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An Online Skin Cancer Risk-Reduction Intervention for Young Adults: Mechanisms of Effects

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Abstract

Objective—The study's purpose was to investigate moderator, implementation, and mediator variables related to the efficacy of UV4.me, an internet intervention that decreased ultraviolet radiation (UV) exposure and increased skin protection behaviors among young adults.

Methods—Nine-hundred sixty-five 18-25 year olds at risk for skin cancer were recruited nationally online. Participants were randomized to an experimental website (UV4.me), a control website, or assessment only. Participant characteristics (moderators), engagement with and perceptions of interventions (implementation measures), and exposure and protection attitudinal variables (mediators) were assessed. Linear regression and mediation analyses were conducted.

Results—Intervention effects on skin protection were greater for participants with a family history of skin cancer ($p = 0.01$). Intervention effects on UV exposure were greater among recent indoor tanners ($p = 0.04$). Improvements in skin protection (but not UV exposure) were associated with perceiving the interventions as satisfying or helpful (ps< .01). The experimental group had better outcomes if they completed more modules (ps< .01) or set more behavioral goals (ps< .01). Knowledge and exposure decisional balance mediated intervention effects for UV exposure (ps < 0.05), and protection decisional balance, self-efficacy, and intentions mediated intervention effects for protection (ps < 0.05).

Conclusions—The experimental intervention was more efficacious for certain high risk groups. The more individuals liked and engaged with the interventions (e.g., by setting goals), the better their outcomes. Mediation results inform theory about change mechanisms and differed by behavioral outcome.

Keywords

intervention mechanisms; skin cancer prevention; young adults; online intervention

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Introduction

Skin cancer is the most common cancer, with nearly five million diagnoses annually in the US, and its incidence has been increasing in recent years (Gordon, 2013; Nikolaou & Stratigos, 2014; Tuong, Cheng, & Armstrong, 2012; USDHHS, 2014). Most skin cancers are caused by ultraviolet radiation (UV) exposure from the sun and indoor tanning and are therefore preventable (Cummings, Tripp, & Herrmann, 1997). It is common for young adults (e.g., aged 18-25 years) to expose themselves to large amounts of natural and artificial UV without proper skin protection (e.g., wearing adequate sunscreen) (Buller et al., 2011; Coups, Manne, & Heckman, 2008; C. J. Heckman, Coups, & Manne, 2008; Stanton, Janda, Baade, & Anderson, 2004). For these reasons, it is important for interventions to be available that are effective in addressing skin cancer risk behaviors among young adults.

With approximately 97% of US young adults using the internet (Pew_Research_Internet_Project, 2014), and the evidence for the impact of internet interventions in improving health behaviors (Tate, Finkelstein, Khavjou, & Gustafson, 2009), the internet is an appropriate modality with which to reach young adults and explore the efficacy of a skin cancer risk reduction intervention for this population. We developed the first web-based intervention to modify skin cancer risk and protective behaviors targeted specifically for young adults (ages 18-25 years), which was informed by the Integrative Model for Behavioral Prediction (IM), which is based on other models such as the theory of reasoned action and the theory of planned behavior (Fishbein, Hennessy, Yzer, & Douglas, 2003). Constructs from the IM that can be considered in skin cancer prevention interventions because of their association with skin cancer risk and protective behaviors include demographics; past UV-related behavior; attitudes such as appearance consciousness (Arthey & Clarke, 1995; Reynolds, 2007); other individual difference variables (e.g., knowledge); UV-related beliefs (Cafri, Thompson, & Jacobsen, 2006; Danoff-Burg & Mosher, 2006; J. Hillhouse, Turrisi, Stapleton, & Robinson, 2008; J. J. Hillhouse, Turrisi, & Kastner, 2000; Mahler, Kulik, Butler, Gerrard, & Gibbons, 2008; Olson, Gaffney, Starr, & Dietrich, 2008; Thieden, Philipsen, Sandby-Moller, & Wulf, 2005); norms (Arthey & Clarke, 1995; Borland & Hill, 1990), self-efficacy (Gritz et al., 2006; Hay et al., 2006; James, Tripp, Parcel, Sweeney, & Gritz, 2002; Myers & Horswill, 2006; Stryker et al., 2004); and intentions (Myers & Horswill, 2006). For example, one meta-analysis found that viewing photo-aging information, intended to impact perceived susceptibility to photo-aging beliefs as well as UV exposure and skin protection intentions, was associated with decreased indoor tanning (Williams, Grogan, Clark-Carter, & Buckley, 2013). Thus, one module of the experimental intervention program (UV4.me) focused on photo-aging (the negative effects of UV exposure on appearance). Additionally, UV4.me was targeted to young adults, personally tailored, and included interactive, multimedia, and goal-setting components.

The experimental intervention was efficacious in significantly decreasing UV exposure and increasing skin protection behaviors among young adults at risk of skin cancer in a national randomized controlled trial conducted from March to October of 2014 (Heckman, Darlow, Ritterband, Handorf, & Manne, 2016). Relatively few studies have directly investigated moderators or mediators of successful UV exposure and skin protection intervention

packages. The purpose of the current study was to investigate moderator, implementation, and mediator variables related to the intervention effects in the prior trial. Participant characteristics (moderators, Aim 1), engagement with and perceptions of the interventions (intervention implementation measures, Aim 2), and UV and protection attitudinal variables from the IM (mediators, Aim 3) were assessed. For the first aim, potential moderators that were consistent with the IM were selected that would not be likely to change during the course of the intervention but that could be associated with outcomes. These included demographic and background variables, cognitive variables, and past UV exposure behaviors. It was hypothesized that intervention effects would be moderated by variables that have been associated with skin cancer risk behaviors previously (age, sex, race/ethnicity, family history of skin cancer, skin cancer risk, appearance concern, indoor tanning, sunburn) and not moderated by variables that are not clearly associated with risk (level of education, difficulty living on income, health literacy, sensation seeking). For example, individuals with a higher score on a skin cancer risk scale would be expected to benefit more from the experimental intervention than those with lower scores who might experience a ceiling effect; whereas, we attempted to create an intervention that would be appropriate for individuals with a wide range of health literacy levels. For the second aim, it was hypothesized that implementation variables such as a higher level of participant engagement (e.g., module completion and goal setting) and satisfaction with the interventions would be associated with better behavioral outcomes. Finally, for the third aim, potential mediators included IM constructs such as knowledge, attitudes, normative beliefs, self-efficacy, and intentions, all of which were expected to be associated with changes in UV exposure and skin protection outcomes. For example, it was expected that the experimental intervention would increase knowledge, increase positive and decrease negative attitudes toward skin protection, decrease positive and increase negative attitudes toward tanning, decrease perceived norms for tanning, increase self-efficacy for UV avoidance and skin protection, and increase intentions for skin protection, which in turn would be associated with improved UV exposure and skin protection outcomes.

Methods

Participants and Procedures

Study methods and interventions have been described previously elsewhere (Heckman, Darlow, Ritterband, Handorf, & Manne, 2016)). Briefly, participants were recruited nationally online by a consumer research company, Survey Sampling International (SSI), using their US consumer opinion panel and partnerships with other panels and online communities. SSI panelists were exposed to brief web banner ads about the study from which they could click to link to the study website. Once at the study website, interested candidates were asked to complete the Brief Skin Cancer Risk Assessment Tool (BRAT), (Glanz et al., 2003) which was scored automatically. Eligible participants were 18-25 years old, had never had skin cancer, and were at moderate to high risk of developing skin cancer based on the BRAT (Glanz et al., 2003). After completing a baseline survey (n = 965), participants were randomized to one of three treatment conditions: the experimental intervention website, a control website, or assessment only. The experimental website (UV4.me) is based on the Integrative Model of Behavioral Prediction (IM) (Fishbein et al.,

2003) and includes 12 main content-oriented modules and several other types of modules and activities (e.g., an avatar) targeted to young adults, personally tailored, and including interactive, multimedia, and goal-setting components. The twelve main modules were: 1. Why do people tan? 2. To tan or not to tan? 3. Indoor tanning, 4. UV & health, 5. Skin cancer, 6. UV & looks, 7. Skin damage, 8. Shade, 9. Clothes, 10. Sunscreen, 11. Sunless tanning, and 12. Skin exams. Constructs from the Integrative Model (Fishbein et al., 2003) were incorporated throughout the modules. For example, in the indoor tanning module, we provided data showing that most young adults do not indoor tan in order to attempt to influence normative beliefs about indoor tanning. The control website was the Skin Cancer Foundation website (SCF; http://www.skincancer.org). Participants completed assessments at baseline in the spring of 2014 (March-June), three weeks after baseline (April-July), and twelve weeks after baseline (June-Oct). This project was approved and monitored by a cancer center's Institutional Review Board, and informed consent was obtained from research participants. Data were collected in 2014 and analyzed 2015-16. The trial was registered with ClinicalTrials.gov (identifier NCT02147080).

Measures

Behavioral Outcomes—These items were administered at baseline and 12-week follow-up.

Skin Protection: Participants were first asked whether they had been outdoors for more than a few minutes at a time in the past month. If answered in the affirmative, the following sun protection behaviors were assessed, using a seven-item scale adapted from Glanz and colleagues (Glanz et al., 2008): wearing sunscreen with an SPF of 15 or more on the face, wearing sunscreen with an SPF of 15 or more on other parts of the body, wearing a shirt with sleeves that cover the shoulders, wearing long pants, wearing a hat, wearing sunglasses, and staying in the shade. Participants indicated how often they engaged in these behaviors over the past month (1 = "Never"; 5 = "Always"). This measure was internally consistent in our sample (Cronbach's alpha = 0.76).

UV Exposure: Participants were asked to indicate how often they engaged in five UV exposure behaviors [wearing clothes that expose the skin to the sun, sunbathing, getting a tan just by being outdoors (i.e., unintentional tanning), tanning indoors, and using products to get a faster or deeper tan] over the past month (1 = "Never"; 5 = "Always"), using a five-item scale adapted by Ingledew and colleagues (Ingledew, Ferguson, & Markland, 2010). This measure had acceptable internal consistency in our sample (Cronbach's alpha = 0.74).

Moderators

Demographic and background: Age, sex (female vs. male), race/ethnicity (dichotomized as white non-Hispanic vs. not), first degree family history of skin cancer (yes vs. no), skin cancer risk (moderate vs. high risk on the 9-item BRAT (Glanz et al., 2003); education (dichotomized as at least a four-year college degree vs. not), and difficulty living on total income (dichotomized as 1,2 = not at all hard, somewhat hard and 3-5 = hard, very hard, extremely hard or impossible) were assessed at baseline. BRAT skin cancer risk items included personal skin cancer history (ineligible), hair and skin color, sensitivity to burning

and tanning, number of moles and freckles, lifetime sunburn history, and climate of childhood residence.

Cognitive: Cognitive variables included appearance concern, health literacy, and sensation seeking and were assessed at baseline. Appearance concern was assessed using the eight-item body surveillance subscale of the Objectified Body Consciousness Scale (Cronbach's alpha = .91), which includes items designed to assess concerns about and preoccupation with one's appearance (McKinley & Hyde, 1996). Health literacy in terms of problems with understanding personal health information and confidence in filling out medical forms was assessed using three items adapted from Chew and colleagues (Chew, Bradley, & Boyko, 2004). This is a well-validated measure of health literacy (Chew et al., 2004). Cronbach's alpha in our sample was 0.69. Sensation seeking or a tendency towards risky activities was assessed with three items from Harden and colleagues (Harden, Quinn, & Tucker-Drob, 2012) and one item from Whiteside and Lynam (Whiteside & Lynam, 2001). Cronbach's alpha in our sample was 0.81.

Behavioral: Frequencies of indoor tanning in the past month and sunburn in the past month (both dichotomized as 0 vs. ≥1 time due to non-normality) were reported by participants at baseline.

Implementation Measures—Whether participants actually accessed their assigned intervention online or not was recorded automatically by the online system for all experimental and control participants. The following variables were available for the experimental condition only: the specific modules completed (e.g., skin cancer, indoor tanning, sunscreen), the number of modules completed (out of 12), and the number of modules at the end of which behavioral goals were set.

The following variables were assessed among both the experimental and control conditions via questionnaire at 3-week follow-up. The Internet Intervention Adherence Questionnaire assessed problems experienced with accessing and using the intervention program (Ritterband et al., 2008). Cronbach's alpha in our sample was 0.93 (16 items). The Internet Evaluation and Perceived Utility Questionnaire assessed how useful, enjoyable, understandable, and easy to use participants perceived the intervention to be (Ritterband et al., 2008). Cronbach's alpha in our sample was 0.69 (13 items). The Perceived Internet Impact and Effectiveness Questionnaire assessed the perceived helpfulness of the intervention (Ritterband et al., 2008). Cronbach's alpha in our sample was 0.93 (12 items).

Mediators—Knowledge about skin cancer and its risk factors was measured using 11 items adapted from Buller and colleagues (Buller et al., 2006), Irwin and colleagues (Irwin, Mauriello, Hemminger, Pappert, & Kimball, 2007), and one investigator-created item ("Even if a sunscreen says it's "water-resistant," you still need to re-apply after swimming."). Response options for each item were true, false, and not sure or strongly disagree to strongly agree, with each item scored as correct or not. Likert-type item responses were collapsed for scoring. For example, "People cannot die from skin cancer" was scored correctly if the response was disagree or strongly disagree. This produced a proportion correct ranging from 0 to 1 (split-half reliability = 0.83, range = 0.75-0.86).

Beliefs and attitudes: An exposure decisional balance scale was created by subtracting the average of the perceived cons of UV exposure from the pros of UV exposure. Pros of UV exposure was assessed using the appearance and health subscales of the tanning motivation measure by Ingledew and colleagues (Ingledew et al., 2010). Cronbach's alpha in our sample was 0.91 (14 items). Cons of UV exposure was assessed using the 5-item photoaging subscale of the Physical Appearance Reasons for Tanning Scale by Cafri and colleagues (Cronbach's alpha = 0.85) (Cafri et al., 2006). Cronbach's alpha of the decisional balance scale was 0.89. A protection decisional balance scale was created by subtracting the average of the perceived cons of skin protection from the pros of protection. Pros of UV skin protection was assessed using the appearance and health subscales of the sun protection motivation measure by Ingledew and colleagues (Ingledew et al., 2010). Cronbach's alpha in our sample was 0.92 (9 items). Cons of sun protection was assessed using eight items from Robinson and colleagues (N. G. Robinson et al., 2008) and nine items from Buller and colleagues (Buller, Buller, Beach, & Ertl, 1996). Cronbach's alpha in our sample was 0.81. Cronbach's alpha of the decisional balance scale was 0.84.

Norms: Perceived exposure and protection norms for significant others was measured using five items adapted from Hillhouse and colleagues (J. J. Hillhouse et al., 2000), Jackson and Aiken's Sunbathing Norm Scales (Jackson & Aiken, 2006), and Ingledew and colleagues (Ingledew et al., 2010). Cronbach's alpha in our sample was 0.80. Perceived societal norms for UV exposure and protection was assessed using three items adapted from Jackson and Aiken (Jackson & Aiken, 2006). Cronbach's alpha in our sample was 0.81. The norms scores for society and significant others were averaged to create a final norms score. Higher scores indicate more perceived support for tanning and a tanned appearance.

Self-efficacy: Six items for assessing self-efficacy for using sun protection and avoiding UV exposure were adapted from a measure by Maddock and colleagues (Maddock, Redding, Rossi, & Weinstock, 2005). Cronbach's alpha in our sample was 0.77.

Behavioral intention: Three items adapted from Mahler and colleagues (Mahler, Kulik, Gerrard, & Gibbons, 2010) were used to assess intentions to engage in sun protection behaviors such as wearing sunscreen. Two items were developed by the investigators to assess intentions for self and healthcare provider skin cancer examination. Cronbach's alpha in our sample was 0.76.

Analyses—For exposure and protection outcomes at 12-week follow-up, moderation was tested using linear regression, with an interaction between treatment and each of the moderating variables assessed at baseline. We included 2 categorical indicators for treatment (control and experimental, with assessment being the referent group), so for each level of each potential moderator, there were 2 separate interaction terms (a simple contrast coding system). To avoid over-fitting, three models were fit for each outcome, where the model contained all pre-specified moderators within the category (demographics and background, cognitive, behavioral). Likelihood ratio tests were used to determine whether the overall interaction effect of treatment type and each moderator was statistically significant at p=0.05. Final models were then created containing only significant interaction terms.

Descriptive analyses of implementation variables were conducted. Linear regressions were conducted to assess potential associations between implementation variables and behavioral outcomes. These outcomes were measured as difference between baseline and 12-week follow-up exposure and protection behaviors. LASSO regression was used to identify specific modules that were most associated with intervention effects (Tibshirani, 1996). This procedure is a modification of ordinary least squares regression, which shrinks covariates toward zero, allowing the subset of most predictive variables to be chosen from a number of correlated variables, as is the case with the implementation variables.

Seven variables were assessed that could potentially mediate the effect of treatment on primary outcomes of exposure and protection behaviors. Briefly, to be considered a mediator, the following conditions must hold. 1) The treatment is correlated with outcome (exposure and protection at 12-weeks), 2) The treatment is associated with the mediator, 3) The mediator affects the outcome, and 4) After controlling for the mediator, the relationship between treatment and outcome is attenuated.

Each of the mediators were first tested separately to determine which variables were of interest. Statistically significant variables were then used in the main model, where all mediators were simultaneously tested using a multiple mediation models (Preacher & Hayes, 2008). This allowed us to estimate the total indirect effect, and account for correlation between the potential mediators. We used the product-of-coefficients approach to estimate effects, and a percentile bootstrap was used to determine significance of all indirect effects in both the single and multiple mediation models. As in other analyses, treatment was coded as a 3-level variable with the assessment only condition being the referent group, although the effects of the experimental condition were of primary interest.

Results

Descriptive data are presented in Table 1.

Moderator Results

For exposure and protection outcomes at 12 weeks, 594 and 545 participants had complete data, respectively. Baseline responses were used for each moderator. Based on the regression models, in the demographics category, a family history of skin cancer was associated with greater protection at 12 weeks in the experimental arm only (interaction effect = 0.48, p=0.012). Approximately 36% of the sample reported a family history of skin cancer, and this proportion did not vary significantly by intervention condition. Family history was not associated with higher protection scores in the assessment only arm, or in the control arm. For the behavioral moderators, a significant interaction between treatment and having indoor tanned in the past month at baseline was found. In the assessment only condition, participants who reported having indoor tanned in the past month at baseline had substantially higher UV exposure scores at 12 weeks (1.18, $p<0.0001$) compared with those who reported no indoor tanning at baseline. However, in both the control arm and the experimental arm, this effect was attenuated (interaction effects: −0.66, −0.515, p= 0.006, 0.038, respectively). In other words, individuals who had indoor tanned in the past month at baseline reported lower UV exposure at 12 weeks in the control and experimental arms

compared to the assessment only arm. See Figure 1 for a depiction of the significant moderator effects. None of the cognitive moderators demonstrated significant interaction, nor did any other demographic or behavioral moderators. However, the study may have lacked power to detect more modest effects of moderators.

Implementation Results

Implementation analyses included data from participants who accessed one of the interventions (i.e., not the assessment only group) and completed the 12-week follow-up questionnaire. Approximately 84% of participants randomized to the control website accessed it, and approximately 70% of experimental participants accessed the intervention materials. Participants reported spending approximately 1.5 hours on the control website and a little over 3 hours on the experimental website.

In the experimental group, approximately 32% accessed the intervention but completed no modules, and 22% completed all 12 main modules. On average, experimental participants accessed 5.8 (SD = 5.0) and completed 5.7 (SD = 5.0) out of the 12 main modules. Note that an average of only 2.7 modules was recommended to participants based on tailoring (e.g., the indoor tanning module was recommended to indoor tanners). The modules that were completed most frequently were “Why do people tan?”, “UV and health”, and “Sunless tanning” (77-90% of participants). The modules completed least often were “Skin damage”, “Shade”, and “Clothes” (45-65%).

Only approximately 6% of experimental participants set no behavioral goals (e.g., indoor tan less frequently) at the end of any module. Approximately 15% of participants set a goal at the end of all 12 modules. A greater decrease in exposure or a greater increase in protection was associated with completing more modules ($t(1) = -3.96$ for exposure and 2.89 for protection, $ps < 0.01$) and setting more goals (Wald chi-square (1) = 14.54 for exposure and 8.99 for protection, $ps < 0.01$).

Completion of any of nine of the twelve modules was associated with improvements in UV exposure and/or skin protection. Using LASSO selection, the modules that were most strongly associated with behavioral improvements were “Indoor tanning” and “Sunscreen” for UV exposure and “To tan or not to tan”, “Sunless tanning”, “Shade”, and “Sunscreen” for skin protection. The only modules that were not associated with behavior change were “Why do people tan?”, “Clothes”, and “Skin exams”. However, when associations between module completion and individual items rather than multi-item scales were examined, completion of the “Skin exam” module was found to be associated with greater increases in self ($p = 0.003$) but not provider skin examination.

Perceived intervention utility and impact were high (4.1-4.3 out of 5), and perceived intervention adherence problems were low (1.3 out of 5). Perceived intervention adherence, utility, and impact did not differ significantly between the two active intervention groups. Greater participant perception of utility or impact of both interventions was significantly associated with greater increases in skin protection (chi squares ranged from 10.57 to 20.22, $ps < 0.01$) but was not associated with UV exposure. Greater perceived problems with intervention adherence were associated with smaller increases in skin protection and smaller

decreases in UV exposure only for experimental participants (chi square = 11.05 for exposure and 5.17 for protection, ps < 0.05).

Mediator Results

The seven potential mediators were first tested separately. For both outcomes, only the experimental treatment was significantly associated with outcome, while the control arm showed no significant differences from assessment only. Therefore, although all data was included while estimating parameters in the mediation models, all mediation effects described below are only for the experimental intervention.

For the exposure outcome, 519 participants (n = 157 in the experimental condition) had complete data on each mediator at three weeks and 12-week exposure behavior. Using independent mediation analyses, five of the six mediators met preliminary requirements to be tested in multiple mediation models: knowledge, exposure decisional balance, protection decisional balance, self-efficacy, and intentions.

In multiple mediation models (Table 3), a significant total indirect effect through these five mediators (-0.155, 95% CI: −0.256, −0.061) was found. This effect was mainly driven by two of the five mediators: knowledge and exposure decisional balance. These two variables met all criteria for mediation within the multiple mediation framework, and had statistically significant indirect effects of −0.057 (95% CI: −0.120, −0.002) and −0.076 (95% CI: −0.135, −0.027), respectively. The total effect of the experimental treatment on exposure was −0.309. Of this, −0.155 was mediated through the five variables, with a remaining direct effect of −0.154. This direct effect was still statistically significant after including the five potential mediators (p=0.031), indicating that the overall effect of the intervention was partially, but not fully, mediated by the variables described above.

For protection, 478 participants (n = 157 in the experimental condition) had complete data on each mediator at three weeks and 12-week follow up. Using independent mediation analyses, four of the six mediators met mediation criteria: exposure decisional balance, protection decisional balance, self-efficacy, and intentions.

In multiple mediation models, a significant total indirect effect through these four mediators (0.234, 95% CI: 0.142, 0.339) was found. This effect was mainly driven by three of the four mediators: protection decisional balance, self-efficacy, and intentions. These variables met all criteria for mediation within the multiple mediation framework, and had statistically significant indirect effects of 0.080 (95% CI: 0.019, 0.161), 0.081 (95% CI: 0.031, 0.161), and 0.073 (95% CI: 0.022, 0.137), respectively. The total effect of the experimental treatment on protection was 0.505. Of this, 0.234 was mediated through the four variables, with a remaining direct effect of 0.271. This direct effect was statistically significant after including the four potential mediators (p=0.004), indicating that the overall effect of the intervention was partially, but not fully, mediated by the variables described above.

Discussion

This study's purpose was to investigate moderator, implementation, and mediator variables associated with the efficacious UV4.me skin cancer risk reduction intervention. The national sample was at moderate to high risk for skin cancer with 54% reporting having been sunburned in the last 30 days prior to the baseline survey.

Moderators

Based on the findings from the moderator analyses for aim 1, better outcomes were reported by individuals randomized to the experimental intervention among certain high risk groups including individuals with a family history of skin cancer and those who reported indoor tanning in the last 30 days at baseline. However, this varied by behavioral outcome. Interestingly, protection was greater among individuals with a family history of skin cancer, and overall UV exposure was lower among indoor tanners. It is important to note that differences were not found for other groups such as women and men, who have less often been the focus of skin cancer prevention interventions. Similarly, though prior research has most commonly focused on college women, the current study did not find moderator effects by age, education level, difficulty living on income, or health literacy. Prior studies of moderation in skin cancer prevention interventions have focused primarily on relationship variables in dyadic interventions including patients and partners or children and parents (Hultgren, Turrisi, Mallett, Ackerman, & Robinson, 2016; Robinson, Stapleton, & Turrisi, 2008; Turrisi, Hillhouse, Robinson, Stapleton, & Adams, 2006). However, one study found that an appearance-focused workbook reduced indoor tanning specifically among low-knowledge female college indoor tanners (Stapleton, Turrisi, Hillhouse, Robinson, & Abar, 2010). In the current study, knowledge was found to be a significant mediator of intervention effects on UV exposure (see below). Another study by the same group found moderating effects of reported opiate-like reactions to tanning and dissatisfaction with natural skin tone (J. Hillhouse, Turrisi, Stapleton, & Robinson, 2010), which were not assessed in the current study.

Implementation

In terms of implementation variables included in aim 2, most participants accessed an intervention, UV4.me participants completed an average of 5.7 of the 12 available modules (which is typical for web-based health interventions (Cugelman, Thelwall, & Dawes, 2011; Kelders, Kok, Ossebaard, & Van Gemert-Pijnen, 2012)), and most experimental participants set a behavioral goal. Completion of most of the individual modules or a greater number of modules was associated with greater improvements in exposure and/or protection outcomes.

The somewhat lower intervention access rate for the experimental intervention group overall is probably due to being required to first access instructions and items required for intervention tailoring before actually accessing the intervention materials. Within the experimental group, there are several potential reasons why participants may have completed specific modules more or less frequently than others. Each module was recommended based on responses to tailoring items. For example, if participants reported that they liked "the look of tanned skin better than untanned skin", they were recommended to view the

"Sunless tanning" module. "Why do people tan?" was recommended to all experimental participants to ensure that at least one module was recommended to everyone regardless of their responses to the tailoring items. In terms of the association of specific modules and behavior change, one of the modules that was not associated with outcomes was the "Clothes" module. A prior meta-analysis found evidence for the efficacy of behavioral interventions on sun exposure, sunburns, and sun protection in general but not for wearing protective clothing specifically (Rodrigues, Sniehotta, & Araujo-Soares, 2013). Perhaps this behavior is more difficult to modify because wearing protective clothing on hot, sunny days is unappealing. However, the "Clothes" module was also completed less often than some of the other modules, thus potentially limiting its effects on behavior.

Finally, regarding intervention implementation, participants perceived the interventions similarly favorably. Interestingly, greater participant perception of utility or impact of both interventions was significantly associated with greater improvements in skin protection but was not associated with UV exposure. Perceived problems with intervention adherence such as low motivation to use or difficulty using the website due to computer or internet problems was associated with less improvement in behavioral outcomes for the experimental group. This may have been in part because the control website had a more familiar layout and navigation scheme that is typical of an informational website, as opposed to the experimental website, which was highly interactive. The study of implementation of online interventions is especially important given the potential for cost-effective dissemination yet sometimes low observed uptake of such interventions (Cugelman et al., 2011; Kelders et al., 2012) . Few prior studies have assessed implementation of skin cancer prevention or control interventions and have found participant-perceived intervention credibility, interventionist-perceived treatment alliance, and various intervention components (e.g., viewing a video) to be associated with behavior change (C. J. Heckman et al., 2013; Lee, Weinstock, & Risica, 2008).

Mediators

For aim 3, intervention effects on UV exposure were found to be partially mediated by knowledge and exposure decisional balance; whereas, effects on protection were partially mediated by protection decisional balance, self-efficacy, and intentions. Similar to the current study, a prior study found several tanning and skin cancer related attitudes to mediate the effects of an appearance-focused workbook on indoor tanning among female college students but also identified normative beliefs as mediators (J. Hillhouse et al., 2008). It is somewhat surprising that norms were not found to be mediators in the current study given that people tan primarily for appearance enhancement and other socially-oriented reasons. Additionally, though exposure and protection are essentially "two sides of the same coin", their mechanisms of change appear to be slightly different from one another. However, perceived pros and cons of exposure or protection were important to each. A prior study found that, although the pros of exposure or protection did not individually mediate the effects of an intervention on the protection behaviors of adolescents, their decisional balance (pros of protection minus pros of exposure) did (Adams, Norman, Hovell, Sallis, & Patrick, 2009). Self-efficacy may have emerged as a mediator of intervention effects for protection but not exposure perhaps because simply avoiding a behavior such as tanning is somewhat

easier than actively engaging in a behavior such as skin protection. Additionally, the intentions scale that was used here pertained only to protection and not exposure, so it makes sense that it would mediate effects for protection only.

Study Strengths, Limitations, and Conclusions

Study strengths are that it is based on a large national RCT and assessed several different types of variables informed by theory. The limitations of the study are that it focused only on 18-25 year olds, many of whom were female. However, this is a high risk population for skin cancer risk behaviors. Additionally, the sample was recruited from a commercial research panel, though several studies have shown similar demographic representativeness and follow-up rates comparable to traditional recruitment methods (Gardner et al., 1996; West et al., 2006). Finally, self-report methods were used for outcome assessments. However, several studies have demonstrated the reliability and validity of self-report questionnaires of UV exposure and protection compared to observation and objective measures with no systematic bias identified among various populations (Glanz et al., 2010; O'Riordan et al., 2009).

In summary, the present study demonstrated better outcomes in the experimental group for high risk young adults including those with a family history of skin cancer and indoor tanners. Future studies should include more generalizable (non-commercial) samples. The study confirmed the importance of implementation variables such as engagement in (and specifically goal setting) and satisfaction with online interventions to outcomes (Crutzen et al., 2011; Cugelman et al., 2011; Kelders et al., 2012; Schubart, Stuckey, Ganeshamoorthy, & Sciamanna, 2011). The field might benefit from interventions focused on increasing the use of protective clothing (Rodrigues et al., 2013). The current study extends the prior literature on specific theoretical change mechanisms that have been investigated in RCTs related to skin cancer prevention beyond melanoma patients, parents, and female college students to young adults in general. Interventions that improve knowledge, attitudes/beliefs, and self-efficacy can improve skin cancer risk and protective behaviors.

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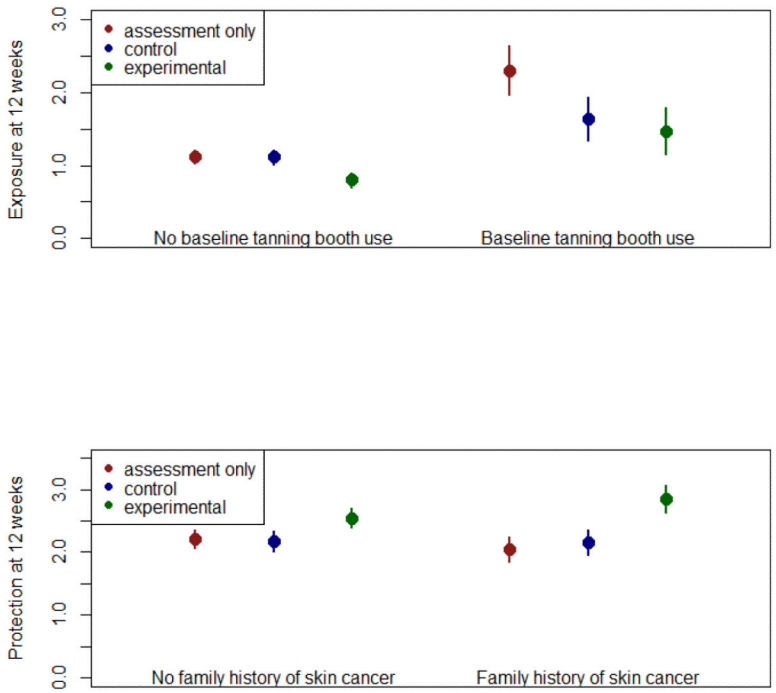

Figure 1.
Moderator Results

Table 1

Descriptive Statistics for Variables of Interest

BEHAVIORAL OUTCOMES (n = 594 with data at both baseline and 12-weeks)		**Possible Range**
Exposure, M (SD)	Baseline = 1.45 (0.79) 12 weeks = 1.09 (0.75)	0-4
Protection, M (SD)	Baseline = 1.88 (0.78) 12 weeks = 2.3 (0.90)	0-4
MODERATORS (assessed at baseline, n = 594 with data at both baseline and 12-weeks)		
Demographic		
Age in years, M (SD)	21.98 (2.15)	18-25
Male sex, % (n)	24 (145)	
White non Hispanic, % (n)	82 (490)	
Family history of skin cancer % (n)	36 (214)	
High risk of skin cancer, % (n)	44 (262)	
College Degree, % (n)	21 (125)	
Not hard to live on income, % (n)	37 (218)	
Cognitive		
Appearance Concern, M (SD)	3.19 (0.74)	1-5
Health Literacy, M (SD)	3.38 (0.69)	0-4
Sensation Seeking, M (SD)	3.39 (0.86)	1-5
Behavioral		
Indoor Tanned Last Month, % (n)	9 (55)	
Sunburned Last Month, % (n)	54 (319)	
IMPLEMENTATION VARIABLES (n = 344 who accessed an intervention and had data at 12 weeks)		
Accessed Intervention, % (n)	78 (487)	
# of Modules Completed, M (SD) (UV4.me only)	5.7 (5.0)	0-12
# of Goals Set, M (SD) (UV4.me only)	7.3 (4.0)	0-12
Perceived Adherence (problems)	1.27 (0.40)	1-5
Perceived Utility	4.14 (0.69)	1-5
Perceived Impact	4.20 (0.77)	1-5
MEDIATORS (assessed at 3-weeks, n = 519 with data at both 3 and 12 weeks)		
Knowledge, M (SD)	0.90 (0.17)	0-1
Exposure Decisional Balance, M (SD)	−1.53 (1.68)	−4-4
Protection Decisional Balance, M (SD)	0.99 (1.58)	−4-4
Norms, M (SD)	3.3 (0.69)	1-5
Self-efficacy, M (SD)	3.44 (0.88)	1-5
Intentions, M (SD)	4.12 (0.69)	1-5

Table 2

Association of Module Completion with Change in Behavioral Outcomes from Baseline to 12-week Follow-up (n = 183 for UV exposure and 161 for skin protection)

Module and Outcomes	Participants who did not complete module	Participants who completed module	Difference between completers and non-completers	p-value
Why do people tan?				
Change in protection	0.45	0.76	0.31	0.133
Change in exposure	−0.22	−0.53	−0.30	0.196
UV and Health				
Change in protection	0.25	0.82	0.57	0.0166
Change in exposure	−0.15	−0.56	−0.41	0.0368
UV and Looks				
Change in protection	0.38	0.85	0.46	0.02
Change in exposure	−0.21	−0.59	−0.38	0.0167
Skin Cancer				
Change in protection	0.61	0.80	0.19	0.2006
Change in exposure	−0.30	−0.61	−0.31	0.0071
Skin Damage				
Change in protection	0.65	0.81	0.16	0.2293
Change in exposure	−0.37	−0.64	−0.27	0.0251
Indoor Tanning				
Change in protection	0.50	0.87	0.37	0.0147
Change in exposure	−0.22	−0.66	−0.43	0.0009
To Tan or Not to Tan				
Change in protection	0.36	0.86	0.50	0.006
Change in exposure	−0.18	−0.61	−0.43	0.0017
Sunless Tanning				
Change in protection	0.21	0.84	0.64	0.0045
Change in exposure	−0.28	−0.54	−0.26	0.1597

Module and Outcomes	Participants who did not complete module	Participants who completed module	Difference between completers and non-completers	p-value
Shade				
Change in protection	0.47	0.91	0.44	0.0008
Change in exposure	−0.31	−0.62	−0.32	0.0058
Sunscreen				
Change in protection	0.34	0.86	0.53	0.0054
Change in exposure	−0.13	−0.62	−0.49	0.0008
Clothes				
Change in protection	0.64	0.80	0.16	0.2867
Change in exposure	−0.37	−0.60	−0.23	0.0628
Skin Exams				
Change in protection	0.48	0.80	0.32	0.1179
Change in exposure	−0.28	−0.56	−0.28	0.1471

Table 3

Mediator Results (n = 519 for UV exposure and n = 478 for skin protection)

Skin Protection	**Effect**	**p-value**
Total indirect effect	0.23	<0.001
Exposure decisional balance	0.00	0.958
Protection decisional balance	0.08	0.012
Self-efficacy	0.08	<0.001
Intentions	0.07	<0.001
Direct effect	0.27	0.004
Total effect (Direct + Indirect)	0.50	<0.001
UV Exposure	**Effect**	**p-value**
Total indirect effect	−0.15	0.004
Knowledge	−0.06	0.044
Exposure decisional balance	−0.08	0.004
Protection decisional balance	−0.02	0.296
Self-efficacy	−0.03	0.162
Intentions	0.03	0.072
Direct effect	−0.15	0.031
Total effect (Direct + Indirect)	−0.31	<0.001