.

[§]Significant at $P < 0.001$.

Table 3. Relationship between age, gender, and objective melanoma risk factors, sun protective behavior, and motivational/attitudinal factors (all scales range from 0-4)

	Total use of recommended sun protection	Perceived vulnerability	Perceived severity	Worry about developing a melanoma	Benefits of protection behavior	Self-efficacy to protect	Attitude toward suntans	Barriers to sun protection
Gender	<i>P</i> < 0.001	<i>P</i> < 0.001	<i>P</i> < 0.001	<i>P</i> < 0.001	<i>P</i> < 0.001	<i>P</i> < 0.001	N.s.	N.s.
Men	1.38 (0.76)	2.03 (0.85)	3.12 (0.62)	2.69 (0.77)	2.86 (0.61)	2.43 (1.10)	2.72 (0.76)	1.79 (0.54)
Women	1.51 (0.80)	2.12 (0.83)	3.25 (0.60)	2.91 (0.69)	2.99 (0.58)	2.31 (1.10)	2.78 (0.77)	1.80 (0.56)
Age	<i>P</i> < 0.001	<i>P</i> < 0.001	<i>P</i> < 0.001	<i>P</i> < 0.001	<i>P</i> < 0.001	N.s.	<i>P</i> < 0.001	<i>P</i> < 0.001
<25	1.28 (0.74)	2.00 (0.81)	3.14 (0.61)	2.85 (0.74)	2.88 (0.62)	2.30 (1.13)	2.85 (0.77)	2.02 (0.53)
25-30	1.46 (0.78)	2.05 (0.79)	3.22 (0.58)	2.88 (0.68)	2.98 (0.57)	2.37 (1.06)	2.78 (0.74)	1.82 (0.55)
31-40	1.52 (0.78)	2.14 (0.83)	3.22 (0.60)	2.90 (0.70)	2.99 (0.57)	2.36 (1.09)	2.78 (0.73)	1.77 (0.55)
41-50	1.59 (0.82)	2.18 (0.88)	3.27 (0.61)	2.85 (0.75)	2.99 (0.59)	2.40 (1.12)	2.73 (0.81)	1.69 (0.53)
>50	1.57 (0.83)	2.13 (0.86)	3.24 (0.62)	2.77 (0.74)	2.93 (0.58)	2.13 (1.11)	2.63 (0.78)	1.65 (0.53)
Hair color	<i>P</i> < 0.001	<i>P</i> < 0.001	<i>P</i> < 0.001	N.s.	N.s.	N.s.	<i>P</i> < 0.001	N.s.
Black/brown	1.45 (0.79)	2.04 (0.82)	3.20 (0.61)	2.84 (0.72)	2.95 (0.59)	2.34 (1.11)	2.51 (0.66)	1.80 (0.55)
Blond/red	1.57 (0.80)	2.27 (0.86)	3.26 (0.61)	2.89 (0.74)	2.98 (0.59)	2.35 (1.08)	2.44 (0.68)	1.79 (0.56)
Fitzpatrick skin type	<i>P</i> < 0.001	<i>P</i> < 0.001	<i>P</i> < 0.001	<i>P</i> < 0.001	<i>P</i> < 0.001	N.s.	<i>P</i> < 0.001	<i>P</i> < 0.001
III/IV	1.32 (0.74)	1.95 (0.78)	3.18 (0.61)	2.79 (0.72)	2.91 (0.60)	2.34 (1.10)	2.59 (0.62)	1.85 (0.54)
I/II	1.80 (0.81)	2.39 (0.87)	3.28 (0.59)	2.98 (0.71)	3.05 (0.55)	2.35 (1.10)	2.28 (0.71)	1.70 (0.57)
Presence of freckles	<i>P</i> < 0.001	<i>P</i> < 0.001	<i>P</i> < 0.001	<i>P</i> < 0.001	<i>P</i> < 0.001	N.s.	<i>P</i> < 0.001	<i>P</i> < 0.001
None	1.32 (0.76)	1.91 (0.79)	3.17 (0.61)	2.73 (0.74)	2.88 (0.61)	2.37 (1.11)	2.56 (0.64)	1.83 (0.55)
A few/many	1.60 (0.79)	2.25 (0.84)	3.25 (0.60)	2.95 (0.69)	3.01 (0.56)	2.33 (1.09)	2.43 (0.68)	1.77 (0.55)
Sunburn before age 16 y	<i>P</i> < 0.001	<i>P</i> < 0.001	<i>P</i> < 0.001	<i>P</i> < 0.001	<i>P</i> < 0.001	<i>P</i> < 0.001	<i>P</i> < 0.001	N.s.
Never	1.32 (0.77)	1.78 (0.79)	3.13 (0.62)	2.68 (0.74)	2.85 (0.61)	2.24 (1.14)	2.57 (0.63)	1.81 (0.55)
1-3 times	1.51 (0.78)	2.08 (0.80)	3.22 (0.60)	2.87 (0.70)	2.97 (0.57)	2.42 (1.07)	2.46 (0.65)	1.78 (0.56)
Almost every summer	1.62 (0.83)	2.49 (0.83)	3.31 (0.59)	3.01 (0.73)	3.04 (0.59)	2.31 (1.12)	2.44 (0.73)	1.80 (0.58)
No. of large mole (>6 mm)	<i>P</i> < 0.001	<i>P</i> < 0.001	<i>P</i> < 0.001	<i>P</i> < 0.001	<i>P</i> < 0.001	<i>P</i> < 0.001	<i>P</i> < 0.001	N.s.
None	1.32 (0.77)	1.78 (0.79)	3.13 (0.62)	2.68 (0.74)	2.85 (0.61)	2.24 (1.14)	2.57 (0.63)	1.81 (0.55)
1-2	1.44 (0.77)	1.93 (0.75)	3.17 (0.61)	2.81 (0.68)	2.90 (0.57)	2.37 (1.10)	2.48 (0.64)	1.78 (0.56)
≥3	1.57 (0.80)	2.27 (0.83)	3.27 (0.60)	2.94 (0.72)	3.20 (0.58)	2.39 (1.09)	2.45 (0.69)	1.79 (0.56)
Family history of melanoma	<i>P</i> < 0.001	<i>P</i> < 0.001	<i>P</i> < 0.001	<i>P</i> < 0.001	<i>P</i> < 0.001	N.s.	<i>P</i> < 0.001	<i>P</i> < 0.001
No	1.45 (0.78)	2.04 (0.81)	3.20 (0.61)	2.82 (0.72)	2.94 (0.59)	2.35 (1.10)	2.50 (0.66)	1.81 (0.55)
Yes	1.80 (0.82)	2.82 (0.78)	3.44 (0.57)	3.21 (0.69)	3.10 (0.55)	2.25 (1.07)	2.33 (0.69)	1.68 (0.58)
Previous melanoma	<i>P</i> < 0.001	<i>P</i> < 0.001	<i>P</i> < 0.001	<i>P</i> < 0.001	<i>P</i> < 0.001	<i>P</i> < 0.001	<i>P</i> < 0.001	<i>P</i> < 0.001
No	1.43 (0.77)	2.00 (0.77)	3.20 (0.61)	2.81 (0.71)	2.95 (0.59)	2.36 (1.09)	2.51 (0.65)	1.81 (0.55)
Yes	2.09 (0.84)	3.41 (0.57)	3.49 (0.56)	3.48 (0.65)	3.06 (0.57)	2.14 (1.27)	2.28 (0.78)	1.56 (0.55)
Total number of risk factors	<i>P</i> < 0.001	<i>P</i> < 0.001	<i>P</i> < 0.001	<i>P</i> < 0.001	<i>P</i> < 0.001	N.s.	<i>P</i> < 0.001	<i>P</i> < 0.001
0-3	1.27 (0.74)	1.76 (0.73)	3.14 (0.62)	2.71 (0.74)	2.86 (0.62)	2.32 (1.12)	2.62 (0.62)	1.85 (0.55)
4-5	1.48 (0.77)	2.08 (0.77)	3.22 (0.60)	2.85 (0.69)	2.98 (0.57)	2.39 (1.09)	2.47 (0.66)	1.81 (0.54)
>5	1.84 (0.81)	2.64 (0.83)	3.33 (0.58)	3.09 (0.70)	3.06 (0.55)	2.33 (1.10)	2.30 (0.71)	1.70 (0.58)

Abbreviation: N.s., not significant.

the analysis. Several previous studies have found *gender* differences in sun protective behavior, with women reporting more protection than men (for a review, please see ref. 22). Several studies have also found a decreasing use of sun protection with age, that is, from childhood up to young adulthood (23-26), and then an increase of protection with age among adults (27, 28).

The factors most strongly associated with reduced sun protection were perceived barriers to sun protection and a positive view of suntans. Both factors predicted sun protection behavior when demographic and clinical factors were statistically controlled, and they were significant predictors of sun protection behavior both in participants with and without a previous melanoma. Perceiving sun protection as beneficial and something that reduce the risk of skin cancer was also related to increased use of protection. However, perceived vulnerability to melanoma, perceived melanoma severity, and worry about melanoma were less related to self-reported sun protection behavior. The weak relations between risk perceptions and related concepts to concurrent reports of sun protection behavior are somewhat surprising and contrary to some previous findings (29, 30), as well as being inconsistent with health behavior models in general. But these findings were consistent across regions. In summary, our results suggest that targeting barriers (that is, perceived inconvenience and preference to acquire a tan) and strengthening facilitators (that is, having sun protection as part of the daily routine) would be the most important ways to promote sun protection. The data also suggest that it is important to influence the positive views of suntans. These attitudes might be difficult to change, but some studies focusing on information about

personalized risks and risks related to appearance have shown promising results in changing people's intentions to tan and protect in the sun (31-35).

In the analysis, the proportion of explained variance was higher among those without a previous melanoma (45%) than for those with a previous melanoma diagnosis (29%). This might be due to the fact that the motivational/attitudinal variables used in the study were derived from theories about health behaviors, such as the Health Belief Model and the Protection Motivation Theory, primarily developed to explain health behaviors in the general population and not the behavior of specific groups of patients. It is most likely that these models need to be refined and expanded to better explain the behaviors of individuals with the experience of a specific disease. Despite the difference in explained variance, there were striking similarities between those with and those without a previous melanoma diagnosis, as both perceived barriers and attitude toward suntans were important correlates to sun protection.

Overall, sun protection was negatively associated with severe sunburn experiences, at least when using recommended ways to protect. Our findings give support for continued emphasis on clothing, the use of shaded areas, and avoidance of midday sun as the best ways to lower the risk of severe sunburns. Sunscreen was the most frequently reported way of protecting one's skin from damage caused by the sun, although sunscreen in general is only recommended as a complement to other forms of protection (36). Our findings indicate that sunscreen is not always used in combination with other forms of protection, which may explain the low degree of reduction in sunburns associated with the use of sunscreen. Reported use of sunscreen with a SPF of <15 seemed to be related to

Table 4. Mean values and SDs for total sun protection behavior and motivational factors for sun protection, and correlations between the variables (all scales have a range from 0-4)

	Mean	SD	2	3	4	5	6	7	8	8a	8b	8c
1 Total use of recommended sun protection	1.48	0.79	0.20*	0.16*	0.18*	0.32*	0.16*	-0.37*	-0.56*	-0.47*	-0.40*	0.52*
2 Perceived vulnerability	2.10	0.83		0.21*	0.47*	0.14*	0.00	-0.07*	-0.05*	-0.02	-0.07*	0.07*
3 Perceived severity	3.22	0.61			0.34*	0.26*	0.10*	-0.08*	-0.08*	-0.06*	-0.11*	0.06*
4 Worry about developing a melanoma	2.85	0.72				0.24*	0.04†	0.03†	-0.03†	-0.01	-0.02	0.07*
5 Benefits of protection behavior	2.95	0.59					0.29*	-0.15*	-0.21*	-0.19*	-0.14*	0.18*
6 Perceived self-efficacy to protect	2.35	1.10						-0.06*	-0.20*	-0.20*	-0.12*	0.15*
7 Attitude toward suntans	2.49	0.67							0.31*	0.24*	0.34*	-0.23*
8 Barriers to sun protection	1.80	0.55								0.93*	0.62*	-0.83*
a. Perceiving use of sun protection as inconvenient	1.72	0.59									0.42*	-0.68*
b. Perceiving sun protection as problematic as it reduces the possibility to develop a suntan	1.69	0.94										-0.35*
c. Having sun protection as a part of one's daily routine	2.01	0.62										

*P < 0.001.

†P < 0.01.

Table 5. Regression analysis showing associations between demographic, clinical, attitudinal/motivational factors, and sun protection behavior

		Standardized β s		
		Step 1	Step 2	
Previous melanoma				
Step 1: demographic and clinical factors	Age	0.05	-0.02	
	Gender (men = 1, women = 2)	0.19*	0.14 [†]	
	No. of melanoma risk factors	0.14 [†]	0.08	
	Latitude of residence (increasing value with increased proximity to the equator)	0.08	0.03	
	Step 2 Attitudinal/motivational factors	Perceived vulnerability		0.04
		Perceived severity		0.08
		Worry about developing a melanoma		0.10
		Benefits of protection behavior		0.03
		Perceived self-efficacy to protect		0.05
		Barriers of or facilitators to sun protection [‡]		-0.37*
	Attitude toward suntans	-0.14 [†]		
R ²		0.07*	0.29*	
R ² change			0.22*	
No previous melanoma				
Step 1: demographic and clinical factors	Age	0.10*	0.01	
	Gender (men = 1, women = 2)	0.06*	0.04*	
	No. of melanoma risk factors	0.21*	0.13*	
	Latitude of residence (increasing value with increased proximity to the equator)	0.31 [†]	0.13 [†]	
	Step 2 Attitudinal/motivational factors	Perceived vulnerability		0.006
		Perceived severity		-0.005
		Worry about developing a melanoma		0.04 [†]
		Benefits of protection behavior		0.14*
		Perceived self-efficacy to protect		0.01
		Barriers of or facilitators to sun protection [‡]		-0.44*
	Attitude toward suntans		-0.16*	
R ²		0.16*	0.45*	
R ² change			0.29*	

* $P < 0.001$.[†] $P < 0.01$.[‡]Initially, each of the subscales measuring barriers to sun protection was entered into the model at the fourth step, but due to collinearity the total score measuring barriers/facilitators was used in the final model.

an increased likelihood of sunburn. Several studies have found a positive association between sunscreen use and time spent in the sun, sometimes called *the sunscreen paradox* (37, 38). Instead of using sunscreen as a complement to other means of avoiding excessive sun exposure, sunscreens are often used to extend time spent in the sun. Further, sunscreen use on children has been linked to a higher number of melanocytic nevi, indicating a higher degree of sun exposure among children using sunscreens (39). Some studies have also found an increased risk of skin cancer among sunscreen users (40), although the overall epidemiologic data does not support such an association (41). One possible reason for the use of sunscreens to increase time spent in the sun could be that some people try

to acquire a "safe" suntan, that is, people may want to experience a certain level of sun exposure and acquire a suntan, but at the same time try to avoid getting sunburnt. Having these double goals may lead to insufficient use of sun protection and unwanted sunburns. Thus, it seems critical that future skin cancer prevention campaigns and public health education messages highlight the sunscreen paradox and emphasize the importance of thorough and frequent applications of sunscreen (in addition to other forms of sun protection) when outdoors and in the sun for extended periods of time.

Respondents with a previous melanoma were less likely to have experienced severe sunburn and more likely to report sun protective behavior. They were also more

successful in their use of sun protection, as reported use of sun protection was more strongly related to reduced likelihood of sunburn among those with a previous melanoma. The association between motivational factors and sun protective behavior was, however, very similar to those reported by participants without a previous melanoma.

Study strengths and limitations

One of the key strengths of the present study was the innovative use of the Internet and an online survey designed to reach a large number of people across a wide range of geographic locations. The translation of the study questionnaire into 10 different languages also increased study accessibility. The study, however, is not without limitations. Due to the varying recruitment strategies used in different countries, conclusions about actual population differences should be made with great caution. The differences in severe sunburn frequency in different regions, with higher frequencies of reported severe sunburn in countries with weaker ambient UV radiation, could reflect an actual difference between countries but might also be an effect of selection bias. The same is true about the finding about country difference in frequency of reported sun protection behavior. It was highest in countries with a high degree of ambient UV radiation (e.g., Australia) and lowest in countries with lower UV radiation (e.g., Sweden and Latvia). In addition, between 30% and 89% of survey respondents in each country were women, and the mean age of participants in different regions varied between 30.2 and 42.5 years, indicating that the study is based on a fairly young population and with substantial gender variability between countries. The relatively large proportion of individuals with a personal experience of melanoma indicates that this type of recruitment strategy generated a significant number of participants interested in and/or concerned about skin cancer-related issues. These facts also indicate a substantial self-selection bias in the sample. Further, we did not ask whether the participants had reviewed the educational material provided on the GenoMEL Web site, which could potentially have influenced the answers given.

A further limitation in the study was that the questionnaire used, and the many different language version, was not tested for reliability before the study. However, many of the items had been used previously and have shown adequate reliability in previous studies. A study using a Swedish sample found fair to good test-retest agreement for both sun-related behavioral questions and motivational/attitudinal variables (16). Finally, as this is a cross-sectional study, it is not possible to draw conclusions about causal pathways among attitudinal/motivational variables, and reported behavior (42, 43). It does,

however, give some indication about the type of beliefs that it may be beneficial to target and try to change in a melanoma prevention intervention on the Internet, a major aim of the study.

Conclusion

A substantial proportion of the study participants in different locations around the world reported experiencing severe sunburn, indicating excessive exposure to UV radiation that put them at increased risk of skin cancer. Even among people with a previous melanoma, a substantial proportion reported severe sunburn. This study suggests several potential avenues for behavior change that might lead to reductions in sunburn and thus, possibly, melanoma incidence. The results also suggest that interventions intended to reduce melanoma incidence could be more efficient if focused on reduction of barriers to protection, emphasis on the benefits of protection, and inclusion of strategies to change positive views of sunbans. This study shows that it is possible to reach respondents with both objective and behavioral risk factors for melanoma through the Internet, and it gives information about factors to consider in the development of an Internet-based melanoma prevention tool.

Disclosure of Potential Conflicts of Interest

No potential conflicts of interest were disclosed.

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BLOOD CANCER DISCOVERY

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