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Research Article

Cancer Epidemiology, Biomarkers & Prevention

The Sun Solutions Intervention for Operating Engineers: A Randomized Controlled Trial

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Abstract

Background: Because Operating Engineers (heavy equipment operators) are outdoor workers at risk for skin cancer, interventions are needed to promote sun safety. The objectives were to determine changes in sunscreen use and sunburning among Operating Engineers randomized to four conditions in the Sun Solutions study: (i) education only; (ii) education and text message reminders; (ii) education and mailed sunscreen; and (iv) education, text message reminders, and mailed sunscreen.

Methods: In this randomized controlled trial, Operating Engineers ($N = 357$) were recruited at required safety training sessions throughout Michigan during winter/spring of 2012 to 2013 and provided baseline surveys. The four interventions were delivered over the summer. Postintervention surveys were collected in the fall (82.1% follow-up).

Results: Sunscreen use improved significantly from baseline to follow-up in all four conditions ($P < 0.05$), except sunscreen use among those receiving education and text message reminders was only marginally significant ($P = 0.07$). There were significantly greater increases in sunscreen use in the two conditions that were mailed sunscreen ($P < 0.001$). There was a significant decrease in the number of reported sunburns from baseline to follow-up in all four conditions ($P < 0.001$), but there were no significant differences in sunburns among the groups. Participant evaluated the interventions highly with those who received mailed sunscreen rating the intervention the highest.

Conclusions: Providing proper sun-safety education and minimizing barriers to sunscreen use can increase sunscreen use and decrease reported sunburns.

Impact: The implementation of the Sun Solutions intervention may be an effective method to modify skin cancer–related behaviors. *Cancer Epidemiol Biomarkers Prev; 27(8); 864–73.* *©2018 AACR.*

Introduction

Nearly 5 million cases of nonmelanoma skin cancer occur annually (1). U.S. rates of melanoma, the most deadly form of skin cancer, are mostly attributed to ultraviolet radiation (UVR) exposure and are expected to increase at a rate of 3% per year through 2019 (2). Melanoma accounts for approximately 75% of skin cancer–related deaths in the United States (3). In 2017, it is estimated that there will be 87,110 new cases of melanoma, and an estimated 9,370 will die from the disease (4). The annual cost of treating newly diagnosed melanomas is estimated to increase from $457 million in 2011 to $1.6 billion in 2030 (2). Many people diagnosed with skin cancer are Caucasian men over the age of 50, and 1 out of 33 Caucasian males will develop skin cancer in his lifetime (1).

Outdoor workers are exposed to high UVR levels and have lower sun protection behaviors (5), increasing their risk of malignant melanoma (6) and nonmelanoma skin cancer (7, 8). Among outdoor workers, being male, younger, and reporting perceived barriers to using sun protection have been shown to be associated with lower levels of sun protection behaviors (5). Male outdoor workers may feel that it is not masculine to protect themselves from the sun (9), especially when around other men. Furthermore, putting on sunscreen and wearing long sleeves are often viewed as uncomfortable and "a hassle" (10–12). Positive attitudes toward tans may prevent those regularly exposed to UVR from taking sun protection seriously (11).

Sunscreen use and other sun protection behaviors have been shown to decrease sunburning and the risk of developing squamous cell carcinoma and melanoma (13–19). Past skin cancer–prevention interventions for outdoor workers such as lifeguards, other recreation workers, farmers, and mail carriers have often included multiple components such as education, placing messages at the worksite, videos discussing sun protection methods and the cancerous effects of UVR exposure, showing ultraviolet filtered photos of the face demonstrating existing skin damage, sending text message reminders of the weather report, role modeling, physician skin examinations, environmental support such as sunscreen dispensers and shade structures, and policy changes (20–26). At least 13 moderate to high-quality studies from the United States and elsewhere have demonstrated desirable intervention effects of up to a year on various sun-safety behaviors (i.e., sunscreen, hat, long-sleeve, sunglasses, and shelter use) and in some cases, sunburn (27, 28).

However, a systematic review concluded that outdoor workers' knowledge and attitudes about sun protection behaviors were inadequate (28). Similarly, our team found that among mostly

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male Operating Engineers (heavy equipment operators), 80% ($n = 498$) reported spending 4 to 5 hours in the sun during summer weekdays, yet approximately two thirds reported never or rarely wearing sunscreen (29). Almost half reported two or more first-degree sunburns per summer and a median of blistering two times in their lifetime. Hence, the Sun Solutions study, based on the Health Belief Model (30, 31), was conducted among Operating Engineers. A preliminary study showed that the educational component significantly improved perceived self-efficacy, perceived barriers to and benefits of use of sunscreen, and perceived susceptibility to and severity of sunburning (12).

This randomized controlled trial (RCT) evaluated the efficacy of four Sun Solutions interventions on sunscreen use and sunburning among Operation Engineers. Among the four interventions, the educational component was designed to increase perceived susceptibility to and severity of sun burning and enforce the benefits of sunscreen use. Mailed sunscreen was designed to reduce barriers and served as a cue to action. Text messages were designed to emphasize perceived benefits and served as cues to action. The study is unique in that it recruits participants during their regularly scheduled safety training and compares four interventions of varying intensity. The hypothesis was that a greater number of intervention components would be associated with greater improvements in sunscreen use and decreased sunburning.

Materials and Methods

Design

A 2 × 2 factorial design allowed the effects of text message reminders and mailed sunscreen to be tested simultaneously. As detailed in a protocol paper (32), Michigan Operating Engineers were randomized to either: (i) Education Only; (ii) Education and Text Message Reminders; (iii) Education and Mailed Sunscreen; or (iv) Education, Text Message Reminders, and Mailed Sunscreen. All participants provided written informed consent in accordance with the Declaration of Helsinki, International Ethical Guidelines for Biomedical Research Involving Human Subjects, the Belmont Report, and the U.S. Common Rule. Institutional review board approval was obtained from the University of Michigan.

Setting and sample

Participants were recruited from December 2012 to April 2013 during their annual winter safety training sessions provided by Michigan Local Union 324 Operating Engineers Training Centers. Education was provided at this time and additional interventions were provided between May and September (interventions described in the following sections). Operating Engineers were included if they: (i) were at least 18 years of age; (ii) were interested in enrolling in the sun protection study; (iii) owned a cell phone that accepted text messages; and (iv) were willing to share their phone number with the research institution.

Procedures

A research nurse consented participants and provided them with an information packet, which included a baseline survey. Using a computerized random number generator, a statistician randomly allocated the consented participants to one of the four intervention arms with an equal allocation (or, 1:1:1:1 allocation). Both the researchers and the participants were blinded to the condition of randomization. Participants were sent a follow-up survey in October following the sun protection interventions. Participants received $10.00 for each survey completed (baseline and follow-up).

Description of interventions

Education only. To increase knowledge and foster behavior change (21, 27, 33, 34), participants in all four conditions were shown a 30-minute PowerPoint presentation during their annual safety trainings. The content was gathered from published articles, the FDA, the U.S. Preventive Services Task Force (USPSTF), and the American Academy of Dermatology. The presentation included information on: (i) the current use of sun protection among Local 324 members taken from our prior survey of this population (29); (ii) the incidence and prevalence of skin cancer especially among outdoor workers; (iii) the types of skin cancers and skin cancer risk factors; and, (iv) methods to prevent sunburning, including choosing from different products and reading Sun Protection Factor (SPF) labels, correct application of sunscreen, and preventive measures such as wearing hats, UVR-blocking sunglasses, and using shade. Because pictures and graphs can enhance understanding (35), adapting information to address specific populations can gain attention and change attitudes and behaviors (20, 27, 36–39). And because pictures of skin cancer can motivate people to action (21, 40), pictures were shown of: Operating Engineers working in the sun, skin cancer, different SPF labels, and sunscreens. Perceived barriers and opinions about using sunscreen were discussed.

Education and text message reminders. Although recall of sun protection messages is problematic (41), the provision of cellular text message reminders has been found to increase adherence to sunscreen application (22). Hence, in addition to the educational presentation, the second group also received computer-generated cellular telephone text messages on three random weekdays between 8 and 10 a.m. for the months of May, June, July, August, and September for a total of 60 unique messages in random order over the 20-week summer period. The text bank was first drafted by faculty and students and then modified with feedback from a few Operating Engineers. Because positive messages have been found to appeal to the reader's desire for happy emotions (42), negatively oriented text messages were excluded. Sample text messages included: "Your family and friends love you—put on sunscreen!," "Yikes it's hot—put on sunscreen!," and "86% of OE's burn each summer—but not you, right?" The text message bank and cell phone numbers were entered into a software program called TXT180. As required by law, the first text message sent by the program informed participants that they may be charged for the messages and allowed them to opt out by replying "STOP" to any messages sent throughout the intervention period.

Education and sunscreen. To reduce barriers to obtaining sunscreen, in addition to educational presentation, the third group also received mailed sunscreen three times over the summer, including large bottles of SPF30 lotion and a small bottle that could be refilled and attached to their key rings (as keys are important to heavy equipment operators). A letter accompanying the mailing reminded them of proper sunscreen application techniques.

Education, text message reminders, and sunscreen. To determine whether the combination of these interventional components

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results in improvements above and beyond the individual parts, the fourth intervention group received the educational presentation, text message reminders, and mailed sunscreen.

Measures

Sun solutions intervention. The four interventions were Education Only, Education and Text Message Reminders, Education and Mailed Sunscreen, and Education, Text Message Reminders, and Mailed Sunscreen.

Sun exposure covariates. Participants were asked about their sun exposure with the following questions: In general, during the summer weekdays, about how many hours a day are you outside between 10 a.m. and 3 p.m.? (43). In general, during the summer holidays and weekends, about how many hours a day are you outside between 10 a.m. and 3 p.m. (less than an hour, 1 to 2 hours, 2 to 3 hours, 3 to 4 hours, 4–5 hours)? (43). Which best describes how your skin generally reacts to the sun when you are not using any sun protection (always burn, unable to tan; usually burn, then can tan if I work at it; sometimes mild burn, then tan easily; rarely burn, tan easily)? (43, 44). About how many times in your life do you recall having had a sunburn severe enough to cause your skin to blister? (43, 44).

Other covariates. Because demographic factors may influence sun protection behaviors, participants were surveyed about demographics including: age, sex, ethnicity/race, educational level, marital, and veteran status. Because comorbidities can affect health motivation, probable depression was measured using the well validated Patient Health Questionnaire-2 (PHQ-2; ref. 45), and medical comorbidities were measured using a validated self-report instrument (46). Poor health habits have been shown to cluster together (47–49), and our prior research has shown that problem drinking, greater body mass index (BMI), and greater physical activity levels predict greater sunburning (29). Hence, validated questions were asked about smoking in the past 30 days (50), problem drinking (Alcohol Use Disorders Identification Test-C: AUDIT-C; ref. 51), diet (two questions on fruit and vegetable intake from the validated Willett food frequency questionnaire; ref. 52), physical activity (53), self-reported height and weight to determine BMI, and sleep quality (54). Job characteristics measured included the occupational exposure of heat stress, extent of cab enclosure (partially enclosed or not enclosed), and percentage of time with doors and windows of cab open. Several other measures described in the protocol paper (32) were reported in a prior article (12).

Outcome variables. Sun exposure and protection was assessed using two validated questions. In the past summer, on the days when you were outside in the sunlight, how often did you use sunscreen (never, some of the time, about half the time, most of the time, always)? On average, how many times did you get a sunburn this past summer (0, 1, 2, 3, 4 or more times)? (43, 44)

Evaluation measures. Participants were asked to evaluate specific intervention components on "ease of understanding," "helpfulness," "satisfaction," "likelihood that they would use sunscreen," and "would recommend intervention to others" with 5-point Likert response categories, and if they purchased sunscreen in the past summer (yes/no).

Statistical analysis

Descriptive statistics were calculated for all variables. The equivalence of the intervention arms was tested using χ^2 or Fisher's exact tests of association for categorical variables and ANOVA tests for continuous variables. Because the differences between baseline and follow-up survey dependent variables (sunscreen use and sunburns) were roughly normally distributed, paired t tests were used to test for baseline to follow-up differences in use of sunscreen and sunburning for each treatment arm. Using an intent-to-treat analysis, ANOVA was used to estimate the effects of text message reminder, mailed sunscreen, their interaction, and *post hoc* comparisons among the groups on baseline, follow-up, and baseline to follow-up changes in self-reported use of sunscreen and sunburning. Power analyses indicated that a final sample size of 256 participants was needed to provide 80% power to detect medium-sized effects with a two-tailed alpha of 0.05 (32). On basis of prior experience with Operating Engineers, it was expected that 460 individuals would need to be approached to produce the intended final sample. *Post hoc* comparisons were performed with Tukey's HSD (honest significant difference) test.

Additional analyses conducted included: (i) ordinal logistic regression analyses which treated the dependent variable as ordinal; and (ii) multivariate linear regressions that controlled for baseline differences across treatment arms. Evaluation questions were analyzed using the Kruskal–Wallis test statistic. Two-tailed tests with alpha of 0.05 were conducted. Analyses were conducted using SAS version 9.2 (SAS Institute Inc.).

Results

Description of study sample

Figure 1 shows that of the 535 who attended the classes, 357 were consented and eligible (66.7% participation rate), and 293 participants were followed (82.1% follow-up rate). Participants lost to follow-up were marginally more likely to be younger ($P = 0.07$), nonwhite ($P = 0.02$), and smoke cigarettes ($P = 0.02$) than those followed. About 46.9% ($n = 84/179$) of those assigned to receive text messages immediately opted out using the "STOP" feature due to a legally mandated warning "Msg&data rates may apply." There was no significant difference in the opt-out rate between the two groups eligible to receive text messages (47.7% vs. 46.2%, $P = 0.84$).

A description of the population can be seen in Table 1. The average age was 44.2 years, and the majority were non-Hispanic white males. About one quarter had high blood pressure. Approximately one quarter of the population reported smoking cigarettes, almost two thirds reported hazardous drinking, and almost half were obese.

Participants reported an average of 6.1 severe burns throughout their lifetime. About 82.9% reported spending 4 to 5 hours per day outside between 10am and 3pm during summer week days and 70.3% reported spending 4 to 5 hours per day outside between 10 a.m. and 3 p.m. during summer holidays and weekends. About 18.8% reported that their skin always or usually burns when they are outside in the sun without any sun protection. The most common hazardous exposure was heat stress (62.2%). Most had at least a partially (38.7%) or fully (48.1%) enclosed cab. Even so, almost half (48.9%) operated the cab with doors and windows open 76% to 100% of the time and another

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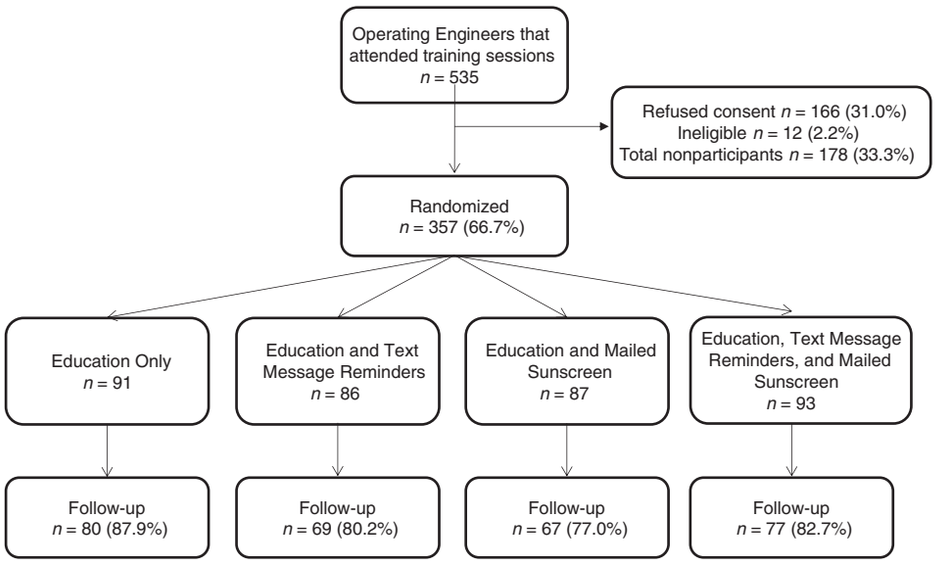

Figure 1.
Consort diagram. The consort diagram displays how participants were recruited, randomized, and retained. Follow-up rates are provided by intervention arm.

20.9% did so 50 to 75% of the time. The percentage of participants who reported never wearing sunscreen when outside in the sunlight decreased from 38.1% at baseline to 21.8% at follow-up. The percentage of participants who reported burning 4 or more times during the past summer was 18.6% at baseline and decreased to 5.8% at follow-up. The only baseline difference ($P = 0.04$) across treatment conditions was that those who received education only reported having significantly more high blood pressure (36.7%), whereas those who received education and mailed sunscreen only reported the lowest percentage (17.4%).

Changes in sunscreen use and sunburns

In Table 2 the unadjusted intention-to-treat analyses show that sunscreen use increased significantly for all treatment conditions ($P < 0.05$), except significance was only marginal for those who received education and text message reminders ($P = 0.07$). Both follow-up sunscreen use and mean differences in sunscreen use from baseline to follow-up were statistically different across the four treatment groups ($P < 0.001$). Moreover, the number of reported sunburns decreased significantly from baseline to follow-up in all four treatment conditions ($P < 0.001$). Although there were no statistically significant decreases in sunburning among the different conditions, the greatest decrease in sunburns were in the groups that received mailed sunscreen, particularly the group that received all three interventions. Additional analyses treating the dependent variables as ordinal and controlling for baseline differences (high blood pressure) across groups produced similar results to those reported in Table 2, and are therefore not reported. When sunscreen use and change in sunscreen use were regressed on indicator variables for receipt of text messages, receipt of mailed sunscreen, and an interaction term for receipt of text messages and receipt of mailed sunscreen, the interactions were nonsignificant and therefore not reported. Post hoc analyses showed that the two groups that received mailed sunscreen were significantly more likely to use sunscreen than the two groups that were not mailed sunscreen (see Fig. 2).

Evaluation of the interventions

Table 3 shows the participants' opinions about the four interventions rated on a 5-point scale on perceived: (i) understanding, (ii) helpfulness, (iii) satisfaction, and (iv) likelihood of increased sunscreen use.

Understanding and helpfulness. The mean rating for understanding of the educational intervention was 4.46; those in the Education, Text Message, and Mailed Sunscreen group rated it the highest ($P = 4.49$), whereas those in the Education and Text Message group rated it the lowest (4.31; $P < 0.05$). The mean rating of helpfulness was 4.37 for the educational intervention, 4.48 for the mailed sunscreen, but only 3.67 for text messages.

Satisfaction and likelihood of using sunscreen. The mean rating of satisfaction was 4.40 for the educational intervention, 4.48 for mailed sunscreen, but was only 3.59 for text messages. Those who received Education, Text Messages, and Mailed Sunscreen tended to be the most *satisfied* with the educational intervention ($P = 0.031$) compared with the other groups. The mean rating of the *likelihood of using sunscreen* as a result of the educational intervention was 4.03, as a result of the mailed sunscreen was 4.27, but was only 3.56 for text messages. Both groups that received mailed sunscreen indicated that the educational presentation increased the *likelihood of using sunscreen* (means = 4.17 and 4.18), compared with Education and Text Messages (mean = 3.98) and Education Only (3.83) groups ($P = 0.031$).

Recommendation of intervention and purchase of sunscreen. Overall, the mean score for likelihood of recommending the intervention to others was 4.34 with the two conditions receiving mailed sunscreen marginally more likely to recommend (means = 4.48 and 4.37) than the other two conditions (means = 4.26 and 4.24; $P = 0.079$). About 57.4% said they had purchased sunscreen over the summer. Not surprisingly, those who were not mailed sunscreen were more likely to have purchased sunscreen over the summer, compared with those participants who were mailed sunscreen ($P < 0.001$).

Discussion

This study showed that all four conditions of the Sun Solutions intervention increased sunscreen use and decreased the number of

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Table 1. Characteristics of Operating Engineers ($N = 357$)[a]

Variables Variables with means	Total $N = 357$ (100%) Mean (SD)	Education only $N = 91$ (25.5%) Mean (SD)	Education and texts $N = 86$ (24.1%) Mean (SD)	Education and mailed sunscreen $N = 87$ (24.4%) Mean (SD)	Education, texts, and mailed sunscreen $N = 93$ (26.1%) Mean (SD)
Age ($n = 355$)	44.2 (10.5)	45.1 (10.2)	44.7 (10.3)	43.7 (11.2)	43.4 (10.5)
Physical activity score (population mean = 40.8; $n = 356$)	41.9 (5.5)	41.9 (6.1)	41.4 (4.9)	42.5 (5.8)	41.9 (5.2)
MOS Sleep scale (population mean = 71.4; $n = 356$)	71.4 (16.6)	71.3 (17.7)	71.2 (16.8)	71.7 (16.6)	71.5 (15.4)
About how many times in your life do you recall having had a sunburn severe enough to cause your skin to blister? ($n = 351$)	6.1 (12.9)	7.0 (16.8)	7.5 (16.9)	5.3 (7.8)	4.7 (6.7)
Variables with percentages	**N (%)**	**N (%)**	**N (%)**	**N (%)**	**N (%)**
Total	357 (100.0)	91 (25.5)	86 (24.1)	87 (24.4)	93 (26.1)
Demographics					
Sex ($n = 355$)					
Male	325 (91.6)	82 (90.1)	79 (91.9)	77 (90.6)	87 (93.6)
Race ($n = 355$)					
Non-Hispanic white	318 (89.6)	80 (87.9)	74 (86.1)	76 (88.4)	88 (95.7)
Marital status ($n = 355$)					
Married/domestic partner	223 (62.8)	51 (56.0)	54 (62.8)	55 (64.0)	63 (68.5)
Education ($n = 355$)					
GED/High school or less	209 (58.9)	58 (63.7)	50 (58.1)	48 (55.8)	53 (57.6)
U.S. veteran ($n = 353$)					
Yes	38 (10.8)	8 (8.8)	10 (11.8)	9 (10.6)	11 (12.0)
Comorbidities					
Screened positive for depression ($n = 355$)					
Yes	84 (23.7)	19 (20.9)	24 (28.2)	18 (20.7)	23 (25.0)
Medical comorbidities ($n = 354$)					
Cancer	12 (3.4)	3 (3.3)	5 (5.9)	2 (2.3)	2 (2.2)
Lung disease	18 (5.1)	4 (4.4)	3 (3.5)	5 (5.8)	6 (6.5)
Heart disease	18 (5.1)	3 (3.3)	3 (3.5)	6 (7.0)	6 (6.5)
High blood pressure[b]	**96 (27.1)**	**33 (36.7)**	**24 (28.2)**	**15 (17.4)**	**24 (25.8)**
Psychiatric problems	21 (5.9)	9 (10.0)	4 (4.7)	3 (3.5)	5 (5.4)
Substance abuse	17 (4.8)	8 (8.9)	3 (3.5)	1 (1.2)	5 (5.4)
Diabetes	22 (6.2)	5 (5.6)	5 (5.9)	6 (7.0)	6 (6.5)
Arthritis	14 (4.0)	4 (4.4)	4 (4.7)	1 (1.2)	5 (5.4)
Baseline health behavior covariates					
Smokes cigarettes ($n = 357$)					
Yes	88 (24.7)	18 (19.8)	27 (31.4)	24 (27.6)	19 (20.4)
Uses any smokeless tobacco ($n = 357$)					
Yes	57 (16.0)	15 (16.5)	11 (12.8)	14 (16.1)	17 (18.3)
Hazardous drinker ($n = 353$)					
Yes	211 (59.8)	61 (67.8)	44 (51.2)	53 (60.9)	53 (58.9)
Over the past year, how many servings of fruit do you usually eat, not counting juices? ($n = 355$)					
≤1 per week	94 (26.5)	22 (24.2)	28 (33.3)	26 (29.9)	18 (19.4)
2–4 per week	122 (34.4)	36 (39.6)	22 (26.2)	31 (35.6)	33 (35.5)
5–6 per week	44 (12.4)	10 (11.0)	10 (11.9)	10 (11.5)	14 (15.1)
≥1 per day	95 (26.8)	23 (25.3)	24 (28.6)	20 (23.0)	28 (30.1)

(Continued on the following page)

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Table 1. Characteristics of Operating Engineers ($N = 357$)[a] (Cont'd)

Variables Variables with means	Total $N = 357$ (100%) Mean (SD)	Education only $N = 91$ (25.5%) Mean (SD)	Education and texts $N = 86$ (24.1%) Mean (SD)	Education and mailed sunscreen $N = 87$ (24.4%) Mean (SD)	Education, texts, and mailed sunscreen $N = 93$ (26.1%) Mean (SD)
Over the past year, how many servings of vegetables do you usually eat, not counting salad or potatoes? ($n = 357$)					
≤1 per week	44 (12.3)	12 (13.2)	9 (10.5)	12 (13.8)	11 (11.8)
2–4 per week	121 (33.9)	29 (31.9)	28 (32.6)	30 (34.5)	34 (36.6)
5–6 per week	60 (16.8)	15 (16.5)	16 (18.6)	16 (18.4)	13 (14.0)
≥1 per day	132 (37.0)	35 (38.5)	33 (38.4)	29 (33.3)	35 (37.6)
BMI (kg/m^2; $n = 352$)					
Underweight (BMI < 18.5)	1 (0.3)	1 (1.1)	0 (0.0)	0 (0.0)	0 (0.0)
Normal weight (BMI 18.5–24.9)	49 (13.9)	13 (14.3)	11 (12.9)	15 (18.1)	10 (10.8)
Overweight (BMI 25.0–29.9)	140 (39.8)	30 (33.0)	41 (48.2)	30 (36.1)	39 (41.9)
Obese (BMI 30–34.9)	162 (46.0)	47 (51.7)	33 (38.8)	38 (45.8)	44 (47.3)
Baseline sun exposure covariates					
In general, during the summer weekdays, about how many hours a day are you outside between 10 a.m. and 3 p.m.? ($n = 357$)					
Less than 1 hour to 4 hours	61 (17.1)	11 (12.1)	11 (12.8)	17 (19.5)	22 (23.7)
4 to 5 hours	296 (82.9)	80 (87.9)	75 (87.2)	70 (80.5)	71 (76.3)
In general, during the summer holidays and weekends, about how many hours a day are you outside between 10 a.m. and 3 p.m.? ($n = 357$)					
Less than 1 hour to 4 hours	106 (29.7)	24 (26.4)	25 (29.1)	22 (25.3)	35 (37.6)
4 to 5 hours	251 (70.3)	67 (73.6)	61 (70.9)	65 (74.7)	58 (62.4)
Which best describes how your skin generally reacts to the sun when you're not using any sun protection? ($n = 356$)					
Always burn, unable to tan if I work at it/usually burn, then can tan if I work at it	67 (18.8)	16 (17.6)	20 (23.3)	14 (16.3)	17 (18.3)
Sometimes mild burn, then easily tan	179 (50.3)	44 (48.4)	38 (44.2)	49 (57.0)	48 (51.6)
Rarely burn, tan easily	110 (30.9)	31 (34.1)	28 (32.6)	23 (26.7)	28 (30.1)
Selected job characteristics					
Hazard to which you are regularly exposed—heat stress ($n = 357$)					
Yes	222 (62.2)	58 (63.7)	57 (66.3)	47 (54.0)	60 (64.5)
What type of cab does the equipment you usually operate in the summer months have? ($n = 349$)					
Completely enclosed	168 (48.1)	42 (47.2)	37 (44.6)	42 (48.8)	47 (51.6)
Partially enclosed	135 (38.7)	34 (38.2)	37 (44.6)	32 (37.2)	32 (35.2)
Completely open	46 (13.2)	13 (14.6)	9 (10.8)	12 (14.0)	12 (13.2)
How often do you operate heavy equipment during the summer months with the doors and/or windows of the cab open? ($n = 350$)					
More than 75% of the time	171 (48.9)	46 (52.9)	49 (58.3)	39 (44.8)	37 (40.2)
50%–75% of the time	73 (20.9)	19 (21.8)	17 (20.2)	17 (19.5)	20 (21.7)
25%–49% of the time	34 (9.7)	6 (6.9)	3 (3.6)	13 (14.9)	12 (13.0)
Less than 25% of the time	72 (20.6)	16 (18.4)	15 (17.9)	18 (20.7)	23 (25.0)
Outcome variables					
Baseline: In the past summer, on the days when you were outside in the sunlight, how often do you use sunscreen? ($n = 354$)					
Never	135 (38.1)	40 (44.4)	32 (37.2)	32 (36.8)	31 (34.1)
Some of the time	116 (32.8)	24 (26.7)	24 (27.9)	30 (34.5)	38 (41.8)
About half of the time	55 (15.5)	14 (15.6)	15 (17.4)	13 (14.9)	13 (14.3)
Most of the time/always	48 (13.6)	12 (13.3)	15 (17.4)	12 (13.8)	9 (9.9)
Follow-up: In the past summer, on the days when you were outside in the sunlight, how often do you use sunscreen? ($n = 293$)					0.001 CS
Never	64 (21.8)	29 (36.3)	20 (29.0)	11 (16.4)	4 (5.2)
Some of the time	75 (25.6)	22 (27.5)	16 (23.2)	13 (19.4)	24 (31.2)
About half of the time	61 (20.8)	12 (15.0)	17 (24.6)	16 (23.9)	16 (20.8)
Most of the time/always	93 (31.7)	17 (21.3)	16 (23.2)	27 (40.3)	33 (42.9)

(Continued on the following page)

Table 1. Characteristics of Operating Engineers ($N = 357$)[a] (Cont'd)

Variables Variables with means	Total $N = 357$ (100%) Mean (SD)	Education only $N = 91$ (25.5%) Mean (SD)	Education and texts $N = 86$ (24.1%) Mean (SD)	Education and mailed sunscreen $N = 87$ (24.4%) Mean (SD)	Education, texts, and mailed sunscreen $N = 93$ (26.1%) Mean (SD)
Baseline: On average, how many times did you get a sunburn this past summer? ($n = 355$)					
0	63 (17.8)	18 (20.0)	16 (18.6)	16 (18.4)	13 (14.1)
1	97 (27.3)	17 (18.9)	30 (34.9)	22 (25.3)	28 (30.4)
2	91 (25.6)	24 (26.7)	17 (19.8)	27 (31.0)	23 (25.0)
3	38 (10.7)	15 (16.7)	7 (8.1)	9 (10.3)	7 (7.6)
4 or more times	66 (18.6)	16 (17.8)	16 (18.6)	13 (14.9)	21 (22.8)
Follow-up: On average, how many times did you get a sunburn this past summer? ($n = 293$)					
0	104 (35.5)	23 (28.8)	27 (39.1)	27 (40.3)	27 (35.1)
1	94 (32.1)	22 (27.5)	21 (30.4)	20 (29.9)	31 (40.3)
2	59 (20.1)	20 (25.0)	14 (20.3)	15 (22.4)	10 (13.0)
3	19 (6.5)	8 (10.0)	4 (5.8)	2 (3.0)	5 (6.5)
4 or more times	17 (5.8)	7 (8.8)	3 (4.4)	3 (4.5)	4 (5.2)

[a]Totals vary due to missing data.
[b]The χ^2 test for differences in proportions between conditions significant at $P = 0.04$.

sunburns from baseline to follow-up. Although the greatest decreases in sunburning were in the group that received mailed sunscreen, there was no significant difference among the groups in sunburning. The majority of participants found all interventions to be helpful, satisfactory, and likely to increase sunscreen use. Even a simple educational PowerPoint presentation tailored to Operating Engineers, which was rated to be highly understandable, was enough to make a difference in both sunscreen use and sunburning.

A study conducted by Armstrong and colleagues (22) found text messaging to be effective in changing sun protection behaviors. Yet in the current study, those who received Education and Text Message Reminders only marginally improved sunscreen use and participants evaluated text messaging lower than education and mailed sunscreen. It is difficult to determine whether some of the lower scores for text messaging were due to the intervention itself or because almost half of participants eligible to receive text messages chose to opt out, which we anecdotally believe was due to potential costs. In retrospect, it may have been advantageous to educate the participants upon recruitment, that if they had free text messaging, they would not be charged for the text messages. Although the interaction of text messages and mailed sunscreen was not significant, compared with the other groups, those who received Education, Text Message Reminders, and Mailed Sunscreen reported slightly more sunscreen use and tended to evaluate the intervention higher, suggesting the possibility that text messages enhanced the effect of mailed sunscreen.

Other technology-based interventions shown to improve sun protection behaviors include mobile apps, although usage has been shown to be low. In one study only 41% of participants used a smart phone app (55), which is similar, but even less than the 53.1% that participated in the text messages in this study. This may be because mobile apps require active participation, whereas text messages can be passively sent to participants, unless they opt out.

Post hoc analyses showed that the two groups that were mailed sunscreen were more likely to use sunscreen than the other groups. Moreover, groups receiving mailed sunscreen tended to evaluate all of the intervention components more positively. The study is similar to an efficacious study that provided sun prevention interventions, including free sunscreen to mostly male postal workers (34). However, in the former study, the sunscreen was placed in locker rooms versus this study that mailed sunscreen to the participants' homes. Either way, the provision of sunscreen seems to have eliminate the barriers to access to sunscreen. It is possible that the key chain sunscreen samples decreased barriers to reapplication, as the keys are hanging directly in front of them all day long as they are driving. Outdoor workers are more likely to use sunscreen than wear long-sleeve clothing during summer time (27).

Despite the fact that most had access to partially or totally enclosed cabs, many chose to operate their equipment with the doors and/or windows of the cab open. Almost half of the participants were obese, and about a quarter screened positive from problem drinking, both of which have been shown to be associated with sunburning (29, 49, 56, 57), although the exact reasons for these associations are unknown. Physical activity scores were a bit higher than average and high physical activity, most likely due to more outdoor exposure, has been shown to be associated with a higher rate of sunburning (29). The majority of participants were males and men are less inclined to engage in sun

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Table 2. Unadjusted differences in sunscreen use and sunburns from baseline to follow-up and across conditions among Operating Engineers ($N = 357$)

	Education only ***N* (%)** **91 (25.5)** **Mean (SD)**	**Education and texts** ***N* (%)** **86 (24.1)** **Mean (SD)**	**Education and mailed sunscreen** ***N* (%)** **87 (24.4)** **Mean (SD)**	**Education, texts and mailed sunscreen** ***N* (%)** **93 (26.1)** **Mean (SD)**	***P* value comparing differences among groups**
Sunscreen use					
Baseline	2.0 (1.1)	2.2 (1.1)	2.1 (1.0)	2.0 (0.9)	0.69
Follow-up	2.2 (1.2)	2.4 (1.1)	2.7 (1.2)	2.8 (1.0)	<**0.001**
Mean difference	0.2 (1.0)	0.2 (1.0)	0.6 (1.0)	0.8 (1.0)	<**0.001**
P value comparing baseline to follow-up	**0.02**	0.07	<**0.001**	<**0.001**	
	Mean (SD)	**Mean (SD)**	**Mean (SD)**	**Mean (SD)**	***P***
Number of sunburns					
Baseline	1.9 (1.4)	1.7 (1.4)	1.8 (1.3)	1.9 (1.4)	0.64
Follow-up	1.4 (1.2)	1.2 (1.3)	1.2 (1.2)	1.2 (1.2)	0.50
Mean difference	−0.5 (1.4)	−0.5 (1.0)	−0.6 (1.3)	−0.7 (1.1)	0.50
P value comparing baseline to follow-up	<**0.001**	<**0.001**	<**0.001**	<**0.001**	

protection behaviors (9–12). Although this population was highly at risk for sunburning and two thirds reported heat stress as an occupational exposure, work-site interventions such as the Sun Solutions intervention introduced during mandated safety training sessions have the potential to improve sun protection behaviors.

Strengths and limitations of the study

The study was an RCT design guided by the Health Belief Model and the high participation and follow-up rates increase the generalizability of the results and emphasize participant interest and the feasibility of the intervention. The study had the potential to control for a number of co-variates, including comorbidities, other health behaviors, and job characteristics. The study relied on self-reported data on sunscreen use and sunburns, which may result in bias related to poor recall, improved recall by those who sunburn, and over-reporting desirable behaviors postintervention, but because all groups received some amount of intervention, the potential for socially desirable reporting is reduced. Moreover, several authors have previously validated self-report against direct observation among outdoor workers and found self-report to be accurate (34, 44, 58, 59). The fidelity of the text messaging intervention was compromised due to the 23.5% opt-out rate.

Conclusion

Heat stress is a major concern of the Occupational Safety & Health Administration. The USPSTF recommends that interventions to change behaviors should aim to reduce exposure to UVR including: (i) avoiding sun during the UVR peak times; (ii) using a broad-spectrum high-SPF sunscreen; (iii) wearing sun protective clothing; and (iv) avoiding indoor tanning (13). However, avoiding the sun during the UVR peak time is unrealistic for outdoor workers. Hence, sun protection interventions such as the

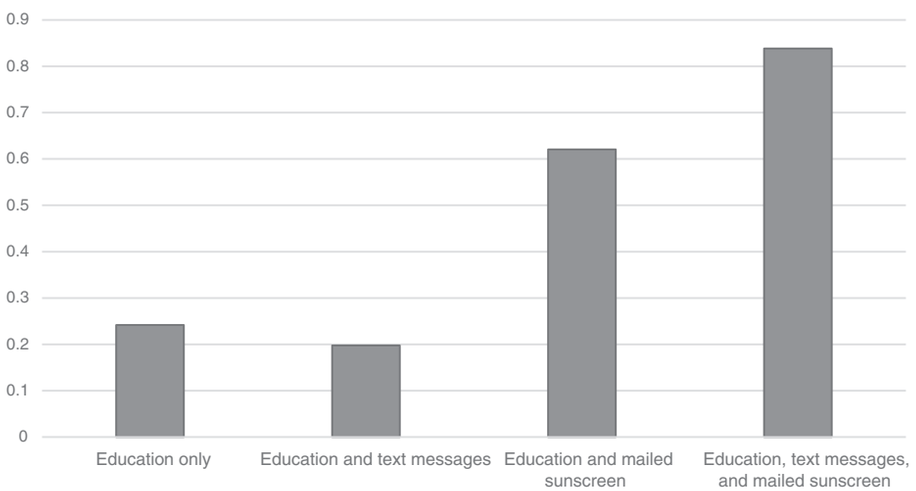

Figure 2.
Mean difference in sunscreen use (baseline to follow-up) by intervention group. This figure displays participants' mean changes in sunscreen use from baseline to follow-up by intervention group. Frequency of sunscreen use was assessed on a five-point scale of Never/Some of the time/About half of the time/Most of the time/Always. A positive change indicates increased frequency of sunscreen use.

**Post hoc* analysis using Tukey's HSD.
Group 1 versus 2: (NS)
Group 1 versus 3: ($P < 0.062$)
Group 1 versus 4: ($P < 0.001$)
Group 2 versus 3: ($P < 0.032$)
Group 2 versus 4: ($P < 0.001$)
Group 3 versus 4: (NS)

Table 3. Operating Engineers' evaluation of the interventions ($N = 293$)

Variable	Total $N = 293$ (100%) Mean (SD)	Education only $N = 80$ (27.3%) Mean (SD)	Education and texts $N = 69$ (23.6%) Mean (SD)	Education and mailed sunscreen $N = 67$ (22.9%) Mean (SD)	Education, texts, and mailed sunscreen $N = 77$ (26.3%) Mean (SD)	Kruskal–Wallis comparing differences among groups P
The educational presentation was easy to understand ($n = 271$)	4.46 (0.58)	4.57 (0.52)	4.31 (0.56)	4.46 (0.56)	4.49 (0.65)	**0.0466**
The educational presentation was helpful ($n = 271$)	4.37 (0.67)	4.45 (0.62)	4.24 (0.69)	4.33 (0.67)	4.44 (0.69)	0.1951
The text message reminders were helpful ($n = 120$)	3.67 (1.19)	n/a	3.53 (1.22)	n/a	3.78 (1.17)	0.2308
The mailed sunscreen was helpful ($n = 133$)	4.48 (0.82)	n/a	n/a	4.41 (0.78)	4.54 (0.86)	0.0892
Overall, I was satisfied with the educational presentation ($n = 271$)	4.40 (0.63)	4.38 (0.56)	4.26 (0.57)	4.44 (0.64)	4.50 (0.72)	**0.0319**
Overall, I was satisfied with the text message reminders ($n = 120$)	3.59 (1.21)	n/a	3.47 (1.27)	n/a	3.71 (1.15)	0.3031
Overall, I was satisfied with the mailed sunscreen ($n = 132$)	4.48 (0.80)	n/a	n/a	4.37 (0.83)	4.57 (0.75)	0.0899
The educational presentation increased the likelihood that I will use sunscreen ($n = 271$)	4.03 (0.85)	3.83 (0.93)	3.98 (0.80)	4.18 (0.71)	4.17 (0.90)	**0.0316**
The text message reminders increased the likelihood that I will use sunscreen ($n = 119$)	3.56 (1.25)	n/a	3.33 (1.29)	n/a	3.75 (1.19)	0.0663
The mailed sunscreen increased the likelihood that I will use sunscreen ($n = 132$)	4.27 (0.87)	n/a	n/a	4.21 (0.85)	4.33 (0.90)	0.2473
I would recommend the sun safety intervention to others ($n = 271$)	4.34 (0.68)	4.26 (0.66)	4.24 (0.62)	4.48 (0.59)	4.37 (0.82)	0.0797

Sun Solutions intervention, that educate outdoor workers and reduce barriers to sunscreen use, can be effective primary prevention methods to reduce skin cancer–related morbidity and mortality in this population (60, 61).

Disclosure of Potential Conflicts of Interest

No potential conflicts of interest were disclosed.

Disclaimer

The Blue Cross Blue Shield of Michigan Foundation was not involved in the design, collection, analysis, interpretation of data, writing of the article and in the decision to submit the article for publication.

Authors' Contributions

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Analysis and interpretation of data (e.g., statistical analysis, biostatistics, computational analysis): S.A. Duffy, S.V. Hall, A. Tan, S.A. Cooper
Writing, review, and/or revision of the manuscript: S.A. Duffy, S.V. Hall, A. Tan, A.H. Waltje, S.A. Cooper, C.J. Heckman
Administrative, technical, or material support (i.e., reporting or organizing data, constructing databases): S.A. Duffy, S.V. Hall, A.H. Waltje, S.A. Cooper
Study supervision: S.A. Duffy

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