Solar UV Forecasts: A Randomized Trial Assessing Their Impact on Adults' Sun-Protection Behavior

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This study examined the effectiveness of solar UV forecasts and supporting communications in assisting adults to protect themselves from excessive weekend sun exposure. The study was conducted in Australia, where 557 adult participants with workplace e-mail and Internet access were randomly allocated to one of three weather forecast conditions: standard forecast (no UV), standard forecast + UV, standard forecast + UV + sun-protection messages. From late spring through summer and early autumn, they were e-mailed weekend weather forecasts late in the working week. Each Monday they were e-mailed a prompt to complete a Web-based questionnaire to report sun-related behavior and any sunburn experienced during the previous weekend. There were no significant differences between weather forecast conditions in reported hat use, sunscreen use, sun avoidance, or sunburn. Results indicate that provision of solar-UV forecasts in weather forecasts did not promote markedly enhanced personal sun-protection practices among the adults surveyed.

Keywords: *UV forecasts; skin cancer prevention; sun protection; intervention*

Australia has extreme levels of solar ultraviolet radiation because of its location in the middle and low latitudes of the Southern Hemisphere and its relatively clean and cloudless skies (Lemus-Deschamps, Rikus, & Gies, 1999). The overall incidence of

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skin cancer in Australia is higher than for all other forms of cancer combined (Staples, Marks, & Giles, 1998), and it is increasing (Marks & McCarthy, 1990; Marks, Staples, & Giles, 1993). The high incidence of health problems caused by sun exposure in this country is attributed to extreme solar ultraviolet radiation (UVR), a predominantly fair-skinned population, and an outdoor lifestyle that results in high personal sun exposure.

Protective behaviors can moderate people's exposure to solar ultraviolet radiation and potentially their risk of skin cancer, such as wearing protective clothing, hats, sunscreen, and sunglasses, using shade, or remaining indoors when ambient UVR levels are high (Hill, Boulter, & Dixon, 1998; Hill et al., 1992). Reducing people's exposure to solar UVR is likely to significantly decrease health care costs by reducing UV-induced diseases and to save lives (Carter, Marks, & Hill, 1999; International Commission on Non-Ionising Radiation Protection, 1995). There is now evidence of a reduction in basal cell carcinoma incidence in younger cohorts (Staples et al., 1998), which may be attributed to comprehensive public health programs on sun protection (Borland, Hill, & Noy, 1990) and the behavior change associated with them (Hill, White, Marks, & Borland, 1993).

Solar UV forecasts are potentially useful cues for warning people about the degree of harmful ultraviolet radiation that could exist on a particular day (Roy & Gies, 1997). These forecasts are presented using the UV Index (UVI), which is an internationally standardized index for reporting intensity of biologically effective solar ultraviolet radiation. The UVI was devised by the World Health Organization, World Meteorological Organization, United Nations Environment Program, and the International Commission on Non-Ionizing Radiation (World Meteorological Organization Global Atmosphere Watch, 1998). In Australia, UVI reports for the previous day have been produced by the Australian Radiation Protection and Nuclear Safety Agency since the early 1990s. The Australian Bureau of Meteorology has produced UV forecasts for the next day since 1996. The UV forecast predicts the amount of UV radiation that will reach the Earth's surface at local noon on the next day; it includes a clear sky value and an adjusted value accounting for the effects of expected cloud cover for that day (Lemus-Deschamps et al., 1999). Usually, the forecast UVI value and a corresponding danger category are presented. For example: UVI = 11, extreme. At the time this study was conducted, the qualitative danger categories used were *moderate* for values less than 3, *high* for values between 3 and 6, *very high* for values between 7 and 9, and *extreme* for values of 10 and higher.[1]

To date, there has been no widespread public education in Australia concerning the applicability of the UVI to promoting appropriate sun protection. Dissemination of the UVI varies with season, and if the UVI is included in news media weather bulletins, it tends to be presented as secondary information alongside other weather information and without reference to human skin damage or sun protection. Cross-sectional surveys in several Australian states indicate that the majority of adults have seen or heard UVI reports or forecasts, yet a minority said that they used the UVI in determining their sun-protection behavior (Alberink, Valery, Russell, & Green, 2000; Kricker & Armstrong, 1998; White, Hill, Borland, & Dobbinson, 1997). A U.S. survey conducted in a context in which there was fairly widespread media coverage of the UVI also found that although more than half of the respondents had heard of the UVI, a minority (38%) stated that they or their family changed their sun-protection practices as a result of the UVI (Geller et al., 1997). It is unclear whether this gap between awareness and behavior is because of infrequent and inconsistent media dissemination of the UVI, lack of variability (and thus lack of interest) in UV values during the summer, lack of understanding of what the UVI represents, or because the UVI does not serve as a prompt for sun-protective behavior.

The UVI is a potentially useful and cost-effective tool for promoting sun protection in Australia, yet its utility in this regard has not undergone any rigorous evaluation. At the time this study was conducted, the only behavioral data available on the subject came from cross-sectional surveys. The need for additional research on communication and evaluation of the UVI was recognized at an international meeting of experts on the standardization of UV indices in 1998 and was further highlighted at a national workshop of health, meteorology, and radiation experts held in Melbourne in 1999 (Dixon, & Armstrong, 1999). From an epidemiological standpoint, the greatest benefit of using UVI forecasts is likely to be obtained by targeting recreational sun exposure (Armstrong & Kricker, 1998). Therefore, in this study, we focused on evaluating the impact of UV forecasts on a sample of adults' recreational sun exposure during weekends. Because it was essential to use a method of disseminating the forecasts to participants in a timely manner, the Internet and e-mail were selected as communication channels because of their capacity to reach an audience efficiently, for the ease with which information could be updated, and to enable the use of Internet surveys to monitor responses to the intervention.

The present study sought to systematically evaluate the impact of UV forecasts on a sample of Australian adults' sun-protection behavior using a randomized-controlled trial during 18 weeks from late spring through summer to early autumn. Based on previous meta-analysis on the use of fear appeals in public health campaigns (Witte & Allen, 2000), it might be expected that a weather forecast highlighting the risk of exposure to skin-damaging UV rays would serve as a persuasive fear appeal that would promote adaptive danger control actions (i.e., carrying out personal sun protection). Such a message should be more encouraging of sun protection than a standard weather forecast that does not mention solar UV risk. Furthermore, if such messages were accompanied by high efficacy messages concerning sun-protective behavior, then this should promote even greater adaptive behavior change. We tested the hypothesis that the inclusion of solar UV forecasts in weather forecasts would enhance sun-protective behavior and assessed whether additional behavior prompts directly referring to sun protection would further enhance sun-protective behavior. A secondary aim was to monitor the utility of e-mail and the Internet as media for health education and research. To our knowledge, this is the first study to experimentally evaluate the effect of UV forecasts on the sun-protection behavior of people living in a high-risk solar UV environment.

METHOD

Design

Study participants were adult employees with weekday access to e-mail and the Internet. After enrolling in the study, participants were randomly allocated to one of three weather information conditions: (a) standard weather forecast, no UV forecast; (b) standard weather forecast + UV forecast and definition; and (c) standard weather forecast + UV forecast and definition + protective recommendations (a range of recommendations were evaluated). Weather forecasts were e-mailed to participants at the end of the working week as a prompt for their sun-related activity over the weekend ahead. On Mondays, participants were prompted by e-mail to complete a Web-based survey about their sun-related behavior during the previous weekend. The study ran from November to March (late spring to early autumn) with a 2-week break during the

Table 1. Demographic Profile of Participants in Each Condition

Characteristic	No UVI (*n* = 184)	UVI (*n* = 183)	UVI + SPB (*n* = 190)	Total (*N* = 557)	
Age (years)					
<25	17%	14%	8%	13%	$\chi^2(8) = 10.63$,
25-29	26%	25%	31%	27%	$p = .223$, *ns*
30-39	28%	33%	32%	31%	
40-49	19%	18%	16%	18%	
≥50	10%	11%	13%	11%	
Gender					
Male	36%	33%	32%	34%	$\chi^2(2) = 0.72$,
Female	64%	67%	68%	66%	$p = .700$, *ns*
Education					
Secondary/technical	23%	22%	25%	23%	$\chi^2(2) = 0.56$,
University/college	77%	78%	75%	77%	$p = .756$, *ns*
Skin type					
Just burn, not tan	30%	30%	23%	28%	$\chi^2(4) = 4.46$,
Burn, then tan	60%	61%	63%	61%	$p = .348$, *ns*[a]
Not burn, just tan	10%	7%	14%	10%	
Nothing happens, born with dark skin	0%	2%	0%	1%	

NOTE: UVI = UV Index; SPB = sun-protection behavior.
a. Chi-square test performed with upper two categories combined, to achieve adequate cell size.
ns, $p > .05$.

Christmas–New Year period—18 weeks in total. Participants' introduction to the intervention was staggered over 4 weeks, so as to achieve a range of different weather conditions under which participants completed their preintervention survey on sun protection. One quarter of the participants in each condition started in Week 1, one quarter in Week 2, one quarter in Week 3, and one quarter in Week 4.

Participants

Approval to conduct the study was obtained from The Cancer Council Victoria's Human Research Ethics Committee. Staff of three Melbourne-based consulting firms and one university were invited to participate in a study in an explanatory e-mail message authorized by their management. Participants were staff with e-mail and Internet access from the host organizations who voluntarily enrolled in the study. The study sample comprised 557 participants who submitted baseline data and at least 1 week of Monday survey data. Participants were randomly allocated to intervention conditions, resulting in a comparable participant profile across conditions (see Table 1). A range of age groups was represented, two thirds (66%) of the participants were female, most (77%) had a university or college degree, and most (89%) had a skin type susceptible to sunburn.

Materials and Procedure

Consent Form. In each host organization, an article outlining the upcoming study was included in staff newsletters. Employees in the host organizations who had staff e-mail accounts were also e-mailed a more detailed explanatory letter outlining the procedures involved in the study and directing them to a Web-based consent form. Respondents indicated their willingness to participate in the study by submitting a completed consent form via the Internet.

Baseline Questionnaire. Staff who agreed to participate in the study were e-mailed a message notifying them of their identification number (to use in their follow-up surveys) and listing a hyperlink directing them to an Internet page where the baseline questionnaire was set up. The baseline questionnaire assessed demographic characteristics, outdoor recreations, weather usage, and sun-related beliefs, attitudes, and behavior. Participants self-completed the questionnaire online and submitted it when complete. Participants who failed to submit the baseline questionnaire within a week of the initial prompt were sent a reminder e-mail.

Weekly Weather Forecasts. When participants enrolled in the study, they were randomly allocated to one of the three intervention conditions. Table 2 lists sample forecasts for each condition. The first condition served as a control condition, and the second as an enhanced weather information condition highlighting the level of threat of exposure to solar UV radiation. The third condition highlighted the personal relevance of the weather information provided and suggested efficacious strategies for averting the risk of excessive sun exposure. An issue with repeated prompts of the same type of message is that people might lose interest. For the third condition (UV forecasts plus behavioral prompts), we wanted to emphasize the personal relevance of the weather forecasts, provide enabling suggestions for preventive action, and vary the messages to maintain participants' interest. Each week we included messages relevant to the weather expected for the coming weekend. For example, if there was a cloudy weekend scheduled, the sun-protection message might mention that solar UV levels can still be strong on days with scattered cloud.

On Thursday evenings, all participants were e-mailed a weather forecast for the weekend ahead. This procedure was designed to ensure that participants would receive the forecast by Friday morning to guide their sun-related behavior over the weekend. The Bureau of Meteorology Research Centre provided weather forecasts (http://www.bom.gov.au) and UV forecasts. The procedures for this study necessitated providing UV forecasts for 3 days ahead. The cloud-adjusted UV forecasts were prepared by obtaining the cloud forecasts for Friday, Saturday, and Sunday, and then multiplying the clear-sky UV value by the relevant cloud correction factor.[2] The cloud correction factor is a function of the total cloud cover expected (Lemus-Deschamps et al., 1999). The types of cloud condition and their corresponding factors are clear sky and scattered clouds (1.0), broken clouds (0.7), overcast (0.4), and extremely overcast (0.2).

Monday Questionnaire. The week before participants commenced receiving their e-mailed weekly weather forecasts, they were prompted by e-mail to complete a "pre-intervention" Monday questionnaire. Once the intervention commenced, respondents were prompted by e-mail each Monday morning to complete the same Monday questionnaire to report sun-related behavior and any sunburn experienced during the previous weekend. The e-mail prompts reminded participants of their ID number and listed the hyperlink to the Monday questionnaire. Participants filled out and submitted the Monday questionnaire online. The questionnaire could only be accessed from Monday to Wednesday to exclude delays of more than 3 days in completing it. The Monday questionnaire items assessed weekend activities such as time spent outdoors, sun-protection behavior, clothes coverage, the occurrence of sunburn, and perceived reactions to the forecast for the previous weekend. The questions on reported sunburn and sun-related behavior came from a survey instrument used in monitoring sun-related behavior in Australia since 1988 (Hill et al., 1993).

Table 2. Sample Forecasts for Each Weather Information Condition

Condition	Sample Forecast
Standard forecast, no UV	Dear Helen, The 3-day forecast for Melbourne is as follows: FRIDAY: Fine. Temperature: Minimum 17 degrees, maximum 35 degrees. SATURDAY: Cooler change. Few showers. Temperature: Minimum 21 degrees, maximum 27 degrees. SUNDAY: Fine. Temperature: Minimum 15 degrees, maximum 25 degrees.
Standard forecast + UV	Dear Helen, The 3-day forecast for Melbourne is as follows: FRIDAY: Fine. Temperature: Minimum 17 degrees, maximum 35 degrees. UV Index: *Extreme* (12) decreasing to *very high* (8) under cloud. SATURDAY: Cooler change. Few showers. Temperature: Minimum 21 degrees, maximum 27 degrees. UV Index: *Extreme* (12) decreasing to *high* (4) under cloud. SUNDAY: Fine. Temperature: Minimum 15 degrees, maximum 25 degrees. UV Index: *Extreme* (12) decreasing to very *high* (8) under cloud. **The UV index is a measure of the amount of skin-damaging UV radiation expected to reach the earth's surface at midday, adjusting for expected cloud cover*.
Standard forecast + UV + behavior prompt	Dear Helen, The 3-day forecast for Melbourne is as follows: FRIDAY: Fine. Temperature: Minimum 17 degrees, maximum 35 degrees. UV Index: *Extreme* (12) decreasing to very *high* (8) under cloud. SATURDAY: Cooler change. Few showers. Temperature: Minimum 21 degrees, maximum 27 degrees. UV Index: *Extreme* (12) decreasing to *high* (4) under cloud. SUNDAY: Fine. Temperature: Minimum 15 degrees, maximum 25 degrees. UV Index: *Extreme* (12) decreasing to very *high* (8) under cloud. **The UV index is a measure of the amount of skin-damaging UV radiation expected to reach the earth's surface at midday, adjusting for expected cloud cover.* **Reduce the amount of time you spend outside during the hottest period of the day. Schedule outdoor activities for before 10am or after 3pm during the hotter months.*

Use of E-Mail and the Internet. The method of e-mail dissemination and Web survey mechanism were piloted extensively prior to the main study. During the main study, the e-mail application was monitored for "error" or "unsuccessful delivery" messages to check that the e-mail forecasts and e-mail prompts directing participants to complete questionnaires were successfully disseminated. Response rates for the weekly surveys were also monitored to help verify that the e-mail prompts had reached participants and encouraged them to fill out the Web surveys.

Data Analysis

Data were downloaded directly from the questionnaires completed via the Internet page. The data were formatted so as to be readable to the statistical analysis package, Stata. The focus of the data analysis was on assessing whether there were any differences in sun-related behavior and the occurrence of sunburn between participants in the different weather-forecast information conditions. Stata's "svytab" survey command was used to account for clustering in responses because of repeated monitoring of the same group of participants. This method of analysis computes appropriate adjustments for multiple responses from the same individual. The results reported are the distribution of responses for the pooled repeated measures data for participants in each forecast condition. The design-based F test was used to assess whether the forecasts had a significant impact once possible correlations between responses from the same individual were taken into account.

Manipulation Check

In addition to the main study assessing behavioral responses to ongoing exposure to forecast communications, a manipulation check assessing short-term reactions to a sample forecast communication was performed among a convenience sample of 20 office workers. Participants were randomly assigned one of the three forecast communications presented in Table 2. A trained interviewer presented each participant with a show card displaying the communication, then concealed the show card and presented him or her with a series of statements asking him or her to indicate his or her level or agreement or disagreement (response options ranged from 1 = *strongly disagree* to 5 = *strongly agree*). The constructs under investigation and the items used to assess them were as follows: perceived risk (i.e., "The weather forecast emphasized the risks associated with sun exposure."), perceived susceptibility (i.e., "In summer in Melbourne, I am at personal risk of skin damage from the sun."), perceived severity (i.e., "Exposing your skin to the summer sun is harmful."), perceived self-efficacy (i.e., "I am able to take actions to protect my skin from sun damage."), and perceived response efficacy (i.e., "Avoiding excessive sun exposure reduces your risk of skin damage."). One-way ANOVAs were used to compare mean scores on each of these items as a function of the three message conditions. A multiple response item assessed participant's recall of the message content: "Which of the following things did the weather forecast contain?" The following were response options: predicted temperatures, predicted UV levels, suggestion for reducing sun exposure, and social events around Melbourne. Chi-square tests were performed comparing responses as a function of message condition.

RESULTS

Manipulation Check

Table 3 presents the distribution of responses for the items assessing short-term reactions to a sample forecast message among a convenience sample of 20 participants. Recall of the message content was strongly consistent with the intended manipulation.

Table 3. Summary of Responses to Manipulation Check Items as a Function of Forecast Condition

	No UVI (n = 7)		UVI (n = 7)		UVI + SPB (n = 7)		Overall (N = 21)		
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	
Perceptions									
Perceived risk	1.57	1.13	3.71	0.95	4.00	0.58	3.10	1.41	$F(2,18) = 14.66$, $p < .001$***
Perceived susceptibility	4.29	0.95	4.57	0.54	4.86	0.38	4.57	0.68	$F(2,18) = 1.29$, $p = .301$, *ns*
Perceived severity	4.43	1.51	4.71	0.49	4.43	0.54	4.52	0.93	$F(2,18) = 0.20$, $p = .818$, *ns*
Perceived self-efficacy	4.29	1.50	4.71	0.49	5.00	0.00	4.67	0.91	$F(2,18) = 1.10$, $p = .36$, *ns*
Perceived response efficacy	4.29	1.50	4.57	0.54	4.71	0.49	4.52	0.93	$F(2,18) = 0.36$, $p = .70$, *ns*
Content recall	*n*	%	*n*	%	*n*	%			
Predicted temperatures	7	100%	7	100%	7	100%			NA
Predicted UV levels	0	0%	7	100%	6	86%			$\chi^2(2) = 17.37$, $p < .001$***
Suggestion for reducing sun exposure	0	0%	1	14%	5	71%			$\chi^2(2) = 9.8$, $p < .01$*

NOTE: UVI = UV Index; SPB = sun-protection behavior.
ns, $p > .05$. *$p < .05$. ***$p < .001$.

There was also some evidence of short-term impact on perceptions. Those who received forecasts that included the UVI or UVI plus behavior prompt (UVI + SPB) reported significantly higher perceived risk than those who did not (Tukey's HSD: $p = .001$ and $p < .001$, respectively); the latter two conditions did not differ significantly on perceived risk (Tukey's HSD: $p = 0.831$). There were no significant main effects of message condition on the other perceptions assessed. However, nonsignificant trends suggested that perceptions of susceptibility, self-efficacy, and response efficacy were highest for the UVI + SPB condition, followed by the UVI condition compared to the temperature only condition. The lack of statistically significant effect for these items is probably partly because of the lack of statistical power owing to the small sample used for the manipulation check. There was no such trend for perceived severity.

Weekend Weather During the Main Study Period

Weekend weather data for the period of the randomized trial were examined. For Saturdays, the mean maximum temperature was 26° Celsius (*SD* = 5°), and for Sundays, the mean maximum temperature was 24° (*SD* = 4°). The forecast maximum temperatures for Saturdays were significantly positively correlated with the measured maximum Saturday temperatures ($r = .75$, $p = .001$). However, the forecast maximum temperatures for Sundays were less accurate ($r = .47$, $p = .057$) owing to the longer lead time in generating more advanced forecasts. During the study period, maximum daily UVI scores ranged between 3 (*high*) and 11 (*extreme*), averaging 9 (*very high*). Thirty-two out of 34 (94%) of the cloud-adjusted forecasts for Saturdays and Sundays were within one category of the measured solar UV category at noon for that day.

Table 4. Self-Reported Responses to Forecasts as a Function of Forecast Condition for the Pooled Repeated Measures Data

Item	Responses	No UVI (%)	UVI (%)	UVI + SPB (%)	
Reported sun protection precautions in response to forecast	More	19	23	25	$F(3.56,1633.94) = 3.01$, $p = .022$*
	Less	7	4	3	*No. of obs.* = 2,376,
	No effect	74	73	72	*PSUs* = 460
For those who took more precautions, the aspect of the forecast that influenced their sun protection was:	Fine/sunny	20	10	5	$F(5.56,1307.25) = 28.58$, $p < .0001$***
	Temperature	75	17	16	*No. of obs.* = 586,
	Temperature & UV	1	10	15	*PSUs* = 236
	UV	4	63	64	

NOTE: Obs. = observations; PSUs = number of person standardized units; UVI = UV Index; SPB = sun-protection behavior.
*$p < .05$. ***$p < .001$.

Response Rates

Based on estimates of staff numbers provided by the host organizations, more than 90% of staff had e-mail and Internet access, making them eligible for the study. Of those invited to participate, approximately 10% enrolled in the randomized-controlled trial. Owing to the staggered introduction to the study, the maximum number of weeks for which participants could have submitted Monday survey data ranged between 15 and 18. The median number of Monday surveys submitted per participant was 13.00 ($M = 11.68$, $SD = 4.73$). On average, 70% of participants submitted their questionnaire each week. Most weeks, more than 80% of respondents submitted their Monday surveys on Monday. The remainder submitted it on either Tuesday or Wednesday. The prompt response indicates that participants were recalling their weekend sun-related behavior close to when it occurred.

Self-Reported Response to the Forecasts

Table 4 lists responses to the question, "Did the forecast lead you to take more or less precautions to protect yourself from the sun when you were outdoors?" Participants who received forecasts that did not include predicted UV were less likely to report that the forecasts had led them to protect themselves more (19%) than respondents in the conditions in which predicted UV (23%) or predicted UV plus behavioral prompts (25%) were included in the forecasts. The direction of the trend in the results suggests that increasing amounts of information in the forecasts were associated with a tendency to report relatively more sun protection in response to the forecasts.

Respondents who reported carrying out precautions in response to the forecasts were asked to complete the following open-ended question: "Which information from the forecast influenced your level of sun protection?" Among those participants who said they took more precautions in response to the forecast, common responses to this item were examined as a function of intervention condition. The results indicate that participants who received UV forecasts were more likely to use forecast UV than forecast temperature to guide their behavior, whereas those who did not receive UV forecasts were more likely to report relying on forecast temperature to guide them.

Each week, all respondents who reported having read their weekly forecast were asked, "Overall, which of the following factors was most important in determining whether or not you carried out sun protection over the weekend?" The distribution of responses for the pooled data indicated that the most important factors were weather (59%), followed by personal habits (34%) with a minority listing forecast (7%). The distribution of responses did not differ significantly between forecast conditions, $F(3.62,1899.38) = 1.74$, $p = 0.14$.

Sun-Protection Behavior

In each Monday survey, respondents who had been in Victoria (the geographic region to which the forecasts applied) and spent time outdoors between 11 a.m. and 3 p.m. on either Saturday or Sunday were required to describe sun protection undertaken that day. Table 5 presents the distribution of reported sun-protection behavior for the pooled responses from participants in each condition. For each behavioral measure, the table lists the design-based *F* statistic testing for effects of weather information condition, taking into account the repeated measures design. Although the trend for choosing to stay out of the sun suggests that sun avoidance may be positively associated with the level of information contained in the forecast, the design-based tests of association indicated that there were no significant differences between conditions for this behavior. There were also no significant differences in participants' weekend hat use, torso cover, or sunscreen use as a function of weather information condition. For lower body cover on Saturday, there was a significant effect for forecast condition indicating higher levels of lower body cover for the UVI only group, compared with both the no UVI and the UVI plus sun protection behavior prompt conditions. A similar, though nonsignificant, trend was evident for Sundays.

Sunburn

Each Monday, participants were required to report whether they got at all sunburned on Saturday or Sunday. Table 6 presents the distribution of reported weekend sunburn for the pooled responses from participants in each condition. There were no significant differences in sunburn rates for participants in the different weather information conditions.

DISCUSSION

Responses to the Forecasts

We monitored a sample of Australian adults' weekend sun exposure and sun-protective behavior during spring, summer, and early autumn to determine their reactions to different types of weather forecasts. The results indicate that the provision of solar UV forecasts (risk messages) and supporting communications (efficacy messages) did not promote markedly improved sun-protection behavior among participants. Although

Table 5. Reported Sun-Protection Behaviors (SPB) as a Function of Forecast Condition for the Pooled Repeated Measures Data

Behavior	Responses	No UVI (%)	UVI (%)	UVI + SPB (%)	
Choose to stay out of the sun (Saturdays)	Yes	34	37	40	$F(1.99,1024.87) = 1.60$, $p = .202$, *ns*
	No	66	63	60	
Choose to stay out of the sun (Sundays)	Yes	35	37	40	$F(2.00,1010.19) = 1.08$, $p = .341$, *ns*
	No	64	63	60	
Hat use (Saturdays)	No hat	72	71	69	$F(5.64,2878.36) = 1.60$, $p = .149$, *ns*
	Peaked cap	14	14	18	
	Narrow brim	7	5	7	
	Wide brim	7	10	6	
Hat use (Sundays)	No hat	66	66	66	$F(5.72,2894.07) = 1.19$, $p = .307$, *ns*
	Peaked cap	17	18	17	
	Narrow brim	9	5	8	
	Wide brim	8	11	9	
Torso cover (Saturdays)	Nothing	4	3	3	$F(5.63,2884.54) = 0.80$, $p = .563$, *ns*
	Sleeveless	14	13	12	
	Short sleeves	57	56	61	
	Long sleeves	25	28	24	
Torso cover (Sundays)	Nothing	4	3	3	$F(5.64,2859.73) = 0.60$, $p = .724$, *ns*
	Sleeveless	14	13	14	
	Short sleeves	58	56	59	
	Long sleeves	25	28	24	
Lower body cover (Saturdays)	Bare legs	3	1	2	$F(5.59,2862.96) = 2.65$, $p = .017$*
	Shorts	21	16	16	
	Midlength	25	25	32	
	Full length	51	58	50	
Lower body cover (Sundays)	Bare legs	3	2	3	$F(5.67,2875.28) = 2.10$, $p = .054$, *ns*
	Shorts	19	19	17	
	Midlength	27	24	32	
	Full length	50	55	48	
Sunscreen use (Saturdays)	No	58	58	59	$F(2.00,1027.60) = .01$, $p = .988$, *ns*
	Yes	42	42	41	
Sunscreen use (Sundays)	No	57	54	57	$F(2.00,1010.18) = 0.29$, $p = .750$, *ns*
	Yes	43	46	43	

NOTE: UVI = UV Index.
ns, $p > .05$. *$p < .05$.

their self-reflections indicated that those who received UV forecasts—and especially UV forecasts accompanied by sun-protection prompts—were slightly more likely to report taking "precautions" in response to the forecasts, the more specific behavioral measures (i.e., choosing to stay out of the sun, hat wearing, and sunscreen use) and the more epidemiologically relevant indicator of sun exposure (reported sunburn) did not show significant evidence of a positive impact of the additional weather forecast information provided. The findings of the manipulation check for the study indicated that exposure to a single forecast presenting UV information increased participants' perceived risk of skin damage, with a similar effect when the efficacy messages were also included.

Table 6. Self-Reported Sunburn as a Function of Forecast Condition for the Pooled Repeated Measures Data

	Responses	No UVI (%)	UVI (%)	UVI + SPB (%)	
Sunburn (Saturdays)?	No	90	90	91	$F(1.97,1010.63) = 0.30$,
	Yes	10	10%	9	$p = .741$, *ns*
Sunburn (Sundays)?	No	86	86	86	$F(1.99,1009.37) = 0.03$,
	Yes	14	14	14	$p = .966$, *ns*

NOTE: UVI = UV Index; SPB = sun-protection behavior.
ns, $p > .05$.

However, the results for the main study indicate that even if the provision of UV forecasts led to some changes in perceptions, repeated exposure to them was insufficient to promote marked behavioral change. The findings from our experimental study parallel those of earlier cross-sectional surveys conducted in Australia that indicate that awareness of the UVI was not necessarily associated with enhanced sun-protection behavior (Alberink et al., 2000; Kricker & Armstrong, 1998; White et al., 1997). They are also consistent with the findings of a recent randomized-controlled trial conducted in Sweden, which found that provision of an information brochure about the UVI or a personal UVR-intensity indicator did not decrease sunbathing and sunburn more than general, written information about sun protection (Branstrom, Ullen, & Brandberg, 2003). The Swedish study also found that people favored and were more likely to have used the general sun-protection brochure than the UV resources.

Participants' self-reports suggest that, in most cases, judgments about personal sun protection were based on how the weather turned out on the day, followed by personal habits. A minority said that weather forecasts were most important in determining their level of sun protection. Apparently most people base their sun-related behavior on an evaluation of conditions in the setting in which the behavior occurs. In our study, the time interval and contextual difference between receiving the forecast late in the week at work and carrying out sun-related behavior while at leisure on weekends may have meant the cue to action was not sufficiently salient in the circumstances in which sun protection was relevant. People's relative lack of reliance on forecasts in guiding their sun-protection behavior could reflect failure to recall the forecasts in the setting in which they are needed or to perceived inaccuracies of weather forecasts. In the present study, we provided forecasts for 3 days ahead, and the accuracy of the forecasts was better for Saturdays than Sundays, highlighting the decline in accuracy with more distal forecasts. Comparisons between daily clear-sky UV forecasts and clear-sky measured UV across the year in Melbourne indicate fairly good agreement between the measures, although the bias increases in summer (Lemus-Deschamps et al., 1999). Meteorologists also recognize that clouds are the most difficult parameter to include in UV forecast parameters owing to their temporal and spatial variability. When making judgments about sun-protection behavior, people may perceive that a personal evaluation of the weather conditions made at the time and setting they are in is more definitive.

Nonetheless, personal evaluations of the need for sun protection based on observable weather conditions may not always be reliable. Previous research suggests that people often get "caught out" by sunburn on cooler sunny days when the strength of the sun is less obvious. Hill and colleagues (1992) found that compared to temperatures less than 19 degrees Celsius, adults were approximately 3 times more likely to be burnt in temperatures between 19 and 27 degrees, whereas they were only about 60% more likely to suffer sunburn at temperatures greater than 27 degrees. Measured solar UV showed a more linear relationship with sunburn. Because people can feel temperature—but not UV—temperature may serve as a more salient cue for guiding their sun-related behavior when outdoors.

Implications for Practice

In our study, it was hoped that inclusion of UV forecasts in weather forecasts would serve as a form of fear appeal by highlighting the aspect of the weather that places people at risk of skin damage and educate participants that UV levels can be strong on cooler fine days too, thus prompting greater sun-protection behavior across a range of weather conditions. Our results suggest that among those participants who reported carrying out more precautions in response to the forecasts, those who received UV forecasts were more likely to report using this information than forecast temperature to guide their protective practices. The results for the manipulation check also indicated that UV forecasts promoted increased perceived risk of skin damage. However, results for the randomized trial indicated that overall repeated exposure to the UV forecasts (risk messages) and supporting communications on sun-protection behavior (efficacy messages) did not facilitate greater sun-protective behavior or reduced sun exposure. Furthermore, in the randomized-controlled trial conducted in Sweden, dissemination of personal UVR-intensity indicators was no more effective in promoting sun protection than general information about sun protection (Branstrom et al., 2003), suggesting that enabling people to take time- and setting-specific measures of solar UV was not an especially efficacious educational aid. It would be of interest to examine whether mass dissemination of UV forecasts or readings in an outdoor leisure context, where sun protection is of current relevance (e.g., on the scoreboard at an outdoor, summer sports event), would promote enhanced sun-protection behavior in that setting. UV forecasts have been displayed in a beach setting as part of a multicomponent intervention targeting U.S. children, but their unique contribution to promoting sun-protection behavior was not examined (Dietrich et al., 1998).

Participants mentioned habit as an important determinant of sun-protection behavior. Once established, habitual health behaviors (e.g., always wearing a seat belt when traveling in a motor vehicle or nightly tooth brushing) are resistant to change. From a health promotion perspective shaping context-dependent, habitual sun-related behavior may prove most fruitful. The UVI is probably most useful as a complementary tool to other health promotion cues for helping to generate or maintain public awareness of the desirability of habitually carrying out sun protection in peak UV seasons, settings, and times of day.

In conducting this study, we also entertained the possibility that UVI forecasts could be counterproductive. That is to say, people might gain a false sense of security from forecasts that are not at the highest levels when excessive unprotected exposure may still lead to sunburn and skin damage. The UVI categories forecasted for weekends during our study ranged between high and extreme. If people were basing their behavior on the forecasts, the qualitative danger categories should have implied that there was the potential for skin damage on most days. Another concern is that people could use the UVI to deliberately suntan when the sun is strong. Geller et al.'s (1997) cross-sectional survey conducted in the United States suggested that some people use the UVI in this way. A population survey of Canadian adults found high awareness of the UVI was predictive of sunburn, but being a cross-sectional study, the direction of this association cannot be ascertained (Purdue, Marrett, Peters, & Rivers, 2001). In the present study, we did not find any evidence to suggest that the provision of UV forecasts detracted from people's sun-protection behavior or led to greater sun exposure. Our results suggest that there is unlikely to be any harm done by disseminating UV forecasts to the public during peak UV seasons in Australia. However, because there was also no evidence of a strong positive impact of the forecasts on people's sun-protection behavior, significant investment in this as a skin cancer prevention strategy would be unwarranted.

Another issue with the apparent lack of variability in the danger categories for the UVI relative to temperature is that participants may have lost interest in attending to the UV information within the forecasts because they were perceived as relatively unchanging. Anecdotal evidence suggests that this lack of change in UVI values in some seasons may explain why mass media weather bulletins have previously devoted little attention to broadcasting UV forecasts and reports (Branstrom et al., 2003). The high weekly response rates to the surveys throughout the study indicate that people were reading the e-mail forecasts but that the inclusion of UV did not prompt greater sun protection among participants who received it.

Methodological Issues

This study assessed responses to UV forecasts among adults who live in a country where awareness of the need for sun protection was likely to be high at baseline, owing to long-running skin cancer prevention campaigns in this country. It is possible that in a different context, when people had little prior knowledge of the need for sun protection, provision of UV forecasts could produce a different response. Also, a social desirability mind-set could have led participants to present themselves as carrying out greater sun-protection behavior than they did. However, as a considerable proportion of respondents admitted in their survey data that they had engaged in undesirable sun-protection practices (e.g., failing to wear a hat or sunscreen) or had suffered sunburn suggests that people were being honest in their responses. It is also plausible that completing a survey about sun protection every week served as a form of intervention that raised participants' awareness of the issue of sun protection generally. Yet, because the survey procedure was constant across weather information conditions, if the UV forecasts had been particularly motivating, we should still have found an effect of the forecasts beyond mere involvement in the study. Furthermore, the repeated provision of UV forecasts enabled an assessment of their impact in a manner analogous to a "real-world" scenario of UV forecasts being regularly included in news weather bulletins, if this were to occur. It is possible that some participants could have received UV forecasts and information from sources outside the study. However, media coverage of the UVI in weather bulletins broadcast in Melbourne was sparse at the time that this study was conducted, and given that this potential exposure was constant across intervention conditions, it is unlikely to have confounded the experimental comparison. In the final survey, most respondents (96%) indicated that they never compared forecasts with another colleague in the study, suggesting that experimental manipulation was not compromised by cross-contamination.

Use of E-Mail and the Internet

A secondary aim of this study was to obtain evidence on the utility of e-mail and the Internet as vehicles for disseminating health information and gathering survey data. We found that these media were highly efficient for reaching a large audience with timely prompts for health-related behavior. The advantage of using e-mail prompts was that the messages could be varied at short notice. For example, if a high-UV day were forecast for an approaching weekend, a message promoting positive sun-protection practices during leisure activities could be disseminated as a timely and topical prompt.

This study enabled us to determine that conducting an intervention trial using these techniques of information dissemination and data collection is feasible. The main investment required was in the up-front design and setup of the surveys and data-collection mechanisms. Unlike a traditional mail-out survey, there were no printing or postage costs and little delay in messages reaching recipients. There was no cost of one-on-one interviewing or of manual data entry, and participants could readily access and respond to disseminated information in the course of their everyday activities. The response to the initial recruitment offer was rapid. However, the proportion of those approached who agreed to participate in the study was quite low, probably because of the time commitment required in enrolling in a study that was to involve weekly surveys during several months. Nonetheless, among those who did join the study, attrition rates were low. On average, 70% of the people who enrolled in the study submitted their questionnaire each week. We also collected data on the time at which people submitted their surveys. Most people submitted their surveys on Monday, the day they were prompted to. This is pleasing, as it means people were recalling their behavior close to when it was carried out, which should improve accuracy of recall. A further advantage of collecting the data via Web survey was that it enabled us to directly convert the multiple-choice survey data to spreadsheet data without an intermediate stage of manual data entry.

Another positive feature of using e-mail communications was that participants could readily make contact by reply e-mail if they had a query, and the researchers could respond quickly. For example, participants could notify us if they had difficulty accessing the Web-based questionnaire or if they were going to miss a week of data collection or if they wished to withdraw from the study.

The study procedures worked well with this group of participants who were adult, office-based employees. The methods of forecast dissemination and data collection employed necessitated that people with access to computers in the course of their daily work form the participant pool. This method of participant selection was justified on the basis that incidence and mortality rates of melanoma are generally higher among indoor workers than outdoor workers (English, Armstrong, Kricker, & Fleming, 1997). Through conducting the study, we wanted to monitor such people's weekend sun exposure and determine whether even under ideal conditions (i.e., literate participants, high accessibility of forecasts, reminders, salience of sun protection as a personal issue), UV forecasts would assist in promoting sun-protection behavior. If the forecasts did not have a positive effect under these circumstances, their utility in other domains would be called into question.

Researchers considering using such methods should carefully consider the characteristics of their target audience. For example, surveying participants whose computer access is irregular, whose e-mail address is likely to change, or who are not familiar with using e-mail or the Internet could prove less efficient than more traditional methods of contact such as phone or mail-out. Our data coding procedures worked well for multiple-choice items. However, we also allowed for some open-ended responses in our survey. These were time-consuming to code. Our participants were fairly well educated (Australian Bureau of Statistics, 2000), yet they often made typographical or grammatical errors in their text responses. If surveying less literate participants, we would caution against using open-ended question items using this method of data collection.

Conclusions

The purpose of disseminating solar UV forecasts is to develop public awareness of the risks of excessive sun exposure, to put solar radiation exposure risk into perspective, and to promote appropriate skin cancer prevention practices. Our results suggest that disseminating UV forecasts and supporting communications promoting the efficacy of sun protection in weekly weather forecasts for 4 months did not promote enhanced sun protection or reduced sun exposure among a sample of adults in Australia. Similarly, a randomized-controlled trial in Sweden found that a UVI information brochure and personal UVR intensity indicators were not especially effective at promoting sun protection, compared to a general brochure on sun protection. These disappointing results underscore the need to undertake behavioral studies, preferably before investing significantly in interventions presumed to be health promoting.

Notes

1. The World Health Organization has since released internationally standardized recommendations for categorizing the UV Index (World Health Organization, 2002). The Australian Bureau of Meteorology has now adopted the new standard.

2. During summer in Melbourne, the clear-sky UV values fluctuate little from one day to the next (Lemus-Deschamps, Rikus, & Gies, 1999), so it was deemed appropriate to generalize the clear-sky value forecast for Friday to the remainder of the weekend. However, the cloud-adjusted UV values vary daily based on the expected weather outlook.

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