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Environmental Cues to Ultraviolet Radiation and Personal Sun Protection In Outdoor Winter Recreation

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Abstract

Objective—The prevalence of ultraviolet radiation (UV) at North American ski resorts was predicted using temporal, seasonal, altitudinal, and meteorological factors and associated with a set of adult sun protection behaviors.

Design—UV observations and cross-sectional survey of adults on sun protection were collected.

Setting—Data were collected at 32 high-altitude ski areas located in Western North America in 2001–03.

Participants—The sample consisted of 3,937 adult skier or snowboarders.

Main Outcome Measures—Measurements of direct, reflected, and diffuse UV were performed at 487 measurement points using handheld meters and combined with self-reported and observed sun protection assessed for adults interviewed on chair lifts.

Results—The strongest predictors of UV were temporal proximity to noon, deviation from winter solstice, and clear skies. By contrast, altitude and latitude had more modest associations with UV and temperature had a small positive relationship with UV. Guest sun safety was inconsistently associated with UV: UV was positively related to adults wearing more sunscreen, reapplying it after two hours, and wearing protective eyewear but fewer adults exhibited many of

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Study concept and design: Andersen, Buller, Walkosz, Scott, Cutter and Dignan
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the other sun protection behaviors, such as hats, protective clothing or lip balm, on days when UV was elevated. Guests took more sun safety precautions on clear-sky days but took steps to maintain body warmth on inclement days.

Conclusions—In future sun safety promotions, adults should be encouraged to wear sunscreen on cloudy days because UV is still high and conditions can change rapidly. They need reminders to rely more on season and time of day when judging UV and the need for sun safety.

Skin cancer is an epidemic in America.[1] Over 62,000 new cases of melanoma will occur this year that will claim 8,000 lives,[1] along with over a million cases of basal and squamous skin cancer both of which are associated with cancer at all sites.[2,3,4]The main cause of skin cancer is exposure to ultraviolet radiation (UV).[5,6,7,8,9,10] It is imperative that people use sunscreen, wear protective clothing, and recognize when UV is high. However, humans cannot sense UV, so sun safety requires recognizing when UV is potentially dangerous. Studies suggest that solar UV forecasts are not very effective in promoting sun safety[11,12] because many people do not receive them and people are influenced by subjective impressions of weather that may not be a reliable indicators of UV.

People inaccurately associate two meteorological phenomena with UV, temperature and cloud cover. This results in more burning on cooler days.[13,14]because people are less likely to take precautions. Similarly, people engage in fewer sun safety practices on cloudy days. Dense clouds can impede UV by up to 50%,[15,16,17,18] but clouds do not block all UV, a problem during months when solar UV is moderate to high and can penetrate clouds.

Seasonality, time of day, latitude and altitude, are more reliably associated with UV than meteorological variables. In temperate latitudes, UV peaks on the summer solstice and is lowest at the winter solstice,[19] though indirect, diffuse UV can be high in winter.[17,20,15] UV peaks at solar noon and is highest at low latitudes.[14] Likewise, solar radiation is considerably greater at high elevations rather than sea level.[21,15,16,22,23,24,20,25,26,27] In the clear, dry air of the Andes UV radiation increases by 15% for each thousand meters or 5% for each thousand feet in elevation gain.[23,24] In the cloudier, humid weather of the Alps UV radiation increases 24% per thousand meters or 7% per thousand feet.[20] One study found UV increased up to 19% for each thousand meters or about 5% for each thousand feet [28] and another reported that UV increased 10% per vertical kilometer.[27] Regardless of the exact increase in UV studies all show that altitude, clear air, and reflected UV from snow make the alpine environment dangerous.[18,24,17,25,20,26,15]

The present study investigated the association of meteorological, temporal, and geographic variables with UV levels and with decisions by adults in outdoor recreation to protect their skin from UV to provide data-based recommendations for outdoor recreation and sun safety campaigns. Accordingly, the following research questions and hypotheses were posited:

RQ1: How much UV exists at recreational ski areas?

H1: At ski areas, UV is a) positively related to altitude, deviation from winter solstice, and proximity to noon, and b) negatively associated with cloud cover and latitude.

Skin damage increases when UV is elevated and more sun protection is needed., but People cannot directly perceive UV, so they need to rely on environmental cues to determine when UV is elevated and sun protection is necessary. Thus, we pose two more research questions regarding the association of UV and environmental characteristics on sun protection:

RQ2: Is UV positively associated with increased sun protection (i.e., sunscreen and lip balm use, head covering, goggles/sunglasses, and protective clothing) by adults recreating at ski areas (i.e., alpine skiers and snowboarder)?

RQ3: Are meteorological, temporal, or environmental cues associated with elevated UV positively related to sun protection by adults recreating at ski areas?

Methods

Sample of Ski Areas

Data were collected at 32 ski areas located in Alaska, British Columbia, California, Colorado, Idaho, Montana, New Mexico, Nevada, Oregon, Utah, and Washington over three years (2001–2003) that were members of the National Ski Areas Association (NSAA) and had at least two chairlifts.[29] The areas varied in size, management, ticket prices, and demographics and were located between 34° N and 61°N latitude and at altitudes ranging from 250 ft. to 13,643 ft.

UV was measured by project staff as part of a study evaluating a sun protection program, Go Sun Smart (GSS). GSS sought to improve sun protection by ski area employees and guests. The main trial in 2001 and 2002 involved 26 ski areas in a pair-matched group-randomized pretest-posttest quasi-experimental evaluation design.[30] In 2003, six additional ski areas served as a second control group for a crossover design.

UV was measured with reliable and valid handheld Optix Tech SunSafe meters. Optix reported that SafeSun meter equipment was tested by the U.S. EPA’s SunWise program, World Radiation Center in Switzerland and the Australian Radiation Laboratory and tests demonstrated the accuracy of SafeSun UV meters compared to professional UV metering equipment. Data collectors measured UV at pre-scheduled times each day. UV measurements were taken during each three-day period at each area by the data collector who recorded direct UV by holding the meter facing the sun, diffuse UV by holding the meter toward the sky away from the sun, and reflected UV by holding the meter toward the snowy slope away from the sun. Data collectors repeated these reading resulting in six UV observations (2 direct, 2 diffuse, and 2 reflected) at each time. Test-retest data for the three observations were highly reliable (r=0.97 for direct UV; r=0.94 for diffuse UV; r=0.91 for reflected UV). The correlations among the six UV measures during each data collection period ranged from .83 to .97 (Table 1).

Sun protection behaviors by 3,937 adult guests at 30 of the ski areas, measured in 2001, 2002, and 2003 were used to evaluate Research Questions 2 and 3. Consistent with industry demographics guests in the present study were 96% white, 4% other, while 4% of these groups were Hispanic, 67% college graduates, and 73% male. This sample was limited to guests interviewed at ski areas not using GSS, i.e., all ski areas pretested in the main trial in 2001 (n=25) and ski area randomized to the no-treatment control condition in 2002 (n=13) and in 2003 (n=5). Interviews were conducted from January to April in 2001 (n=2,991; 99.3% completion rate; 0.7% refused [n=23]). 2002 (n=1,846; 98.8% completion rate; 1.2% refused [n=24]), and 2003 (n=265; 99.6% completion rate; 0.4% refused [n=1]). A total of 308 guests (n=203 in 2001; n=103 in 2002; n=2 in 2003) were ineligible (under age 18 [n=49], employee [n=175], previously interviewed [n=71], or non-English speaking [n=13]). Samples varied from 50 to 359 participants at each area due to the number of guests on the mountain. The sub-sample of guests which was analyzed included those interviewed on days in which UV readings were recorded (n=2282 in 2001, n=1420 in 2002, and n=235 in 2003).

Guests were interviewed face-to-face on each chairlift during three-day data collection visits (one weekend day, two weekdays) at each ski area. After boarding, interviewers provide a consent statement. Interviewers recruited the person immediately next to them (if seated in the middle, the person to the right). If the guest refused or was ineligible, another guest on the chair was recruited. Only one interview was completed per ride.

Sun protection was assessed on chairlifts by asking guests about sunscreen (yes/no or don't know; SPF; where it was worn, time first applied, and reapplied) and sunscreen lip balm (yes/no or don't know; SPF). Interviewers observed guests' head cover, neck cover, face cover, gloves, sunglasses/goggles, and ski or snowboard equipment. An overall sun protection score was obtained by summing sunscreen with SPF 15+, lip balm with SPF 15+, goggles, gloves, face cover, neck cover, and head cover (range=0–7). Interviewers recorded time and date, cloud cover (1=sunny, 2=partly cloudy, 3=cloudy), and temperature (°F), and asked guests the time they started skiing/snowboarding (hour:minute). Proximity to noon was defined as the minutes between when they started skiing and noon. Interview date was used to obtain the deviation from winter solstice by counting the days since December 20. Latitude (minutes:seconds) and altitude (feet) of the ski areas were obtained from area records.

Other questions measured guest demographics, skin sun sensitivity,[31] snow sport expertise (self-reported beginner, intermediate, or expert skier/snowboarder), and number of days spent skiing/snowboarding during that winter. Interviewers also recorded precipitation though direct observation. Protocols were reviewed by the IRBs at the participating research organizations and approved as exempt under 4CFR 46.101(b)(2).

Hypothesis one was tested with multiple regression using SAS PROC MIXED. UV readings were nested within ski area, so variance was adjusted by including a random ski area effect in the model. Total UV (mean of six measurements) was regressed on altitude, latitude, temporal proximity to noon, deviation from winter solstice, cloud cover and temperature. Besides cloud cover, all other predictors and mean UV were normalized (0,1).

To test the relationship between UV and sun protection behavior (RQ2), each behavior was regressed separately on Total UV in a univariate model. Additionally the composite sun protection score was regressed separately on Total UV. Individual-level covariates were included in the model, i.e., variables significantly correlated with outcomes and retained in backward stepwise regressions. Thus, each outcome had a unique set of covariates. Covariates were age, education, gender, race, skin sun sensitivity, ability level, days skied this winter, local vs. destination skier, and type of equipment (skis vs. snowboard). Total UV was standardized and a random ski area effect was included. For ease of interpretation, SAS PROC MIXED was used for all guest outcomes, justified because clusters (i.e. guests per area) were large (min=33, max=465). For Research Question 3 each sun protection behavior was regressed separately on the six environmental cues. Variables (excluding cloud cover) were standardized; significant covariates were included (identified through backwards stepwise regression); and a random ski area effect was modeled. To test if the effects of environmental cues on sun protection behaviors differ by gender, age, education, and skin sun sensitivity, regression analyses were repeated to include all four demographic variables as moderators (i.e., regressed on interactions of environmental cues with demographic variables.

Results

UV Index at Ski Areas: Research Question 1

As expected in winter, average UV levels at the 32 ski areas were moderately low but showed substantial variation, with the maximum levels recorded being a standard EPA UV Index of 10 for direct UV (see Table 1). Direct UV was highest on average, but diffuse and reflected UV levels were still substantial by comparison (70% and 57% that of direct UV).

Environmental Characteristics Associated with High UV: Hypothesis 1

Hypotheses one, which predicted that UV levels at ski areas would be associated with temporal, geographic, and meteorological environmental characteristics including deviation from the winter solstice, temporal proximity to noon, higher altitude, lower latitude, and clear skies was supported in a regression analysis for all environmental variables (Table 2). The strongest predictors were temporal proximity to noon, deviation from the winter solstice, and clear skies. Altitude and latitude had more modest associations with UV levels, by contrast. Though not included in the hypothesis, temperature had a small positive relationship with UV level.

Association of UV Level with Sun Protection Behaviors: Research Question 2

Sun protection behaviors did not consistently increase when UV levels were elevated (Table 3). As UV increased, guests were more likely to report wearing sunscreen with an SPF of 15+,more likely to reapply after two hours, and more likely to wear goggles/sunglasses. The positive relationship of UV to sunscreen use was more characteristic of males (slope=0.05) than females (slope=0.01; UV × gender $F[1,3865]=4.31$, $p=0.04$). Fewer guests engaged in other sun protection behaviors (head covering, and covering over their ears, neck, and face) on days when UV was high. Overall sun protection, measured by summing all sun protection behaviors, was negatively related to UV. Use of sunscreen lip balm, application of sunscreen 30 minutes prior to starting skiing, wearing a head cover with a brim, and wearing gloves were unrelated to UV levels. Use of a brim was positively associated with UV for males (slope=0.02) and negatively associated with UV for females (slope=−0.03; UV × gender $F(1,3523)=11.98$, $p<.001$).

Association of Environmental Cues with Sun Protection Behaviors: Research Question 3

Guests at ski areas made decisions about using sun-protective behaviors in two ways, one related to clear skies and sun protection, the other related to inclement weather and cold protection (Table 4). For sun protection, more individuals wore sunscreen, reapplied it after two hours, and wore sunscreen lip balm when skies were clear. Sunscreen and sunscreen lip balm were worn more frequently at lower latitudes. Guests reported more sunscreen use but less lip balm at higher temperatures. Reapplication was more likely by guests interviewed farther from noon. Brims were also worn by more guests at ski areas located at lower latitudes and lower altitudes and on days with higher temperatures. Overall, this appears to be a sun protection pattern.

Sun protection was moderated by sun sensitivity, gender, and age. Lighter-skinner people (Types I and II) reported more sunscreen reapplication at lower latitudes (slope=−0.07) compared to darker-skinned people, whose reapplication decreased at lower latitudes (slope=0.07); latitude × sun sensitivity $F[1,700]=4.58$, $p=0.03$). Sun-sensitive individuals retained constant rates of sunscreen reapplication with increasing altitude (slope=−0.04), whereas darker-skinned guests reported increased reapplication at higher altitude (slope=0.09; altitude × sun sensitivity $F[1,700]=4.31$, $p=0.04$). Males' use of sunscreen stayed constant across the day (slope=0.004), but more females reported wearing sunscreen closer to noon (slope=−0.053; minutes from noon × gender $F[1,2235]=6.29$, $p=0.01$).

Several seasonal effects were moderated by gender: Female sunscreen use was constant across the ski season (slope=0.000); however, male sunscreen use increased toward spring (slope=0.049; deviation from winter solstice × gender $F[1,2235]=4.81$, $p=0.028$). Inversely, males reported constant lip balm use (slope=0.01), whereas females' lip balm use decreased toward spring (slope=−0.06; deviation from winter solstice × gender $F[1,2235]=8.76$, $p=0.003$). An interaction between deviation from winter solstice and gender was found for applying sunscreen 30 minutes before going outside ($F[1,1128]=12.79$, $p<0.001$) and overall sun protection ($F[1,2129]=12.27$, $p<0.001$) with females decreasing toward spring (slope= −0.03 and −0.13, respectively) and males trending upward (slope=0.06 and 0.07, respectively) for both behaviors. Last, an inverse relationship between temperature and sunscreen lip balm use was found for guests over 45 (slope=−0.07) but not for the other age groups (18–35 slope=0.01; 36–45 slope=−0.02; temperature × age $F[2,2251]=3.95$, $p=0.02$).

A second pattern was likely motivated by cold protection. More guests wore headgear, used sunscreen 30 minutes before skiing/snowboarding and covered their ears, neck and face when cloudy and cold. More head and ear covering occurred at higher altitudes and latitudes. Ear and neck covering was more frequent further from noon. More face covering occurred close to noon. Face covering significantly decreased in the afternoon. Interactions between head cover and temperature occurred for sun sensitivity and age, with darker-skinned guests (slope=−0.049) and younger groups (18–35 slope=−0.034; 36–45 slope= −0.066) exhibiting a steeper decline in head covering as temperatures rose (slope=−0.016 and −0.016, respectively; temperature × sun sensitivity $F[1,2133]=4.87$, $p=0.028$; temperature × age $F[2,2136]=3.28$, $p=0.038$).

We also tested if the proximity of the time when guests started skiing/ snowboarding was associated with sun protection behaviors. Those who started skiing/snowboarding closer to noon were more likely to apply sunscreen 30 minutes prior to skiing/snowboarding; those who started skiing/snowboarding farther from noon were more likely to cover their ears and necks.

Discussion

At ski areas, average UV was moderate to low during the winter season, though large variation occurred. Adults at ski areas were intermittently exposed to levels of UV warranting precautions against skin exposure. UV was dangerously high on many late winter and early spring days when UV readings up to 10 were observed. This study found that substantial UV radiation occurred from two other sources: diffuse atmospheric radiation and reflected radiation from the snowy surface. The short wavelength of UV causes dispersion resulting in substantial diffuse UV in the atmosphere and considerable UV is reflected off snowy surfaces.

These three sources produce a multidirectional barrage of UV that explains ski patrollers' anecdotal accounts of sunburning in their nostrils and underscores the need for comprehensive sun protection. Outdoor enthusiasts should stay in shade and wear brimmed hats but these practices may be insufficient to fully protect individuals in high altitude, outdoor, snow-covered winter environments where UV is diffuse and reflected not just direct. Shade and hats should be supplemented with broad-spectrum high SPF sunscreen, sunglasses, and clothing that protect skin surfaces from diffuse and reflected UV radiation in addition to direct solar UV radiation.

People cannot directly detect UV when deciding to take precautions. Instead, they must infer UV levels from its link to temporal, geographic, and meteorological characteristics or rely on UV Index forecasts. As expected, proximity to noon, deviation from the winter solstice, lower latitudes.higher altitudes, and less cloud cover were associated with increased UV. Proximity to noon, deviation from winter solstice, and cloud cover have the most pronounced affect on UV levels at ski areas. The association of temperature with UV may be spurious, produced by increasing infrared radiation toward noon and in early spring when UV also increases.

Skiers and snowboarders evidently monitor outdoor alpine environments in two ways, for sun protection and cold protection. For sun protection, they rely mainly on clear skies as a UV cue. They correctly link clear skies with the need for UV protection and use and reapply more sunscreen since more UV is present on clear days. However, extensive diffuse and reflected UV occurs on cloudy days at midday in the spring, and cloud cover can change within hours. Males pay more attention to seasonality when taking precautions while women pay more attention to time of day. Routine use of moisturizers and make-up with sunscreen may account in part for women's consistent sunscreen use across season. Lighter-skinned individuals appear to base sun protection decisions correctly on latitude but do not adjust for altitude.

A second judgment made by outdoor enthusiasts regards how much clothing to wear to maintain body heat and avoid frostbite. On cloudy days, when the weather is more inclement, skiers and snowboarders are more likely to wear head covering and cover their ears, neck, and face. Ironically these excellent sun safety behaviors are more likely on cloudy days when UV is a bit lower and less likely to be worn on sunny days when UV is higher. Older adults rely less on temperature than younger adults, suggesting they learned not to trust this unreliable UV cue. Sun safety promotions should remind skiers and snowboarders to wear sun protective clothing on sunny days as well. In warm weather changing to lighter-weight headwear and clothing could help manage overheating, on warm, sunny days and still obtain protection.

Unfortunately, little association exists between any sun protection behavior and time of day or season. Skiers and snowboarders appear to ignore both the fact that UV increases as spring approaches and is higher near solar noon each day. While cloud cover does depress the amount of UV reaching the ski area, this reduction, perhaps by as much as 50%, does not eliminate all UV in late winter and early spring and at midday when UV is high. Individuals should be cautious about cloud cover as a UV indicator and need to consider season and time of day the most reliable indicators of UV. One good sign is that sunscreen reapplication was more likely nearer to noon. Unfortunately it appears that warm temperatures, a very unreliable cue to UV levels, continue to be considered in adults' sun protection decisions during winter and spring outdoor recreation just as it is in the summer.[32]

People are both accurate and inaccurate in their UV assessments. People wear sunscreen, lip balm, and headgear with brims based on inferences about UV – using them more frequently on clear days and at lower latitudes. Sunscreen was reapplied when UV was judged to be high. However, protective clothing decisions appear to be motivated by inclement weather concerns rather than elevated UV. Probably people also apply sunscreen more than 30 minutes prior to skiing or snowboarding due to inclement weather rather than due to advice that sunscreen is most effective when applied beforegoing outdoors. They may feel it is more difficult or uncomfortable to apply sunscreen in inclement weather so they do so before arriving on the mountain. Skiers and snowboarders should be encouraged to pre-apply sunscreen on sunny and cloudy days since sunscreen compounds need time to be absorbed by the skin to be effective.[33,34,35]

Outdoor recreation venues should consider publishing UV forecasts to help guests make informed sun safety decisions. However, UV forecasts do not always promote increased sun safety[12] as individuals continue to rely on "rules of thumb" like associating high UV with clear.not cloudy days, and warm, not cold days, regardless of season or time of day.

It was surprising that UV was less strongly related to latitude and altitude than other variables. This finding may be due to restricted range of latitudes (all but one ski area was between 34° N and 50° N) and high base altitudes (all but one were in high altitude mountain locations), Despite these findings, outdoor recreators should still take into account latitude and altitude when judging UV as prior research shows that UV is elevated at low latitudes and high elevation, and when combined may result in UV levels in winter that can burn and damage the skin.

This study was limited to ski areas in Western North America. It would be valuable to examine if outdoor recreation enthusiasts in countries with more sun safety promotion rely on different environmental cues to UV when making sun protection decisions. Our data are also limited to outdoor recreation during the winter and early spring period and not applicable to summer when UV is high and temperatures are much warmer.

During outdoor recreation in winter and spring people in alpine environments are bathed in UV. Fortunately, they take some precautions when UV is high, but their sun protection is associated with clear skies and temperature, not more reliable temporal cues, season or proximity to noon, and geographic cues, altitude and latitude. More sophisticated sun safety promotions are needed that both teach people to take precautions and to judge accurately when UV is high.

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Table 1

Average direct, diffuse, and reflected UV as measured in UV Index Units (n=487 measurement points)

Type of UV[1]	Mean	sd	Maximum[2]	Correlation Between Measures[3]
Direct UV	2.63	2.21	10.0	0.97
Diffuse UV	1.84	1.52	8.0	0.94
Reflect UV	1.49	1.31	9.5	0.90
Total UV	1.99	1.62	8.0	

[1]The two readings taken at each measurement were averaged prior to calculating mean reading; total UV is the mean of all six readings at each measurement.

[2]Minimum value for all measures was 0.0

[3]Pearson correlations between the two measures taken at each measurement.

Table 2

Results of multiple regression of total UV on environmental cues.[1]

Predictor	Regression Coefficient (LS Means for Cloud)	F[2]	p
Altitude	0.137	4.78	0.030
Latitude	−0.168	4.50	0.035
Temporal proximity to noon[3]	−0.346	94.14	<0.001
Deviation from winter solstice	0.414	78.58	<0.001
Cloud cover[4]	Clear = 0.401 Partly Cloudy = 0.041 Cloudy = −0.664	69.58	<0.001
Temperature (°F)	0.164	15.90	<0.001

[1]All variables except cloud cover were standardized N(0,1) prior to analysis.

[2]df=2,276 for Cloud; 1,276 for all others

[3]Low numbers meant closer proximity to noon.

[4]Cloud cover was coded as 1=clear sky, 2=partly cloudy, 3=cloudy.

Table 3

Univariate association of total UV and each separate sun protection behavior and a composite behavior score.

Sun Protection Behavior	Regression Coefficient[1]	F	p
Sunscreen[a,b,c,d,e]	0.048	23.31	<0.001
Sunscreen lip balm[b,c,d,e,f]	0.013	1.94	0.163
Apply sunscreen 30 minutes Prior to starting skiing/ snowboarding[a,c,d,e]	−0.020	3.76	0.053
Reapplied sunscreen after 2 hours[2,d]	0.054	23.93	<0.001
Goggles/sunglasses[d,f,g]	0.015	8.98	0.003
Head cover[g]	−0.018	6.95	0.008
Brim on head cover[a,c,d,h]	0.0026	1.43	0.232
Ears covered[c,d,g,h]	−0.022	8.49	0.004
Neck covered[a,c,d]	−0.082	63.23	<0.001
Face covered[c,d,e]	−0.044	46.14	<0.001
Gloves[e]	−0.007	2.79	0.095
Overall sun protection[a,b,c,d,e,f,h]	−0.078	9.61	0.002

[1]Results adjusted for age (a), education (b), gender (c), skin sun-sensitivity (d), local vs. destination guest (e), ability level (f), days skied/ snowboarded this season (g), and/or equipment (h).

[2]Those who were interviewed within 2 hours of first applying sunscreen were removed from analysis.

Table 4

Results of multivariate regression of sun protection behaviors on environmental cues.[1]

Sun Protection Behavior	Altitude	Latitude	Temporal Proximity to Noon[2]	Deviation from Winter Solstice	Cloud Cover[3]	Temperature (°F)	Start Time Deviation from Noon
Sunscreen[a,b,c,d,e]	−0.003	−0.080*	−0.015	0.024	clear 0.533 partly cloudy 0.428 cloudy 0.329*	0.030*	0.009
Sunscreen Lip Balm[b,c,d,e,f]	−0.012	−0.068*	−0.010	−0.007	clear 0.350 partly cloudy 0.314 cloudy 0.249*	−0.026*	−0.014
Apply Sunscreen 30 Minutes Prior to Starting Skiing/boarding[a,c,d,e]	−0.040	0.0004	−0.007	0.029	clear 0.694 partly cloudy 0.709 cloudy 0.797*	−0.043*	−0.033*
Reapply sunscreen after 2 hours[4,d]	−0.0348	0.006	0.055*	−0.011	clear 0.258 partly cloudy 0.123 cloudy 0.0780*	0.036	0.00002
Goggles/Sunglasses[d,f,g]	−0.008	−0.016	−0.003	0.020	clear 0.909 partly cloudy 0.917 cloudy 0.906	−0.005	−0.003

Sun Protection Behavior	Altitude	Latitude	Temporal Proximity to Noon[2]	Deviation from Winter Solstice	Cloud Cover[3]	Temperature (°F)	Start Time Deviation from Noon
Head Cover[g]	0.059*	0.070*	−0.012	−0.012	clear 0.865 partly cloudy 0.930 cloudy 0.942*	−0.039*	0.005
Brim on Head Cover[a,c,d,h]	−0.056*	−0.061*	0.005	0.016	clear 0.144 partly cloudy 0.174 cloudy 0.193	0.054*	−0.001
Ears Covered[c,d,g,h]	0.106*	0.136*	−0.003	0.001	clear 0.822 partly cloudy 0.825 cloudy 0.892*	−0.024*	0.019*
Neck Covered[a,c,d]	−0.041	−0.034	0.011	−0.026	clear 0.466 partly cloudy 0.521 cloudy 0.617*	−0.034*	0.027*
Face Covered[c,d,e]	−0.007	−0.045	−0.018*	0.018	clear 0.030 partly cloudy 0.100 cloudy 0.202*	−0.040*	0.009
Gloves[e]	−0.013	−0.006	−0.004	−0.002	clear 0.948 partly cloudy 0.958 cloudy 0.963	−0.0001	0.005

Sun Protection Behavior	Altitude	Latitude	Temporal Proximity to Noon[2]	Deviation from Winter Solstice	Cloud Cover[3]	Temperature (°F)	Start Time Deviation from Noon
Overall Sun Protection[a,b,c,d,e,f,h]	−0.021	−0.17	−0.055[*]	0.015	clear 4.002 partly cloudy 4.088 cloudy 4.140	−0.077[*]	0.042

[*] p<.05

[1] All predictors, except cloud cover, were standardized N(0,1) prior to analysis. Standardized regression coefficients are reported for all predictors, except cloud cover for which least-square means are reported by category. Results adjusted for age (a), education (b), gender (c), skin sun-sensitivity (d), local vs. destination guest (e), ability level (f), days skied/snowboarded this season (g), and equipment (h).

[2] Low numbers meant closer proximity to noon.

[3] Cloud cover coded as 1=clear sky, 2=partly cloudy, 3=cloudy.

[4] Those who were interviewed within 2 hours of first applying sunscreen were removed from analysis.