Sun protection behavior after diagnosis of high-risk primary melanoma and risk of a subsequent primary

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Background: Melanoma survivors are at high risk of further primary melanomas.

Objective: To assess sun behavior after melanoma diagnosis and in relation to further primary melanomas.

Methods: We applied repeated measures latent class analysis to reported primary prevention behavior at time of diagnosis and every 6 months for 2 years after diagnosis in patients with clinical stage IB or II melanoma. Correlates of behavior trajectories and risk of subsequent primaries were determined by using multivariable logistic and Cox regression analyses, respectively.

Results: Among the 448 male and 341 female patients, sunscreen use fell into 3 trajectories: stable never-use (26% of males and 12% of females), stable sometimes-use (35% of males and 29% of females), and increased to often-use (39% of males and 59% of females). Most reduced their weekend sun exposure, but in 82% of males and 69% of females it remained increased. Males, smokers, the less educated, those who tanned, and those not self-checking their skin were more likely to have trajectories of inadequate protection. Patients with a history of melanoma before the study doubled their risk of another primary melanoma in the next 2 years if sunscreen use in that time was inadequate (hazard ratio, 2.45; 95% confidence interval, 1.00-6.06).

Limitations: Patient-reported data are susceptible to recall bias.

Conclusion: Our results may assist clinicians in identifying patients not using adequate sun protection and providing information for patient counseling. (J Am Acad Dermatol 2019;80:139-48.)

Key words: behavior; melanoma survivor; second primary; sun exposure; sun protection.

Melanoma has become a common cancer in white populations worldwide.[1,2] Survivors risk further new primaries,[3] and mortality increases with additional invasive melanomas.[4] Exposure to solar ultraviolet radiation is the strongest environmental risk factor for melanoma,[5] and hence melanoma survivors' adoption of sun protection is of paramount importance alongside regular skin surveillance.

Cross-sectional surveys and small cohort studies suggest that some melanoma survivors, particularly females,[6,7] increase their use of sunscreen and protective clothing immediately after diagnosis and regularly attend skin examinations.[8-10] However, it appears that postdiagnosis improvements may not persist,[11-13] and net behavior change is unknown.

A cancer diagnosis can substantially affect patients psychologically and present a teachable moment for positive changes in health behavior for some.[14] Thus, understanding the trajectories of sun protection behaviors in melanoma survivors is important to conducting targeted health promotion. We used latent class analysis (LCA) to depict how both sun protection and exposure behaviors increased decreased or remained stable in a cohort of survivors of primary melanoma with different sun-related behaviors when their melanoma was diagnosed.[15] We also assessed whether risky sun behaviors were associated with further primaries.

METHODS
Study population

Participants were recruited prospectively in 2010-2014 from public hospital clinics, private practices, and pathology services in Queensland, Australia. Patients met the inclusion criteria if they had received a histologic diagnosis of stage T1b to T4b cutaneous melanoma, were at least 16 years old, and were able to complete a questionnaire. Of 1254 invited patients, 825 (66%) consented to take part; 36 of them later proved ineligible, leaving 789. There was no financial compensation given for participation. Patient recruitment and data collection have been described previously.[16] Two institutional human ethics committees approved the study.

Participants completed baseline self-administered questionnaires that collected information on the following: personal factors (sex, age, birthplace,

smoking [current, ex-smoker, or never-smoker], and relationship status [partnered or nonpartnered]; skin type [always burn/never tan, burn then tan, or tan only after acute sun exposure]; use of immunosuppressive medications before diagnosis [yes or no] and general health [excellent to poor]; location of residence [according to the Australian Statistical Geographical Classification]; highest educational level; occupational sun exposure; previous melanoma [yes or no] [later confirmed]; and melanoma in a first-degree relative [yes or no]); psychological characteristics (determined with use of the Hospital Anxiety and Depression Scale[17]); and sun protection behaviors (for this study, frequency of sunscreen use outdoors [never, less than 50% of the time, more than 50% of the time, or always] and weekend sun exposure [0-1, 2-5, and >5 h/d] were deemed primary sun-protective, and sun exposure behaviors of interest and use of protective clothing [long sleeves and hats] was secondary). At diagnosis, participants reported average levels of the aforementioned behaviors in the previous 5 years. Primary melanoma characteristics (thickness [in mm] and body site) were extracted from histopathology reports.

During follow-up, the same questions about frequency of skin protection and amount of weekend sun exposure were repeated every 6 months for 24 months. Patients reported frequency of skin checks by a clinician (3-monthly, 6-monthly, 12-monthly, or less than 12-monthly) and if diagnosed with recurrence of index melanoma or another new primary (confirmed by histology or imaging).

Statistical analysis

Baseline characteristics were described by sex; differences were assessed by using Pearson chi-square tests. We used repeated measures LCA to identify patterns of sun protection behaviors at diagnosis and at 6, 12, 18 and 24 months[15] by sex. For selection of the latent class model, we started with a 1-class model, adding 1 class to each successive model (to a maximum of 5). The optimum number of classes was selected by using the Akaike information criterion,[18] Schwarz Bayesian information criterion,[19] degree of separation of latent classes (entropy), and clinical meaningfulness of the model. For sensitivity analysis, selection of the latent class

CAPSULE SUMMARY

- Melanoma survivors are at high risk of development of a second primary.

- Patients with a history of multiple melanomas had a significantly lower risk of development of a further melanoma if they used sunscreen regularly.

- Identifying patients with inadequate sun protection behaviors at diagnosis can assist clinicians in providing targeted education.

model was repeated with exclusion of patients with a history of melanoma and melanoma recurrence separately.

Posterior probabilities of the repeated measures LCA were used to categorize each patient into 1 latent class for each sun behavior variable. As we were assessing factors associated with improved sun protection, we dichotomized behavior patterns as adequate versus inadequate behavior. Multivariate logistic regression was used to examine the associations between personal, socioeconomic (location of residence, education, and occupation), and psychologic factors and sun behavior latent classes representing adequate sun protection behaviors separately for males and females, with the models unadjusted and then adjusted for variables significantly associated with a sun protection behavior in univariable analysis.

To determine whether inadequate sun behavior was associated with a higher likelihood of a further primary melanoma within 2 years, we used Cox regression with behavior trajectories as exposure variables (inadequate versus adequate) and a subsequent primary as the outcome variable. Those who did not have a further primary or who died were censored at 24 months or date of death, respectively. We adjusted the final model for age, skin type, occupation, skin checks by a physician, and sun exposure and sun protection variables. Because of evidence of effect modification, the final analysis was stratified on the basis of having melanoma before the study (yes or no). Analyses were conducted by using SAS software (version 9.4) and PROC LCA (version 1.3.2),[15] PROC LOGISTIC, and PROC PHREG software (SAS Institute Inc, Cary, NC).

RESULTS
Patient characteristics

Of the 789 study participants, 448 (57%) were male and 341 (43%) were female (mean age at diagnosis, 64 years and 58 years, respectively). Males more commonly had outdoor occupations and melanomas that were thicker or located on the head or neck. Compared with the male participants, female participants were more often without a partner, tended to have a lower level of education, more commonly had clinical or subclinical anxiety, had skin types with a greater tendency to burn, and were more likely to be nonsmokers (all $P < .05$) (Table I).

There was no association between missing data (data missing for 49 participants [6%]) and participant characteristics.

Trajectories of sunscreen and clothing use

Participants' use of sunscreen outdoors from before diagnosis and as reported every 6 months for the next 2 years was best described with models comprising 3 latent class patterns (hereafter referred to as trajectories). These 3 trajectories were similar in males and females; we termed them *stable never-use*, *stable sometimes-use*, and *increased to often-use* (Supplemental Table I; available at http://www.jaad.org). There were 173 (39%) males and 200 (59%) females in the increased to often-use trajectory, which was characterized by an increased probability (from .50-.60 before diagnosis to .90 after diagnosis) of using sunscreen most of the time when outdoors (Fig 1). This increase occurred within 6 months of diagnosis and was maintained throughout the 2-year follow-up. The trajectories of the stable sometimes-users' and the stable never-users of sunscreen varied little over the study period (Supplemental Table I). Very similar trajectories were seen among patients with melanoma for wearing long sleeves in the sun after diagnosis (Supplemental Fig 1 and Supplemental Table II; available at http://www.jaad.org) and for hat wearing (data not shown) when patients with a history of melanoma or a melanoma recurrence were excluded.

Trajectories of weekend sun exposure

On the basis of patients' probability of spending low (0-1 hours), moderate (2-5 hours), or high (>5 hours) amounts of time in the sun on a weekend day from before diagnosis until 2 years after, both male and female patients' weekend sun exposure patterns were again best described by 3 trajectories. In males, these were stable high (22% of males), high to moderate (60%), and moderate to low (18%) (Table II), whereas in females, sun exposure trajectories were fluctuating moderate to high (19% of females), stable moderate (48%), and moderate to low (33%) (Table II). That is, 2 of the male behavior trajectories (accounting for 349 of the males [78%]) and 1 of the female behavior trajectories (accounting for 112 of the females [33%]) showed an overall reduced weekend sun exposure in the first 6 months after diagnosis that persisted for the 24-month follow-up period. The same behavior trajectories were observed when patients with a history of melanoma or those with a melanoma recurrence were excluded during sensitivity analyses.

Table I. Characteristics of the study cohort at melanoma diagnosis by sex

	Male	Female	
	n (%)	n (%)	
Characteristic	448 (57)	341 (43)	P value
Personal			
Age, y			<.0001
<40	19 (4)	43 (13)	
40-59	125 (28)	122 (36)	
60-80	281 (63)	157 (47)	
>80	22 (5)	13 (4)	
Place of birth			.52
Australia or New Zealand	383 (85)	297 (87)	
Other	65 (15)	44 (13)	
Relationship status			.004
Partner	350 (78)	237 (70)	
No partner	96 (22)	104 (30)	
Skin type			<.0001
Always burn	141 (32)	167 (49)	
Burn then tan	248 (56)	151 (44)	
Tan only	56 (13)	22 (6)	
Smoking status			.013
Never-smoker	206 (48)	191 (59)	
Current	37 (9)	22 (7)	
Ex-smoker	185 (43)	111 (34)	
General health			.74
Very good/excellent	254 (58)	199 (59)	
Good	141 (32)	101 (30)	
Fair/poor	44 (10)	38 (11)	
Immunosuppression			.64
No	438 (98)	335 (98)	
Yes	10 (2)	6 (2)	
Self-skin checks			.57
Never	156 (35)	129 (38)	
Every few years	100 (22)	77 (23)	
At least annually	191 (43)	133 (39)	
Previous melanoma			.96
No	354 (79)	270 (79)	
Yes	94 (21)	71 (21)	
Family history of melanoma			.072
No	334 (75)	232 (69)	
Yes	111 (25)	103 (31)	
Skin check by a clinician			.07
At least every 3 months	211 (49)	181 (56)	
Every 6 months or less	216 (51)	142 (44)	
Socioeconomic			
Location of residence			.71
Urban	252 (56)	199 (58)	
Regional	128 (29)	97 (28)	
Rural	68 (15)	45 (13)	
Education			.012
High school or less	214 (48)	190 (56)	
Trade/Diploma	148 (33)	80 (23)	
University	85 (19)	71 (21)	
Occupation			<.0001
Indoors	106 (24)	169 (50)	
Both	217 (48)	164 (48)	
Outdoors	125 (28)	7 (2)	

Continued

Table I. Cont'd

	Male	Female	
	n (%)	n (%)	
Characteristic	448 (57)	341 (43)	P value
Psychologic			
Anxiety			<.0001
No	345 (77)	215 (63)	
Yes	103 (23)	125 (37)	
Depression			.16
No	393 (88)	287 (84)	
Yes	54 (12)	53 (16)	
Tumor			
Thickness, mm			<.0001
<1	96 (21)	112 (33)	
1.01-2.00	182 (41)	151 (45)	
2.01-4.00	116 (26)	61 (18)	
>4	54 (12)	15 (4)	
Body site of melanoma			<.0001
Lower limbs	72 (16)	110 (32)	
Trunk/arms	264 (59)	176 (52)	
Head/neck	112 (25)	55 (16)	
Recurrence of melanoma			.09
No	393 (88)	312 (92)	
Yes	55 (12)	29 (9)	

Factors associated with sun exposure and protection

Among patients with melanoma who had complete data for covariates (n = 743), those who were inadequate users of sunscreen after diagnosis (stable sometimes-users and stable never-users) were older, more likely to never check their own skin, and less likely to have a university education than were those with an increased-to-often sunscreen use trajectory (Table III). Those who did not wear long sleeves regularly when in the sun had similar characteristics (Supplemental Table III; available at http://www.jaad.org).

Compared with participants in the moderate-to-low weekend sun exposure trajectory, participants with trajectories of higher weekend sun exposure, were more commonly younger, more likely to have outdoor versus indoor occupations, and less commonly had head or neck melanomas or clinical or subclinical depression. Males with trajectories of high sun exposure were also less likely to perform self-skin examinations (Table IV). Exploration of the relationship between age (<40, 40-59, 60-79, and >80 years) and sun behavior in univariate analyses revealed that inadequate use of sunscreen was more common in older age groups (≥60 years) in both females (*P* = .003) and males (*P* = .0018), whereas high weekend sun exposure was more common in

Sunscreen
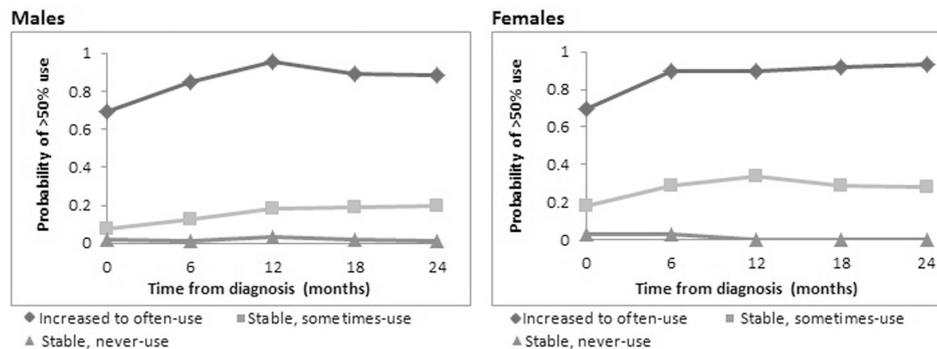
Fig 1. Change over time in the probability of use of sunscreen more than 50% of the time by sunscreen use latent class, and proportions in each class separately for males and females.

Table II. Item response probabilities of minimal (0-1 hours), moderate (2-5 hours), and high (>5 hours) amounts of weekend sun exposure, from baseline until 24 months after diagnosis by sun behavior latent class, separately for males and females

		Weekend sun exposure latent class and item response probabilities								
		Stable high (22%)			High to moderate (60%)			Moderate to low (18%)		
		0-1 h	2-5 h	>5 h	0-1 h	2-5 h	>5 h	0-1 h	2-5 h	>5 h
Sex	Survey time,* mo	(low)	(moderate)	(high)	(low)	(moderate)	(high)	(low)	(moderate)	(high)
Males	0	.00	.16	.84	.04	.68	.28	.41	.56	.04
	6	.00	.18	.82	.07	.90	.04	.64	.36	.00
	12	.00	.31	.69	.04	.85	.11	.71	.28	.02
	18	.00	.16	.84	.05	.86	.09	.70	.26	.04
	24	.01	.21	.79	.10	.82	.08	.76	.23	.01
		Fluctuating moderate high (19%)			Stable moderate (48%)			Moderate to low (33%)		
		0-1 h	2-5 h	>5 h	0-1 h	2-5 h	>5 h	0-1 h	2-5 h	>5 h
	Survey time,* mo	(low)	(moderate)	(high)	(low)	(moderate)	(high)	(low)	(moderate)	(high)
Females	0	.03	.38	.59	.08	.85	.07	.61	.37	.02
	6	.04	.61	.36	.19	.79	.02	.80	.20	.00
	12	.00	.60	.40	.16	.83	.02	.84	.16	.01
	18	.02	.52	.46	.14	.84	.02	.72	.26	.02
	24	.09	.37	.54	.07	.93	.00	.82	.18	.00

*Survey time of 0 months refers to the baseline survey.

younger males (<60 years) ($P < .0001$) but not in females ($P = .14$).

Risk of subsequent melanoma

Of the 75 patients (11%) who developed a subsequent primary melanoma within 2 years, most were male (63%), were older than 65 years (66%), and were receiving more frequent skin checks by a physician after diagnosis (all $P < .05$). We observed that patients with a history of melanoma when the index melanoma was diagnosed had a higher likelihood of a subsequent primary melanoma if their sunscreen use was inadequate in the following 2 years (Table V). Sunscreen use was not associated

Table III. Multivariable regression analysis for the associations between sunscreen use latent classes and patient characteristics by sex

	Males			Females		
	Ref*	Inadequate sunscreen use[†]		Ref*	Inadequate sunscreen use[†]	
Characteristic	n (%) 163 (39)	n (%) 259 (61)	OR, 95% CI	n (%) 192 (60)	n (%) 126 (40)	OR, 95% CI
Personal						
Age, y						
<65	91(56)	98 (38)	1.00	132 (69)	58 (46)	1.00
≥65	72 (44)	161 (62)	2.22 (1.42-3.47)	60 (31)	68 (54)	2.05 (1.18-3.58)
Relationship						
Partner	133 (82)	197 (76)	1.00	146 (76)	75 (60)	1.00
No partner	30 (18)	62 (24)	1.29 (0.76-2.19)	46 (24)	51 (40)	2.44 (1.41-4.22)
Skin type						
Always burn	61 (37)	76 (29)	1.00	104 (54)	53 (42)	1.00
Burn then tan	88 (54)	142 (55)	1.27 (0.80-2.01)	88 (46)	73 (58)	1.79 (1.07-3.00)
Tan only[‡]	14 (9)	41 (16)	1.88 (0.89-3.97)	—	—	—
Smoking						
Never smoker	78 (48)	126 (49)	1.00	119 (62)	68 (54)	1.00
Current	14 (9)	22 (8)	0.90 (0.40-2.02)	13 (7)	9 (7)	1.23 (0.45-3.39)
Ex-smoker	71 (43)	111 (43)	0.79 (0.50-1.23)	60 (31)	49 (39)	1.84 (1.06-3.20)
Self-checks						
At least annually	84 (52)	95 (37)	1.00	60 (31)	55 (44)	1.00
Every few years	38 (23)	58 (22)	1.36 (0.80-2.33)	42 (22)	33 (26)	1.68 (0.87-3.26)
Never	41 (25)	106 (41)	2.25 (1.36-3.72)	90 (47)	38 (30)	2.02 (1.12-3.63)
Socioeconomic						
Location						
Urban	98 (60)	137 (53)	1.00	113 (59)	74 (59)	1.00
Regional	42 (26)	82 (32)	1.30 (0.79-2.12)	52 (27)	39 (31)	1.07 (0.60-1.89)
Rural	23 (14)	40 (15)	1.22 (0.66-2.26)	27 (14)	13 (10)	0.81 (0.37-1.76)
Education						
High school	61 (38)	135 (52)	1.00	92 (48)	84 (67)	1.00
Trade/Dip	59 (36)	84 (33)	0.73 (0.45-1.18)	54 (28)	22 (17)	0.45 (0.23-0.86)
University	43 (26)	40 (15)	0.49 (0.27-0.87)	46 (24)	20 (16)	0.65 (0.33-1.28)
Occupation						
Indoors	43 (26)	59 (23)	1.00	104 (54)	56 (44)	1.00
Both	81 (50)	120 (46)	0.89 (0.52-1.51)	88 (46)	70 (56)	1.30 (0.78-2.18)
Outdoors[§]	39 (24)	80 (31)	1.07 (0.57-1.98)	—	—	—
Psychologic						
Anxiety						
No	122 (75)	205 (79)	1.00	124 (65)	79 (63)	1.00
Yes	41 (25)	54 (21)	0.72 (0.40-1.29)	68 (35)	47 (37)	1.06 (0.60-1.89)
Depression						
No	149 (90)	227 (88)	1.00	164 (85)	105 (83)	1.00
Yes	16 (10)	32 (12)	1.14 (0.78-2.51)	28 (15)	21 (17)	0.99 (0.45-2.16)
Tumor						
Thickness, mm						
<1	34 (21)	57 (22)	1.00	68 (36)	39 (31)	1.00
1.01-2.00	63 (39)	103 (40)	0.76 (0.43-1.34)	81 (42)	59 (47)	1.24 (0.70-2.22)
2.01-4.00	42 (26)	71 (27)	0.73 (0.39-1.35)	35 (18)	22 (17)	1.28 (0.54-2.36)
>4	24 (15)	28 (11)	0.42 (0.20-0.90)	8 (4)	6 (5)	1.20 (0.33-4.43)
Body site						
Lower limbs	31 (19)	38 (15)	1.00	61 (32)	44 (35)	1.00
Trunk/arms	93 (57)	155 (60)	1.34 (0.77-2.49)	98 (51)	62 (49)	0.95 (0.43-2.03)
Head/neck	39 (24)	66 (25)	1.28 (0.66-2.49)	33 (17)	20 (16)	0.95 (0.53-1.70)

Adjusted for all covariables in the table, as well as for history of melanoma.

CI, Confidence interval; *Dip*, diploma; *OR*, odds ratio; *Ref*, reference.

*Reference category refers to increased to often-use latent class.

[†]Inadequate use refers to combined stable never-use, and stable sometimes-use latent classes.

[‡]For female participants, the burn-then-tan and tan-only skin type categories are combined because of small numbers.

[§]For female participants, the both and the outdoor-only occupational categories are combined because of small numbers.

Table IV. Multivariable regression analysis for the associations between weekend sun exposure latent classes and patient characteristics by sex

	Males			Females		
	Ref*	High weekend sun exposure[†]		Ref *	High weekend sun exposure[‡]	
Characteristic	n (%) 75 (18)	n (%) 347 (82)	OR, 95% CI	n (%) 100 (31)	n (%) 218 (69)	OR, 95% CI
Personal						
Age, y						
<65	28 (37)	161 (46)	1.00	51 (51)	139 (64)	1.00
≥65	47 (63)	186 (54)	0.60 (0.34-1.08)	49 (49)	79 (36)	0.39 (0.21-0.73)
Relationship						
Partner	50 (67)	280 (81)	1.00	66 (66)	155 (71)	1.00
No partner	25 (33)	67 (19)	0.59 (0.32-1.08)	34 (34)	63 (29)	0.93 (0.51-1.68)
Skin type[§]						
Always burn	26 (35)	111 (32)	1.00	62 (62)	95 (44)	1.00
Burn then tan	37 (49)	193 (56)	1.18 (0.65-2.15)	38 (38)	123 (56)	2.15 (1.23-3.78)
Tan only	12 (16)	43 (12)	0.98 (0.42-2.30)	-	-	-
Smoking						
Never-smoker	39 (52)	165 (48)	1.00	57 (57)	130 (60)	1.00
Current	7 (9)	29 (8)	0.96 (0.35-2.67)	7 (7)	15 (7)	0.75 (0.25-2.23)
Ex-smoker	29 (39)	153 (44)	1.33 (0.75-2.35)	36 (36)	73 (33)	0.68 (0.37-1.23)
Self-checks						
At least annually	25 (33)	154 (44)	1.00	42 (42)	73 (33)	1.00
Every few years	15 (20)	81 (23)	0.97 (0.46-2.05)	21 (21)	54 (25)	1.19 (0.58-2.46)
Never	35 (47)	112 (32)	0.52 (0.28-0.97)	37 (37)	91 (42)	0.82 (0.44-1.53)
Socioeconomic						
Location						
Urban	46 (61)	189 (55)	1.00	57 (57)	130 (60)	1.00
Regional	19 (25)	105 (30)	1.47 (0.75-2.78)	32 (32)	59 (27)	0.71 (0.25-2.23)
Rural	10 (14)	53 (15)	1.13 (0.51-2.55)	11 (11)	29 (13)	0.83 (0.35-1.93)
Education						
University	32 (43)	164 (47)	1.00	61 (61)	115 (53)	1.00
Trade/Dip	28 (37)	115 (33)	0.73 (0.40-1.33)	17 (17)	59 (27)	1.53 (0.75-3.11)
High school	15 (20)	68 (20)	0.82 (0.38-1.74)	22 (22)	44 (20)	1.06 (0.52-2.17)
Occupation[‖]						
Indoors	27 (36)	75 (22)	1.00	66 (66)	94 (43)	1.00
Both	30 (40)	171 (49)	2.18 (1.15-4.15)	34 (34)	124 (57)	3.27 (1.84-5.81)
Outdoors	18 (24)	101 (29)	2.16 (1.03-4.52)	-	-	-
Psychologic						
Anxiety						
No	61 (81)	266 (77)	1.00	54 (54)	149 (68)	1.00
Yes	14 (19)	81 (23)	1.44 (0.71-2.92)	46 (46)	69 (32)	0.70 (0.38-1.30)
Depression						
No	59 (79)	315 (91)	1.00	72 (72)	197 (90)	1.00
Yes	16 (21)	32 (9)	0.41 (0.20-0.83)	28 (28)	21 (10)	0.32 (0.15-0.69)
Tumor						
Thickness, mm						
<1	11 (15)	80 (23)	1.00	38 (38)	69 (32)	1.00
1.01-2.00	32 (43)	134 (39)	0.67 (0.31-1.46)	45 (45)	95 (43)	1.32 (0.72-2.43)
2.01-4.00	22 (29)	91 (26)	0.68 (0.30-1.56)	12 (12)	45 (21)	3.03 (1.30-7.07)
>4	10 (13)	42 (12)	0.77 (0.29-2.09)	5 (5)	9 (4)	1.81 (0.45-6.81)

Table IV. Cont'd

	Males			Females		
	Ref*	High weekend sun exposure[†]		Ref *	High weekend sun exposure[‡]	
Characteristic	n (%) 75 (18)	n (%) 347 (82)	OR, 95% CI	n (%) 100 (31)	n (%) 218 (69)	OR, 95% CI
Body site						
Lower limbs	4 (5)	65 (19)	1.00	30 (30)	75 (35)	1.00
Trunk/arms	44 (59)	204 (59)	0.35 (0.12-1.03)	50 (50)	110 (50)	0.60 (0.32-1.14)
Head/neck	27 (36)	78 (22)	0.23 (0.07-0.70)	20 (20)	33 (15)	0.41 (0.19-0.91)

Adjusted for all covariables in the table as well as history of melanoma and frequency of skin checks by a clinician.
CI, Confidence interval; *Dip*, diploma; *OR*, odds ratio; *Ref*, reference.
*Reference refers to moderate to low latent class.
[†]High weekend sun exposure (males) refers to combined stable high and high to moderate latent classes.
[‡]High weekend sun exposure (females) refers to combined fluctuating, moderate to high, and stable moderate weekend sun exposure latent classes.
[§]For female participants, the burn-then-tan and tan-only skin type categories are combined because of small numbers.
[‖]For female participants, the both and the outdoor-only occupational categories are combined because of small numbers.

Table V. Associations between sunscreen use trajectories and risk of development of a subsequent melanoma within 2-years after diagnosis, stratified by number of previous melanomas

Sunscreen use by sex		No second primary	Second primary	Univariate analysis HR (95% CI)	Multivariate analysis* HR (95% CI)
No prestudy melanoma					
Males	Adequate[†]	132 (41)	11 (38)	1.00	1.00
	Inadequate[‡]	193 (59)	18 (62)	1.12 (0.53-2.37)	0.93 (0.42-2.04)
Females	Adequate[†]	150 (59)	10 (58)	1.00	1.00
	Inadequate[‡]	103 (41)	7 (41)	1.03 (0.39-2.70)	1.24 (0.43-3.54)
Both	Adequate[†]	282 (49)	21 (46)	1.00	1.00
	Inadequate[‡]	296 (51)	25 (54)	1.14 (0.64-2.04)	0.98 (0.53-1.81)
≥1 prestudy melanoma					
Males	Adequate[†]	27 (35)	3 (19)	1.00	1.00
	Inadequate[‡]	51 (65)	13 (81)	2.07 (0.59-7.27)	2.09 (0.57-7.67)
Females	Adequate[†]	37 (64)	4 (31)	1.00	1.00
	Inadequate[‡]	21 (36)	9 (69)	3.47 (1.07-11.29)	5.42 (1.09-27.09)
Both	Adequate[†]	64 (47)	7 (24)	1.00	1.00
	Inadequate[‡]	72 (53)	22 (76)	2.53 (1.08-5.93)	2.45 (1.00-6.06)

CI, Confidence interval; *HR*, hazard ratio.
*Adjusted for age, skin type, occupation, and frequency of skin checks and weekend sun exposure.
[†]Adequate refers to increased to often-use trajectory.
[‡]Inadequate refers to combined stable sometimes-use and stable never-use trajectories.

with risk of a further primary in patients without a history of melanoma (Table V). Also, weekend sun exposure was not associated with a further primary, regardless of melanoma history.

DISCUSSION

A proportion of primary melanoma survivors had a sustained increase in their use of sunscreen (39% of males and 59% of females) and long sleeves (one-third of patients) and a sustained reduction in their weekend sun exposure (78% of males and 33% of females). However, around a fifth of melanoma survivors never engaged in recommended sun safety practices before or after diagnosis; the characteristics associated with poorer behaviors included being male, having a lower education level, having some tanning ability, being a current smoker, not performing skin self-examinations, and having thinner versus thicker melanoma at diagnosis.

Patients who had had a melanoma before their index melanoma and who had trajectories of inadequate sunscreen use had a significantly higher risk of subsequent primary melanoma over 2 years of follow-up. It is possible that we did not observe this effect in patients without prior melanoma, as the 2-year follow-up time may have been insufficient for new disease to occur in less susceptible patients. Although the induction time between ultraviolet

exposure and melanoma development is unknown, our results suggest that patients with multiple melanomas can lower their risk of further primary melanomas by applying sunscreen when outdoors. For more than 30 years there have been widespread skin cancer awareness and prevention campaigns in Australia, as reflected in the high proportion of participants using sun protective behaviors before diagnosis.[20,21] Despite this, at least one-fifth of our study cohort (particularly males) displayed risky sun behaviors before diagnosis of their melanoma, with little or no change after diagnosis, which is consistent with the findings of other reports.[6,7,11] We recommend that future studies seek to identify enablers and barriers for sun behavior change, particularly in patients with melanoma and inadequate protective behaviors.

Unlike the results from small cohort studies showing that initial improvements in sun safety behaviors in melanoma survivors were unsustained,[12,13] our large study showed that the majority of behavioral modifications were maintained over the 2 years after diagnosis of the index melanoma. Sun protection behaviors improved predominantly in the first 6 months, indicating that the period immediately after a melanoma diagnosis is important for patient education. This is consistent with the standard care for patients with melanoma,[22,23] according to which sun safety education should be part of routine management after diagnosis. Patients can also be encouraged to increase specific preventive behaviors such as sunscreen use, and given the generally increased risk of further new primaries, this message should be conveyed to all patients with melanoma, regardless of their history. However, further research into effective patient education and counseling strategies and standardization thereof across health providers is required.

Strengths of this study are its prospective design, large size, and novel use of repeated measures LCA to describe sun behaviors of melanoma survivors at high risk of disease spread. The response rates to sun behavior surveys were high (>80% at all time points). Our 2-year rate of subsequent primary melanomas (11%) is consistent with observations from other cohorts.[24] Limitations included collection of information on prediagnosis sun protection only after diagnosis (potential recall bias) and self-reported behavior (social desirability bias). Those who had a previous diagnosis of melanoma (21%) at recruitment or whose melanoma recurred in the study period (11%) may have behaved differently from other patients, but sensitivity analysis excluding these groups did not alter results. Conscious avoidance of being outdoors as a sun protection measure was not ascertained in study surveys.

CONCLUSION

Our study confirms that a diagnosis of high-risk primary melanoma is a teachable moment for some patients, inducing them to adopt lasting improvements in sun protection. However a proportion of patients appear to persist with inadequate protection: more commonly, they are males, current smokers, those with lower education, those with some tanning ability, or those not performing skin self-examination. Patients with a history of multiple melanomas whose sunscreen use was inadequate on follow-up had a significantly higher risk of another primary. These findings should encourage clinicians to provide sun protection counseling to melanoma survivors and assist in identifying patients who would benefit from targeted education to reduce risk of further primary disease.

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Long-sleeves

Males
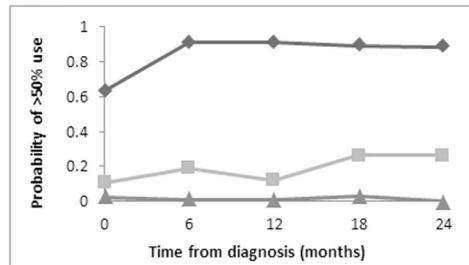
Females
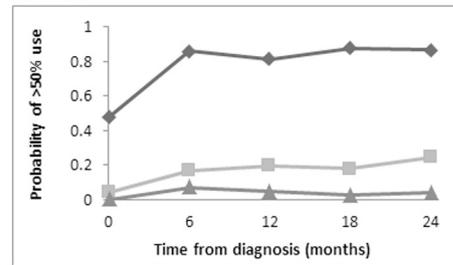
Proportion of total	Increased to often-use	Stable, sometimes-use	Stable, never-use
Males	36%	43%	21%
Females	35%	44%	21%

0=baseline survey

Supplemental Fig 1. Change over time in the probability of use of long sleeves more than 50% of the time by long sleeve use latent class, and the proportions in each class separately for males and females.

Supplemental Table I. Item response probabilities of never, less than 50% of the time, and more than 50% of the time for the use of sunscreen when outdoors, from baseline until 24 months after diagnosis by sunscreen use latent class, separately for males and females

		Sunscreen use latent class and item response probabilities								
		Increased to often-use (39%)			**Stable sometimes-use (35%)**			**Stable never-use (26%)**		
Sex	**Survey time, mo***	**Never**	**<50% (sometimes)**	**>50% (often)**	**Never**	**<50% (sometimes)**	**>50% (often)**	**Never**	**<50% (sometimes)**	**>50% (often)**
Males	0	.05	.25	.69	.13	.80	.08	.57	.41	.02
	6	.06	.09	.85	.12	.72	.13	.86	.13	.01
	12	.01	.04	.96	.07	.74	.19	.89	.08	.04
	18	.00	.10	.91	.05	.76	.19	.79	.19	.02
	24	.01	.11	.89	.09	.71	.20	.82	.16	.01
		Increased to often-use (59%)			**Stable sometimes-use (29%)**			**Stable never-use (12%)**		
	Survey time, mo*	**Never**	**<50% (sometimes)**	**>50% (often)**	**Never**	**<50% (sometimes)**	**>50% (often)**	**Never**	**<50% (sometimes)**	**>50% (often)**
Females	0	.00	.31	.69	.14	.69	.18	.68	.29	.03
	6	.01	.09	.89	.19	.52	.28	.97	.00	.03
	12	.01	.09	.90	.14	.52	.34	.90	.10	.00
	18	.00	.08	.92	.10	.61	.29	.92	.08	.00
	24	.01	.05	.93	.11	.61	.28	.81	.19	.00

*Survey time of 0 months refers to the baseline survey.

Supplemental Table II. Item response probabilities of never, more than 50% of the time, and less than 50% of the time for the use of long sleeves when outdoors, from baseline until 24 months after diagnosis by long sleeves use latent class, separately for males and females

		Long sleeves latent class and item response probabilities								
		Increased to often-use (36%)			Stable sometimes-use (43%)			Stable never-use (21%)		
Sex	Survey time,* mo	Never	<50% (sometimes)	>50% (often)	Never	<50% (sometimes)	>50% (often)	Never	<50% (sometimes)	>50% (often)
Males	0	.08	.29	.63	.23	.66	.11	.78	.20	.02
	6	.04	.06	.91	.22	.60	.19	.84	.15	.01
	12	.00	.09	.91	.17	.71	.12	.83	.16	.01
	18	.01	.10	.89	.10	.64	.26	.77	.21	.03
	24	.01	.10	.89	.12	.62	.26	.88	.12	.00
		Increased to often-use (35%)			Stable sometimes-use (44%)			Stable never-use (21%)		
	Survey time,* mo	Never	<50% (sometimes)	>50% (often)	Never	<50% (sometimes)	>50% (often)	Never	<50% (sometimes)	>50% (often)
Females	0	.09	.44	.47	.26	.70	.04	.87	.13	.00
	6	.05	.09	.86	.19	.65	.17	.78	.15	.07
	12	.01	.18	.81	.07	.73	.19	.77	.18	.05
	18	.01	.12	.88	.12	.71	.18	.79	.18	.02
	24	.02	.11	.87	.11	.64	.25	.83	.14	.04

*Survey time of 0 months refers to the baseline survey.

Supplemental Table III. Multivariable regression analysis for the associations between use of long sleeves and patient characteristics by sex

	Males			Females		
	Ref,*	Inadequate use of long sleeves,†		Ref,*	Inadequate use of long sleeves,†	
	n (%)	n (%)		n (%)	n (%)	
Characteristic	149 (35)	273 (65)	OR, 95% CI	111 (35)	207 (65)	OR, 95% CI
Personal						
Age, y						
<65	77 (52)	112 (41)	1.00	65 (59)	125 (60)	1.00
≥65	72 (48)	161 (59)	1.56 (0.98-2.48)	46 (41)	82 (40)	0.81 (0.46-1.39)
Relationship						
Partner	115 (77)	215 (79)	1.00	81 (73)	140 (68)	1.00
No partner	34 (23)	58 (21)	0.79 (0.46-1.36)	30 (27)	67 (32)	1.40 (0.81-2.41)
Skin type						
Always burn	62 (42)	75 (27)	1.00	58 (52)	99 (49)	1.00
Burn then tan	69 (46)	161 (59)	2.09 (1.29-3.37)	53 (48)	108 (52)	0.15 (0.70-1.91)
Tan only‡	18 (12)	37 (14)	1.64 (0.80-3.35)	—	—	—
Smoking						
Never-smoker	84 (56)	120 (44)	1.00	70 (63)	117 (56)	1.00
Current	11 (8)	25 (9)	1.74 (0.74-4.12)	2 (2)	20 (10)	5.54 (1.20-25.65)
Ex-smoker	54 (36)	128 (47)	1.56 (0.99-2.47)	39 (35)	70 (34)	1.04 (0.61-1.77)
Self-checks						
At least annually	75 (50)	104 (38)	1.00	35 (31)	75 (36)	1.00
Every few years	30 (20)	66 (24)	1.56 (0.89-2.75)	23 (21)	52 (25)	1.61 (0.85-3.07)
Never	44 (30)	103 (38)	1.65 (1.00-2.74)	53 (48)	80 (39)	1.70 (0.96-3.01)
Socioeconomic						
Location						
Urban	82 (55)	153 (56)	1.00	59 (53)	128 (62)	1.00
Regional	41 (28)	83 (30)	0.98 (0.59-1.63)	33 (30)	58 (28)	0.84 (0.48-1.47)
Rural	26 (17)	37 (14)	0.72 (0.39-1.34)	19 (17)	21 (10)	0.49 (0.23-1.00)
Education						
High school	60 (40)	136 (50)	1.00	59 (53)	117 (56)	1.00
Trade/Dip	50 (34)	93 (34)	0.84 (0.51-1.38)	27 (24)	49 (24)	1.01 (0.55-1.85)
University	39 (26)	44 (16)	0.41 (0.22-0.76)	25 (23)	41 (20)	0.86 (0.45-1.65)
Occupation						
Indoors	26 (17)	76 (28)	1.00	55 (50)	105 (51)	1.00
Both	79 (53)	122 (45)	0.38 (0.21-0.68)	56 (50)	102 (49)	1.06 (0.64-1.76)
Outdoors§	44 (30)	75 (27)	0.39 (0.20-0.77)	—	—	—
Psychologic						
Anxiety						
No	115 (77)	212 (77)	1.00	76 (69)	127 (61)	1.00
Yes	34 (23)	61 (22)	0.86 (0.47-1.59)	35 (31)	80 (39)	1.44 (0.81-2.56)
Depression						
No	133 (89)	241 (88)	1.00	94 (85)	175 (85)	1.00
Yes	16 (11)	32 (12)	0.94 (0.43-2.08)	17 (15)	32 (15)	0.71 (0.33-1.52)
Tumor						
Thickness, mm						
<1	36 (24)	55 (20)	1.00	37 (33)	70 (34)	1.00
1.01-2.00	46 (31)	120 (44)	1.59 (0.89-1.59)	53 (48)	87 (42)	0.77 (0.81-2.56)
2.01-4.00	50 (34)	63 (23)	0.72 (0.39-1.33)	16 (14)	41 (20)	1.38 (0.66-2.89)
>4	17 (11)	35 (13)	1.08 (0.50-2.36)	5 (5)	9 (3)	1.07 (0.30-3.76)
Body site						
Lower limbs	34 (23)	71 (26)	1.00	32 (29)	73 (35)	1.00
Trunk/arms	88 (88)	160 (59)	1.06 (0.58-1.94)	59 (53)	101 (49)	0.69 (0.39-1.22)
Head/neck	27 (27)	42 (15)	1.34 (0.67-2.67)	20 (18)	33 (16)	0.75 (0.36-1.57)

Adjusted for all covariables in the table, as well as for history of melanoma.

CI, Confidence interval; *Dip*, diploma; *OR*, odds ratio; *Ref*, reference.

*Reference category refers to the *increased to often-use* latent class.

†Inadequate use refers to the combined latent classes *stable never-use* and *stable sometimes-use*.

‡For female participants, the burn-then-tan and tan-only skin type categories are combined because of small numbers.

§For female participants, the both and outdoor-only occupational categories are combined because of small numbers.