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ORIGINAL RESEARCH

A four-group experiment to improve Western high school students' sun protection behaviors

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Abstract

Multicomponent skin cancer preventive interventions for adolescents that aim to decrease ultraviolet radiation (UVR) exposure and sunburns are particularly needed given their intentional tanning and infrequent use of sun protection. The purpose of this study was to conduct an early-phase study within the Multiphase Optimization Strategy framework that experimentally tested four unique intervention components targeting high school students' skin cancer prevention behaviors. Schools (11 total, $N = 1,573$ students) were assigned to receive one of four interventions: skin cancer education (control), education plus a sunscreen activity (to illustrate sunscreen's UVR-blocking properties), or behavior change worksheet (sun protection goal setting and planning) or receipt of a personalized UV damage photograph (photograph of facial damage). Sun protection, sunburn, and tanning outcomes were assessed before intervention and at 1-month follow-up. Within- and between-intervention changes in outcomes were examined using generalized estimating equation modeling. All interventions were associated with significant improvements in sun protection. The photograph was superior in controlling intentional tanning and sunburn when compared to the behavior change worksheet ($ps < .05$). In contrast, the worksheet was associated with greater increases in sun protection use when compared with the photograph ($ps < .05$). In this experiment testing four skin cancer preventive intervention components that varied in approach, content, and interactivity, the behavior change worksheet was superior in improving sun protection use whereas the UV photograph was superior in controlling intentional tanning and sunburn. Future randomized trials to test combinations of these intervention components are needed, and could identify mechanisms underlying improved effects and demographic or behavioral moderators of intervention effects.

Keywords:

Skin cancer, Prevention, Adolescent, School-based

Implications

Practice: Interactive interventions can be used to improve high school student use of skin cancer prevention behaviors.

Policy: High school settings offer opportunities to assist in early cancer prevention, and these efforts should be more routine components of the school year.

Research: Future studies should employ rigorous study designs to compare the relative effects of different interactive skin cancer prevention programs, the behavioral mechanisms underlying improved effects, and demographic or behavioral moderators of intervention effects.

INTRODUCTION

Prevention of skin cancers, including melanoma, is a major public health priority, given the high costs associated with skin cancer treatment, morbidity, and mortality, and increased incidence over the past decade [1–9]. Non-melanoma skin cancers are estimated to affect more than 3 million people in the USA, and melanoma, the deadliest form of skin cancer, is the fifth most common cancer [8–10]. Prevention of skin cancer is particularly relevant for young populations. Melanoma is one of the most common cancers among young adults [10,11]. Primary prevention of skin cancer should start during the childhood and adolescent years, in order to prevent early life skin damage due to ultraviolet radiation (UVR) and sunburn occurrence that increase risk for skin cancer later in life [12–15].

Adolescents are an especially important group to target in skin cancer preventive interventions because they engage in intentional tanning and do not consistently use recommended sun protection strategies that decrease UVR exposure and decrease risk for developing skin cancer. Approximately 7% of high school students report intentional tanning in the past 12 months, with rates up to 16% among older female high school students [16]. Adolescents also report infrequently implementing recommended sun protection strategies [17,18]. Only 10% of students endorse that they routinely use sunscreen [19]. In addition, rates of protective clothing use (23%), staying in the shade (22%), and wearing a wide-brimmed hat (5%) are low among adolescents [20,21]. Likely due to these low rates of sun protection, more than half of adolescents report

experiencing one or more sunburns in the last 12 months [16]. Interventions to reduce skin cancer risk among adolescents that decrease intentional tanning and sunburn occurrence and increase use of sun protection strategies are therefore greatly needed. In particular, different strategies and modes may be needed for interventions targeting sun protection behaviors versus intentional tanning behaviors.

Schools are an ideal setting in which to deliver skin cancer preventive interventions [1,22]. Almost all children spend a significant portion of their waking hours in school, and schools direct many of the outdoor activities that could affect UVR exposure among youths. The vast majority of school-based interventions for minors have targeted elementary and middle school students [23,24]. However, high school students may have unique intervention needs due to this age group's low use of sun protection and engagement in intentional tanning, as well as their increasing independence from their parents and attention to social norms for tanness and fashion, which could increase interest in tanning and decrease their use of sun protection [16,19–21,24].

Existing interventions for high school students commonly provide educational information delivered via lectures, print materials, or videos on skin cancer risk factors, prevention strategies, and the dangers of intentional tanning [25,26]. Educational interventions can yield significant increases in knowledge and changes in attitudinal factors such as perceived susceptibility to skin cancer, and reported improvements for some forms of sun protection [25,26]. Other school-based interventions for adolescents have included a combination of educational information and activities that reinforce educational concepts presented. For example, interventions have provided feedback on students' UVR-related skin damage, asked students to apply skin cancer prevention knowledge to real-life scenarios, engaged students in activities to demonstrate varying levels of sun protection afforded by different fabrics, and asked students to create drawings or videos to illustrate skin cancer prevention recommendations [27–30]. Intervention outcomes commonly examined include knowledge about skin cancer and prevention strategies, attitudes toward tanning or skin cancer prevention strategies, and intentions to use sun protection or avoid tanning. Most school-based interactive interventions for this age group have not led to significant improvements in use of sun protection or have produced mixed results for sun protection [27,28,31]; however, at least one intervention that used multimedia educational materials and related interactive exercises over six class sessions successfully reduced intentional indoor tanning among high school students [32]. Among older youth populations including college students, interventions that provide personalized UV photographs that display one's UVR-related skin damage have been associated with decreased frequency of reported intentional indoor tanning and improved use of sun protection; however, these interventions have seldom been used with high school students [27,30,33,34].

The goal of the current study was to examine preliminary effects on sun protection, tanning, and sunburn outcomes associated with four brief intervention components for high school students that draw on the Extended Parallel Process Model [35,36]. On the basis of the Extended Parallel Process Model, interventions can communicate health risk and prevention information by targeting one's perceived threat (e.g., susceptibility to skin cancer) and perceived efficacy related to skin cancer prevention (e.g., self-efficacy in carrying about skin cancer prevention strategies, response efficacy). In order to determine which interventions would most efficiently and effectively impact adolescent sun protection and tanning behaviors and for whom, we tested intervention components that varied in their approach, content, and interactivity. Our goal was to identify promising intervention elements that could later be combined as packages and tested in a full-scale randomized controlled trial. This approach is consistent with the optimization phase of the Multiphase Optimization Strategy (MOST) for designing, optimizing, and evaluating behavioral interventions (see Collins et al.[37] for a complete discussion of MOST designs). We tested the interventions in a Western region of the USA that has high incidence rates of melanoma and increased ambient UVR levels due to geographic elevation [38,39]. Drawing on prior findings [27–30,33,34], we hypothesized that sun protection behaviors would increase and tanning behaviors and sunburn occurrence would decrease over time for each intervention component except for the control condition. In addition, we hypothesized that when compared to a control condition, the other intervention components tested would be associated with greater increases in sun protection, greater decreases in intentional tanning, and fewer sunburns.

METHODS

Participants and procedures

Participants (N = 1,573) in grades 9–12 were enrolled from 11 high schools in Utah in March–May 2017. Schools were assigned to one of four conditions: a control group, or one of three experimental groups. Assignment occurred on the school level rather than the classroom level in order to avoid intervention contamination between classrooms within a single school. We allocated schools to conditions so that school-level demographic factors (rural vs. urban location, proportion of student body that was nonwhite in terms of race, proportion of students

receiving free and reduced lunch) were matched to the extent possible across the four conditions.

In terms of recruitment, 85% (11 out of 13) of schools approached agreed to participate in the current study. The intervention was conducted with every student present in the class on the scheduled intervention days. Parents could opt their child out of participating in this study and students were informed that participation was voluntary; however, no students opted out of participating or had a parent who opted them out. All together, 38% of the eligible student body (students in the targeted classes or grades within each school) were included in the current study.

Students were asked to complete study questionnaires during school hours immediately before and after receiving the intervention, and at a follow-up assessment 1-month post-intervention. The outcomes of interest for the current analysis were assessed via questionnaires completed immediately before the intervention and at a 1-month follow-up assessment. All procedures were approved by the appropriate institutional review board and school authorities.

Interventions delivered

Each school received one of four intervention components: control (education only), education plus UV photograph, education plus behavior change worksheet, and education plus sunscreen activity. The interventions were delivered in the classroom, in the context of a single class period, by a team of research assistants. For the majority of participating schools, the interventions were provided during health class, which takes place in 9th or 10th grade in the region. Students attending science classes also participated.

Control

The control condition consisted of a skin cancer education PowerPoint presentation. The presentation included information on skin cancer incidence, risk factors and causes of skin cancer, strategies to prevent and screen for skin cancer, and common misconceptions about skin cancer and prevention strategies. Students had opportunities to ask questions related to the presentation. The educational materials were developed by our multidisciplinary team, which includes behavioral scientists, dermatologists, and health education specialists, and draws from a prior skin cancer prevention educational intervention [40].

UV photograph

In order to target perceived susceptibility to skin cancer, each student received a personalized UV photograph that showed their current facial UV skin damage caused by UVR exposure. Students were photographed using a UV camera system (VISIA, version 4.0c, Facial Complexion Analysis System, Canfield Scientific, Inc) [41]. Photos were taken at the far spectrum of UVA (long-wave UV, 365 nm). Students were each provided with a printed copy of their UV photo. Research assistants led the class in a discussion about how these photos related to UVR-related damage and skin cancer risk, and answered any questions raised. Students also viewed the educational presentation from the control condition.

Behavior change worksheet

The behavior change worksheet aimed to increase self-efficacy for carrying out skin cancer prevention strategies and used an implementation intention setting framework, which draws on self-regulation and motivation theories. Implementation intention setting interventions have been successfully used in a number of health behavior change interventions [42,43]. Students were asked to complete a worksheet that guided them through creation of a plan around their use of a sun protection behavior. Students first selected a sun protection behavior they were willing to commit to implementing in the next month. Then, they were asked to describe when and where they would use this sun protection strategy, and the steps they would take to implement that sun protection strategy. Students also viewed the educational presentation from the control condition.

Sunscreen activity

In order to increase perceived response efficacy of skin cancer prevention strategies, students participated in an experiential learning activity focused on sunscreen. In groups of 3–4 students, students used a UV-generating flashlight and UV sensor to test and record the amount of UVR detected when the light was blocked by sunscreens of differing sun protection factor levels (4, 30, 50, and 70). After performing this experiment, research assistants led the class in a discussion about their findings and the implications of the findings for sun protection. Students also viewed the educational presentation from the control condition.

Measures

Sun protection and tanning behavior outcomes

Both pre- and post-intervention (at 1-month follow-up) students were asked how often in the past month they engaged in sun protection and tanning behaviors on a Likert-type scale from 1 (never) to 5 (always). Sun protection behaviors assessed were sunscreen application and reapplication, wearing a long-sleeved shirt, long pants or long skirt, wearing wide-brimmed hat, using shade when outdoors, and avoiding peak UVR exposure hours (10 am–4 pm). Students were also asked about frequency of intentional outdoor tanning and indoor tanning. These items were based on and adapted from the Sun Habits Survey [44].

Sunburn occurrence

Pre-intervention, students were asked to report on sunburns (red or painful and lasted a day or more) they had sustained in the past 12 months. At both pre- and post-intervention, they were also asked to report on sunburns that had occurred in the past month.

Demographic characteristics

Immediately after receiving the intervention, students were asked their age, grade, gender, race and ethnicity, family history of skin cancer, and skin type using the Fitzpatrick scale [45].

Analytic plan

Descriptive statistics were calculated for all variables of interest, including demographic characteristics, sun protection and tanning behaviors, and sunburn occurrence. Chi-square tests were used to identify differences in demographic characteristics between intervention conditions. Key sociodemographic variables (student gender, race, grade, family history of skin cancer: yes or no, geographic location: rural or urban) were adjusted for in all models that compared the interventions, to account for demographic differences between students attending different schools. Consistent with analytic strategies for clustered data from school-based interventions whereby students were exposed to discrete behavioral interventions [46,47], generalized estimating equation (GEE) modeling was performed in R [48] to examine within- and between-intervention changes in outcomes over time. First, to examine within-intervention changes over time, GEE models were constructed to examine changes in sun protection, risk behavior, and sunburn outcomes pre-intervention to 1-month follow-up for each condition while accounting for within-school clustering. Second, to examine between-intervention changes, GEE models were constructed to compare changes in sun protection, tanning, and sunburn outcomes pre-intervention to 1-month follow-up between conditions while accounting for within-school clustering, adjusted for gender, race, grade, family history of skin cancer, and whether the participant lived in a rural or urban area [49–52], which could influence the outcomes of interest. In order to inform development of future interventions, we also explored the nature of the associations between adjustment factors (student gender, race, grade, family history of skin cancer, rural or urban) and interactions between adjustment factors with study outcomes.

RESULTS

Overall sample characteristics pre-intervention

In total, 1,573 high school students participated. As shown in Table 1, half (50.0%) of participants were male and 62.5% were non-Hispanic white. The majority of participants (78.5%) were in the 9th or 10th grade. Almost one third of participants (29.8%) reported a family history of skin cancer. At the pre-intervention assessment, the most frequently reported form of sun protection was wearing long pants or a long skirt, endorsed by 58% of students. Other recommended forms of sun protection including use of sunscreen and other forms of protective clothing were used more infrequently, with only 10%–28% of students reporting that they regularly used these sun protection strategies. Reapplication of sunscreen was rarely endorsed (8%). Although only 2% of students reported indoor tanning in the past month, 17% reported intentional outdoor tanning. The vast majority (69%) of students experienced one or more sunburns in the past 12 months (Table 2). Of those who experienced one or more sunburn in the past 12 months, 25% (n = 255) reported sustaining one or more sunburn in the past month alone.

Pre- to post-intervention changes in sun protection, tanning, and sunburn outcomes by condition

In order to examine changes in sun protection, risk behavior, and sunburn outcomes between the pre-intervention assessment and the 1-month post-intervention follow-up assessment for each of the four intervention components, unadjusted GEE models were constructed (Table 3). Statistically significant improvements in almost all sun protection behaviors were observed for all interventions (ps < .05). These increases were most often improvements from "rarely" using a sun protection behavior pre-intervention to "sometimes" using the sun protection behavior post-intervention (Table 3). Tanning behaviors (outdoor intentional tanning, indoor intentional tanning) and sunburn occurrence increased over time for all four interventions (ps < .05).

Comparing pre- to post-intervention changes in outcomes between conditions

In order to understand which interventions yielded the greatest changes in outcomes, we next conducted pairwise comparisons to examine pre- to post-intervention changes in sun protection, intentional tanning, and sunburn occurrence between interventions, after adjusting for demographic factors (See Table 4) [49–52]. Figure 1 displays pre- to post-intervention levels of four outcomes (sunscreen, long-sleeved shirt wearing, avoiding peak UVR hours, and indoor tanning) by intervention. The behavior change worksheet was associated with greater increases in frequency of use of all sun protection strategies except wearing long pants or skirts when compared with the UVR photograph. Specifically, increases in reported sun protection were 0.79–1.31 greater among students receiving the behavior change worksheet than

Table 1| Sample demographic characteristics ($N = 1,573$)

	Education only ($n = 565$)		Sunscreen experiment ($n = 354$)		UV photography ($n = 197$)		Intention setting ($n = 457$)		Total ($N = 1,573$)		p[b]
	n	%[a]	*n*	%[a]	*n*	%[a]	*n*	%[a]	*n*	%[a]	
Gender											
Male	293	53.7	136	42.1	98	54.1	208	49.6	735	50.0	0.04
Female	251	46.0	186	57.6	82	45.3	208	49.6	728	49.5	
Other	2	0.4	1	0.3	1	0.6	3	0.7	7	0.5	
Grade											
9th	207	37.6	71	21.4	6	3.3	108	24.9	392	26.2	
10th	289	52.5	185	55.7	128	70.7	181	41.8	784	52.3	<0.001
11th	36	6.5	43	13.0	27	14.9	76	17.6	182	12.1	
12th	19	3.4	33	9.9	20	11.0	68	15.7	140	9.3	
Race											
Non-Hispanic white	283	58.5	171	58.2	83	50.9	285	76.0	822	62.5	
Hispanic	136	28.1	83	28.2	56	34.4	65	17.3	340	25.8	<0.001
African American	13	2.7	7	2.4	12	7.4	5	1.3	37	2.8	
American Indian	7	1.4	9	3.1	2	1.2	8	2.1	26	2.0	
Asian American	19	3.9	13	4.4	4	2.5	6	1.6	42	3.2	
Other	26	5.4	11	3.7	6	3.7	6	1.6	49	3.7	
Family history of skin cancer											
Yes	147	26.7	93	28.3	46	25.4	158	36.7	445	29.8	.004
No	188	34.1	109	33.1	51	28.2	115	26.7	463	31.0	
Not sure	216	38.2	127	35.9	85	43.1	160	35.0	588	31.5	

[a]Due to missing data, some percentages do not equal 100%.

[b]Significance level set at $p<0.05$.

Table 2 | Pre- and post-intervention sun protection, risk behaviors, and sunburn occurrence (N = 1,573)

Sun protection and risk behaviors in past month						
					Often or always, *n* (%)	Mean (*SD*)[a]
Wore sunscreen with SPF 30+						
Pre-intervention					159 (10)	2.01 (1.09)
Post-intervention					212 (16)	2.17 (1.19)
Reapplied sunscreen after being outside for 2 hr, in the water, or sweating						
Pre-intervention					118 (8)	1.70 (1.03)
Post-intervention					136 (10)	1.86 (1.08)
Wore shirt with long sleeves						
Pre-intervention					426 (28)	2.77 (1.13)
Post-intervention					346 (26)	2.63 (1.19)
Wore long pants or long skirt						
Pre-intervention					896 (58)	3.49 (1.22)
Post-intervention					658 (49)	3.23 (1.30)
Wore wide-brimmed hat						
Pre-intervention					167 (11)	1.86 (1.11)
Post-intervention					101 (8)	1.75 (1.02)
Stayed in shade or under umbrella						
Pre-intervention					256 (17)	2.46 (1.09)
Post-intervention					283 (21)	2.57 (1.11)
Avoided being in the sun between 10 am–4 pm						
Pre-intervention					157 (10)	2.09 (1.07)
Post-intervention					172 (13)	2.20 (1.11)
Wore sunglasses						
Pre-intervention					357 (23)	2.48 (1.24)
Post-intervention					361 (27)	2.59 (1.28)
Spent time in the sun to get tan						
Pre-intervention					264 (17)	2.13 (1.24)
Post-intervention					218 (16)	2.09 (1.23)
Spent time in an indoor tanning bed/salon to get tan						
Pre-intervention					28 (2)	1.15 (0.58)
Post-intervention					32 (2)	1.19 (0.67)
Sunburn occurrence, n (%)						
Number of sunburns in the past 12 months	0	1	2	3	4	5+
Pre-intervention	482 (31)	369 (24)	294 (19)	173 (11)	82 (5)	135 (9)
Number of sunburns in the past month	0	1	2	3	4	5+
Pre-intervention	1227 (82)	200 (13)	36 (2)	25 (2)	6 (0.5)	9 (0.5)
Post-intervention	939 (70)	245 (18)	95 (7)	28 (2)	12 (1)	24 (2)

Percentages are calculated based on the number of participants who answered that item.
[a]Reported on a Likert scale of 1 = never, 2 = rarely, 3 = sometimes, 4 = often, and 5 = always.

students receiving the UV photograph (ps < 0.05). Similar findings were observed when comparing the UV photograph to the sunscreen activity or control, whereby students receiving the UV photograph had significantly smaller increases in sun protection over time than students receiving the other two interventions (ps < 0.05).

In contrast, the UV photograph had better sunburn and tanning outcomes than the behavior change worksheet. That is, the UV photograph was superior in controlling sunburn occurrence and indoor and outdoor tanning when compared to the behavior change worksheet (ps < 0.05). Students who received the UV photograph reported that they tended to receive, on average, one less sunburn than students who received the behavior change worksheet (p = 0.03). Increases in indoor and outdoor tanning were significantly greater (0.46 and 1.05, respectively) among students receiving the behavior change worksheet as opposed to students receiving the UVR photograph (ps < 0.05). Similarly, the UV photograph was superior in controlling indoor and outdoor tanning when compared to the sunscreen activity (ps = 0.04 and 0.03, respectively).

The behavior change worksheet was associated with better sunscreen application and reapplication

Table 3 | Outcomes pre-intervention to 1-month follow-up by intervention

	Sunscreen experiment					UV photograph					Behavior worksheet					Control				
	Pre		Post			Pre		Post			Pre		Post			Pre		Post		
	M	95% CI	M	95% CI	*p*	M	95% CI	M	95% CI	*p*	M	95% CI	M	95% CI	*p*	M	95% CI	M	95% CI	*p*
Sunscreen	2.17	2.05, 2.29	2.90	2.77, 3.04	0.001	1.99	1.91, 2.07	2.28	2.19, 2.37	0.009	1.87	1.64, 2.11	3.55	2.45, 4.66	<0.001	2.03	1.98, 2.07	2.60	2.44, 2.77	0.001
Reapplication of sunscreen	1.80	1.80, 1.81	2.54	2.30, 2.78	0.001	1.69	1.50, 1.89	2.14	2.08, 2.20	0.002	1.55	1.33, 1.77	3.29	2.17, 4.41	<0.001	1.77	1.73, 1.81	2.30	2.16, 2.45	0.002
Long-sleeved shirt	2.68	2.61, 2.75	2.87	2.74, 2.99	0.01	2.92	2.65, 3.20	3.04	2.80, 3.29	0.03	2.77	2.60, 2.94	3.80	2.81, 4.80	0.003	2.78	2.71, 2.85	3.12	2.94, 3.30	0.01
Long pants or skirt	3.40	3.33, 3.47	2.84	2.72, 2.97	0.006	3.63	3.60, 3.66	3.27	3.11, 3.43	0.11	3.60	3.41, 3.80	2.69	2.31, 3.07	0.002	3.41	3.31, 3.51	3.29	3.13, 3.45	0.291
Wide-brimmed hat	1.75	1.65, 1.85	2.30	2.20, 2.41	<0.001	1.83	1.55, 2.11	1.99	1.85, 2.13	0.17	1.90	1.78, 2.03	3.11	1.96, 4.27	<0.001	1.91	1.79, 2.03	2.31	2.19, 2.42	0.02
Shade or umbrella	2.62	2.48, 2.76	3.18	3.07, 3.28	<0.001	2.48	2.18, 2.77	2.71	2.46, 2.97	0.01	2.31	2.20, 2.42	3.78	2.69, 4.87	0.001	2.48	2.42, 2.54	3.08	2.86, 3.30	0.003
Avoid peak hours	2.13	1.93, 2.33	2.81	2.61, 3.01	<0.001	2.11	1.89, 2.33	2.44	2.23, 2.65	0.004	1.99	1.91, 2.08	3.56	2.29, 4.83	<0.001	2.14	2.07, 2.21	2.78	2.57, 3.00	0.002
Sunglasses	2.60	2.58, 2.62	3.17	3.09, 3.25	0.01	2.47	2.13, 2.82	2.83	2.66, 3.01	0.06	2.42	2.21, 2.62	3.73	2.74, 4.71	0.003	2.46	2.34, 2.58	2.94	2.82, 3.06	0.04
Outdoor intentional tanning	2.13	1.91, 2.34	2.78	2.74, 2.81	0.001	1.95	1.62, 2.28	2.16	1.96, 2.35	0.047	2.27	2.12, 2.42	3.60	2.43, 4.76	0.002	2.10	1.91, 2.28	2.52	2.28, 2.75	0.008
Indoor tanning	1.09	1.06, 1.12	1.44	1.40, 1.48	<0.001	1.12	1.10, 1.14	1.34	1.26, 1.41	0.001	1.17	1.12, 1.22	1.90	1.36, 2.44	<0.001	1.17	1.14, 1.21	1.45	1.37, 1.53	<0.001
Sunburn	1.35	1.28, 1.42	2.20	2.08, 2.32	<0.001	1.25	1.10, 1.40	1.83	1.75, 1.91	<0.001	1.20	1.05, 1.35	3.12	1.69, 4.54	<0.001	1.35	1.28, 1.42	2.05	1.94, 2.17	<0.001

Bolded *p*-values are significant at $p < .05$. Pre-intervention and 1-month post-intervention estimates and CIs are unadjusted, whereas *p*-values comparing pre–post are adjusted for participant grade, gender, rural/urban status, race, and family history of skin cancer. CI, confidence interval; UV, ultraviolet.

Table 4 | Comparison of pre-intervention to 1-month follow-up outcomes between interventions

	Exp vs. Con			Wor vs. Con			Photo vs. Con			Wor vs. Exp			Photo vs. Exp			Photo vs. Wor		
	Mean diff	95% CI	*p*	Mean diff	95% CI	*p*	Mean diff	95% CI	*p*	Mean diff	95% CI	*p*	Mean diff	95% CI	*p*	Mean diff	95% CI	*p*
Sunscreen	0.23	−0.26, 0.71	0.36	1.01	0.04, 1.98	0.04	−0.30	−0.62, 0.02	0.07	0.78	−0.22, 1.79	0.13	−0.53	−0.98, −0.08	0.02	−1.31	−2.22, -0.41	<.001
Re-application of sunscreen	0.28	−0.21, 0.77	0.26	1.07	0.14, 1.99	0.02	−0.12	−0.41, 0.17	0.42	0.78	−0.19, 1.76	0.11	−0.40	−0.86, 0.06	0.09	−1.19	−2.05, −0.33	<.001
Long-sleeved shirt	−0.06	−0.42, 0.29	0.72	0.59	−0.24, 1.42	0.16	−0.20	−0.51, 0.11	0.20	0.66	−0.13, 1.44	0.10	−0.14	−0.43, 0.16	0.36	−0.79	−1.53, −0.05	0.04
Long pants or skirt	−0.42	−0.60, −0.24	<.001	−0.67	−1.12, −0.21	<.001	−0.18	−0.48, 0.11	0.23	−0.25	−0.70, 0.21	0.29	0.24	−0.05, 0.53	0.11	0.49	−0.03, 1.00	0.07
Wide-brimmed hat	0.17	−0.15, 0.48	0.30	0.70	−0.13, 1.53	0.10	−0.25	−0.66, 0.16	0.24	0.54	−0.25, 1.32	0.18	−0.41	−0.77, −0.05	0.03	−0.95	−1.75, −0.15	0.02
Shade or umbrella	−0.03	−0.29, 0.35	0.84	0.75	−0.18, 1.69	0.11	−0.36	−0.71, −0.02	0.04	0.72	−0.14, 1.58	0.10	−0.39	−0.63, −0.16	0.001	−1.12	−1.96, −0.27	0.01
Avoid peak hours	0.13	−0.27, 0.52	0.53	0.80	−0.24, 1.85	0.13	−0.28	−0.67, 0.11	0.17	0.67	−0.27, 1.67	0.17	−0.41	−0.70, −0.11	0.01	−1.08	−2.05, −0.11	0.03
Sunglasses	0.16	−0.18, 0.50	0.35	0.81	−0.10, 1.72	0.08	−0.11	−0.51, 0.30	0.60	0.65	−0.22, 1.51	0.14	−0.27	−0.64, 0.09	0.15	−0.92	−1.79, −0.05	0.04
Outdoor intentional tanning	0.33	−0.07, 0.74	0.11	0.85	−0.07, 1.77	0.07	−0.20	−0.58, 0.19	0.32	0.52	−0.42, 1.46	0.28	−0.53	−1.00, 0.06	0.03	−1.05	−1.98, -0.12	0.03
Indoor tanning	0.12	−0.05, 0.28	0.18	0.40	0.04, 0.76	0.03	−0.05	−0.22, 0.11	0.53	0.29	−0.06, 0.63	0.10	−0.17	−0.34, 0.00	0.04	−0.46	−0.78, −0.14	0.01
Sunburn	0.26	−0.09, 0.60	0.14	1.01	0.07, 1.96	0.03	−0.11	−0.59, 0.38	0.67	0.76	−0.17, 1.69	0.11	−0.36	−0.87, 0.14	0.16	−1.12	−2.13, -0.11	0.03

Bolded *p*-values are significant at $p < .05$. All mean differences are calculated as the first intervention listed minus the second intervention listed. Estimates, confidence intervals, and *p*-values are adjusted for participant grade, gender, rural/urban status, race, and family history of skin cancer. CI, confidence interval; Con, control (education only); Exp, sunscreen experiment; Photo, UV photography; UV, ultraviolet; Wor, Worksheet.

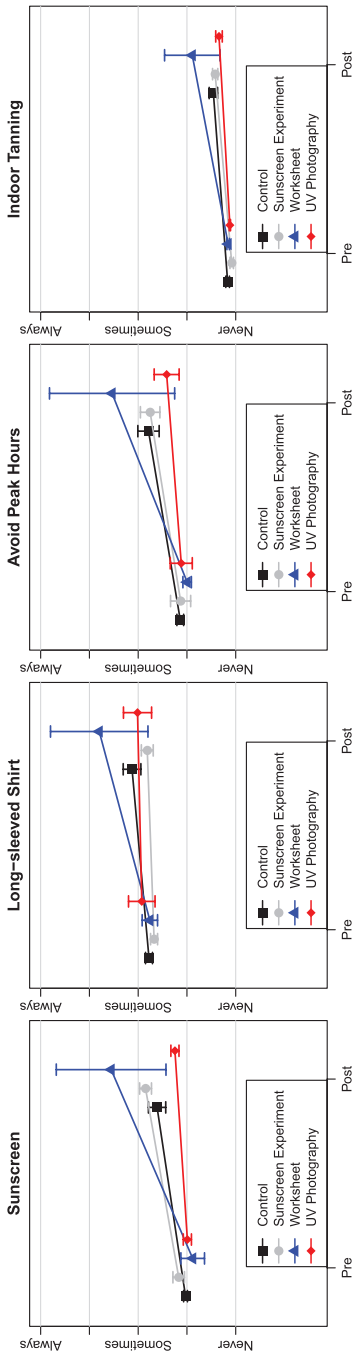

Fig. 1 | Pre- to post-intervention changes in outcomes by intervention.

outcomes than control (ps < 0.05), but the control intervention was better in controlling indoor tanning and sunburn increases than the behavior change worksheet intervention (ps < 0.05). The control intervention was also associated with significantly greater increases in long pant or skirt wearing than the sunscreen activity and behavior change worksheet interventions (0.42 and 0.67 differences, respectively, ps < 0.01).

Demographic predictors of pre- to post-intervention changes in outcomes

Several demographic characteristics were significant predictors of intervention outcomes, including gender, urban or rural location, and race. Gender was a significant predictor of pre- to post-intervention changes in multiple outcomes including sunscreen application and reapplication, long-sleeved shirt wearing, shade use, avoidance of peak UVR hours, intentional indoor and outdoor tanning, and sunburn. Specifically, boys had smaller increases in each outcome than girls (ps < 0.002). Urban/rural location was a significant predictor of changes in sunburn pre- to post-intervention such that rural students reported a 0.9 greater increase in sunburns pre- to post-intervention than urban students (p = 0.022). Nonwhite students reported significantly higher increases in use of several sun protection strategies (sunscreen application and reapplication, long-sleeved shirt use, sunglass wearing; ps ≤ 0.002) pre- to post-intervention than white students. Nonwhite students also reported significantly higher increases in intentional indoor and outdoor tanning and sunburn occurrence than white students (ps ≤ 0.007).

We also explored whether interactions between gender and grade, race, and rural/urban location were significant predictors of changes in outcomes pre- to post-intervention. The interaction between gender and grade was a significant predictor for changes in reported sunglasses use pre- to post-intervention such that girls in later versus earlier grades tended to have larger increases in sunglass wearing than boys in later versus earlier grades (p < 0.001). The interaction between gender and rural/urban location was a significant predictor of changes in hat use pre- to post-intervention such that girls in urban locations were less likely to increase in their use of hats than girls in a rural location (p = 0.047). The interaction between gender and race was not a significant predictor of any changes in outcomes over time.

DISCUSSION

The current study experimentally tested four school-based skin cancer preventive interventions for adolescents that varied in their approach, content, and interactivity. Consistent with the MOST framework, our goal was to identify potentially effective intervention

components that could later be combined and tested in an efficacy trial [37]. All intervention elements tested were associated with significant increases in reported frequency of sun protection use. The UV photograph, which shows students the effects of UVR overexposure, demonstrated the most promise for controlling sunburn and intentional tanning whereas the behavior change worksheet, which encourages use of sun protection to avoid UV overexposure, was associated with better improvements in sun protection behaviors over time. UV photography has demonstrated promise in controlling intentional indoor tanning in prior studies outside of high schools [34,53,54], and only one prior school-based intervention was associated with decreased intentional indoor tanning [32]. Only a limited number of school-based interventions for adolescents have assessed changes in sun protection and in general, those demonstrated no or relatively limited changes in sun protection (e.g., changes in sunglasses use only) [27,28,31]. The behavior change worksheet in the current study may have been particularly effective because students created personalized sun protection plans for a behavior of their choice. In contrast, prior interventions in high schools provided general education and recommendations without opportunities for adolescents to personalize their skin cancer prevention plans.

Contrary to our hypotheses, the control intervention was associated with overall improvements in sun protection over time, as well as better outcomes in some sun protection behaviors and sunburn and tanning than other interventions. The control intervention included comprehensive information on skin cancer risk and prevention, which may have been unexpectedly potent enough to motivate behavior change. Indeed, prior skin cancer preventive interventions for adolescents that have included educational information alone have been associated with improvements in frequency of use of certain sun protection behaviors [25,26].

Reported sunburn occurrence increased significantly over time across all groups, but when compared to the behavior change worksheet, this increase was smaller among students who received the UV photograph that provided a personalized photo of each student's facial UV damage. The universal increases in sunburn occurrence may be due to seasonal rises in ambient UVR levels during the months of study participation, from March through May [55], and also due to adolescents spending more time outdoors during warmer weather. Even with these potential seasonal effects in mind, it was encouraging that the UV photograph intervention attenuated increases in reported sunburn occurrence. Both indoor and outdoor intentional tanning similarly increased significantly over time for all conditions. This may reflect expected peaks in indoor tanning in the spring season tied to a desire for tan skin, as individuals prepare for warmer months and changes in their attire (wearing shorts, short-sleeved shirts, or tank tops) [56,57]. To guide future development of interventions for the high school population, we also examined potential demographic moderators of intervention outcomes. These findings suggest that certain groups, including male students and rural students, could benefit from tailored or targeted interventions to further improve their sun protection, tanning, and sunburn outcomes. Further work is needed to understand the reasons underlying the demographic differences observed, including the higher improvements in use of sun protection but simultaneous higher increases in intentional tanning and sunburn occurrence among non-white students when compared with white students. For example, higher improvements in sun protection use among nonwhite students could be related to lower baseline levels of sun protection use when compared with white students.

This study has several strengths worth noting. We were able to compare the effects of several novel intervention components in the high school classroom setting, several of which have not been previously tested in this population. Also, outcomes examined included intentional outdoor tanning as well as sunburns, which have seldom been examined in prior studies despite their role as key risk factors for skin cancer development [12–15,58]. The results should also be interpreted within the context of study limitations. This was a preliminary study of highly brief interventions to identify potentially promising skin cancer preventive intervention components that could be more definitively tested in future, larger studies, and thus our analyses were exploratory in nature and we tested multiple potential hypotheses. Although prior school-based health interventions that have been brief have led to positive outcomes at six-month follow-ups, it may be beneficial to consider higher dose interventions to facilitate long-term treatment effect maintenance [59,60]. As UV photo technology and accompanying dermatology research advances, interventions incorporating the UV photo could also develop appropriate methods for providing information to students on the degree of UV damage observed. The primary outcomes of interest were assessed using self-reported measures. Future work could seek to incorporate more objective assessments such as observed use of sun protection on school grounds or objective assessments of UVR exposure. Although we drew our sample from a geographic area at increased risk for melanoma [61], future work could seek to replicate the findings in geographically diverse samples. Future studies may also want to account for seasonal fluctuations in UVR levels that could impact outcomes of interest such as sunburn occurrence and sun protection use and include longer follow-up periods.

In conducting the current study, several key lessons learned related to collaborating with schools were observed, which may be useful to other

researchers. First, our team found that it was most effective to contact administrators such as principals or a school district research board (if available) to obtain approval to implement the research study. However, in planning the implementation of the intervention and study within classrooms, it was most useful to communicate directly with individual teachers. Second, we were able to use an approved passive consent process in the current study whereby parents and students could opt-out of study participation because the research team did not collect personally identifiable information about participants. The use of this passive consent process likely improved participation rates. However, one school district that was invited to participate in the current study required active consent procedures only, and thus we did not include them in the current study. In terms of intervention implementation, we found it most effective to deliver the interactive interventions in classroom or small group settings, rather than to large groups of students.

School-based interventions focused on skin cancer prevention are greatly needed [22], especially because few schools adopt formal sun protection policies [62]. Adolescent students are an important priority group for receipt of sun protection interventions, given their multiple barriers to sun protection [63]. In order to continue building the evidence base supporting school-based skin cancer preventive interventions for adolescents, additional work is needed to develop and rigorously test innovative interventions that can be delivered in the classroom setting. Building on the current study and in line with next steps outlined through the MOST framework [37], the intervention components piloted could be combined and tested as packages through an efficacy trial. A comprehensive skin cancer prevention program that includes these intervention components could also synergize with efforts to provide resources and education to school staff and parents, and to catalyze school policies around sun protection. To the best of our knowledge, such comprehensive programs are not currently available in the schools included in the current study. In the long term, this work could contribute to the implementation of skin cancer prevention programs for youth that are able to impact multiple skin cancer prevention outcomes, including sun protection use, sunburn occurrence, and intentional indoor and outdoor tanning. Future work is needed to confirm both the theoretical mechanisms underlying intervention benefits, to identify student- and school-level moderators of intervention outcomes, and to tailor interventions to the needs of particular subgroups of students (e.g., males vs. females). Effective primary preventive interventions that target youth sun protection and tanning behaviors could effectively decrease the burden of skin cancer, and schools offer an ideal setting in which to deliver such interventions.

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Compliance with Ethical Standards

Conflict of Interest: All authors declare that they have no conflicts of interest.

Ethical Approval: All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards."All procedures were approved by the University of Utah Institutional Review Board and school authorities.

Informed Consent: Informed consent was obtained via consent cover letters sent to families allowing the parent or child to opt the child out of participation.

Welfare of Animals: This article does not contain any studies with animals performed by any of the authors.

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