AN ABSTRACT OF THE DISSERTATION OF

Anne K. Julian for the degree of Doctor of Philosophy in Public Health presented on May 4th, 2017.

Title: Measuring Health Beliefs About UV Exposure Among Oregon College Students

Abstract approved:

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Abstract text:

Exposure to ultraviolet (UV) radiation is a primary cause of melanoma and non-melanoma skin cancer and thus represents a critical public health concern. Skin cancer risk behavior research lacks an instrument designed to assess health beliefs about UV exposure that may increase skin cancer risk by increasing risky UV exposure and decreasing protective behaviors such as sunscreen use. The purpose of this dissertation was 1) to develop and validate a scale that measures health beliefs about UV related to health benefits of UV exposure, seasonal mood effects and concerns about the safety of sunscreen use, and 2) to describe the prevalence of such beliefs using the new scale, and examine the relationship of these beliefs to skin cancer risk behaviors.

The initial phase of this study included the development and revision an item pool through expert review and piloting. Oregon State University (OSU) undergraduate students (N = 114) completed the scale in a Qualtrics online survey. Five students completed additional item comprehension interviews. Then I incorporated pilot and interview data, examining item

performance and further refining the item pool. Finally, I administered the refined item pool online to OSU students (N = 335). With these data, I eliminated poorly performing items and analyzed the factor structure of the scale. In Manuscript 1, I describe the development and factor structure of the Health Beliefs About UV (HBAU) scale. The final scale includes eleven items that represent four factors which is named *Sunscreen Toxicity, Health Benefits of Tanning, Seasonal Effects* and *Tanning Through the Winter*. The final four-factor solution demonstrated excellent fit to the data (χ^2 = 36.43, *df* = 38, RMSEA = 0.000, CFI = 1.000, TLI = 1.003).

In Manuscript 2, I describe the prevalence of HBAU constructs in college students and use structural equation modeling to examine the relationship of the HBAU scale to skin cancer risk behaviors. Three of the subscales were associated with skin cancer risk behaviors in a model that adjusted for known covariates of UV exposure and sunscreen use. After adjusting for covariates, *Sunscreen Toxicity* predicted reduced sunscreen use (β = -.12, *p* = .021), *Health Benefits of Tanning* predicted outdoor tanning (β = .43, p < .001), and *Tanning Through the Winter* predicted indoor tanning (β = .31, *p* = .02).

These findings suggest that beliefs about benefits of UV exposure such as the belief that tanning before sun exposure is protective against skin cancer play a role in skin cancer risk behaviors. The scale developed was psychometrically sound and demonstrated the capacity to predict skin cancer risk behaviors in our final sample. Findings provide additional evidence that beliefs related to health benefits of sun exposure, the regional weather, and safety of sunscreen may play a role in skin cancer risk behaviors, and should be addressed in skin cancer prevention efforts.

Measuring Health Beliefs About UV Exposure Among

Oregon College Students

By

Anne Katherine Julian

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APPROVED:

Major Professor, representing Public Health

Head of the School of Social and Behavioral Health Sciences

Dean of the Graduate School

I understand that my dissertation will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my dissertation to any reader upon request.

Anne K. Julian, Author

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CONTRIBUTION OF AUTHORS

Two manuscripts from this work were written with contribution from other authors. Dr. Sheryl Thorburn provided guidance and feedback throughout the study design, data collection, writing and review phases of the work. For both manuscripts, Dr. John Geldhof provided statistical, methodological and analytic guidance, as well as editorial assistance and review of the final product.

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CHAPTER 1: INTRODUCTION

Overview and Context

Exposure to ultraviolet (UV) radiation has been identified as a risk factor for both melanoma and non-melanoma skin cancers (Gandini et al., 2005), and public health efforts aimed at reducing UV exposure and increasing protective behaviors have gained considerable momentum. Although a notable body of research exists examining correlates of indoor tanning behavior and use of sun protection among college students (Holman & Watson, 2013), and indoor tanning has increased in popularity among young adults in the past two decades (Robinson, Kim, Rosenbaum, & Ortiz, 2008), no validated scale exists to measure scientifically informed UV-related health beliefs, which may impact skin cancer risk and protection behaviors.

Public Health Significance

Skin cancer is the most commonly diagnosed cancer in the United States (U.S.), with an estimated 3.5 million cases of non-melanoma skin cancer (NMSC) and 76,000 cases of malignant melanoma annually (American Cancer Society, 2015). Furthermore, between 2002 and 2011, the number of people treated for any skin cancer increased from 3.4 million to 4.9 million (Guy, Machlin, Ekwueme, & Yabroff, 2015). During this same time period, NMSC and melanoma increased significantly among adults 65 years old and older, and melanoma increased among women aged 18-65 (Guy, Machlin, et al., 2015). Adolescent exposure to UV rays (from the sun and from indoor tanning) and history of sunburn increase risk of skin cancer in adulthood (Grant, Pope, & Moan, 2010).

Rising rates of skin cancer present a burgeoning public health cost. Average annual total expenditures for skin cancer increased from a yearly average of $3.6 billion between 2002-2006 to $8.1 billion in the years 2007-2011, an increase of 126.2% whereas cost for all other cancers increased by 25.1% during the same time period (Guy, Machlin, et al., 2015). Average annual total cost of treatment was $4.8 billion for NMSC and $3.3 billion for melanoma (Guy, Machlin, et al., 2015). A cost-effectiveness analysis of the SunWise School Program, a youth-focused component of the Environmental Protection Agency's Sunwise program, found that every dollar spent on the program would save $2-$4 in averted healthcare expenditures and lost productivity (Kyle et al., 2008).

Melanoma survival rates 10 years after diagnosis are as high as 92%-97% when it is detected early (Ali, Yousaf, & Larkin, 2013). Skin cancer is also highly preventable. Boniol, Autier, Boyle and Gandini's (2012) systematic review of the burden of skin cancer in Europe and the U.S. found that 6.9% of melanoma cases in women and 3.7% of melanoma cases among men could be attributed to indoor tanning alone. Furthermore, they found that a history of indoor tanning increased overall risk of melanoma by 20%, and indoor tanning before the age of 35 doubled risk of melanoma. Although genetics and family history contribute to skin cancer risk, the majority of skin cancer cases are attributable to UV exposure (Armstrong & Kricker, 2001; Reichrath, 2009). Skin cancer incidence varies by race, however. Whites are at as much as ten times higher risk for skin cancer than blacks, but melanoma in blacks is generally diagnosed at a later stage and has a higher mortality than among whites (Agbai et al., 2014; Battie, Gohara, Verschoore, & Roberts, 2013). Although five-year melanoma survival rates have increased for non-Hispanic whites from 82% in 1975-1977 to 93% between 2004-2010 (Howlader, Noone, & Krapcho, 2013), survival for blacks 2004-2010 was only 75%. Reduced access to insurance, preventive services, early detection and high quality treatment associated with low socio-economic status underlie this health disparity ("Cancer Facts and Figures 2015," 2015).

The U.S. Surgeon General recently issued a call to action to prevent skin cancer, which focuses on the preventable nature of skin cancer, addressing UV radiation specifically (U.S. Department of Health and Human Services [USDHHS], Office of the Surgeon General, 2014). Exposure to UV rays is a modifiable risk factor for skin cancer. Skin cancer prevention efforts commonly focus on reducing risk behaviors such as intentional outdoor and indoor tanning and increasing protective behaviors such as sun avoidance at midday, use of protective clothing, and use of sunscreen (Seidenberg, Mahalingam-Dhingra, Weinstock, Sinclair, & Geller, 2015). The Surgeon General proposes widespread effort at individual, community, and population levels to increase skin cancer awareness, restrict indoor tanning among minors, and increase sun protective behaviors (USDHHS, Office of the Surgeon General, 2014).

Indoor tanning and outdoor tanning both involve exposure to UV radiation, causing skin damage and increasing risk of skin cancer (Abdulla, Feldman, Williford, Krowchuk, & Kaur, 2005; Coelho & Hearing, 2010; Grant et al., 2010). The UV Index is an internationally accepted scale of irradiance that ranges in value from low (0-2) to medium (3-5), high (6-7), very high (8-10), and extreme (11+) and is calculated using McKinlay and Diffey's (McKinlay & Diffey, 1987) action-spectrum for *UV–induced erythema*, or sunburn. Hornung (2003) calculated the UV index of tanning bed emissions and found that tanning beds had, on average, a UV index of 14, and the highest output from a tanning bed equaled a UV index of 33. Ernst and colleagues reported that tanning lamps on average emit a UV index similar to the peak yearly UV index of Honolulu, HI and Phoenix AZ, but high-emission tanning beds emit more than twice the solar UV of either of these locations (Ernst, Grimm, & Lim, 2015). Although outdoor and indoor tanning present significant health risk, the risk associated with indoor tanning is undeniably greater.

Indoor tanning has become particularly popular in the U.S. since the 1980s (Schneider & Krämer, 2010), although prevalence of tanning differs by age, gender, and racial group. Indoor tanning is more common among women than men at all ages (Hartman, Guy, Holman, Saraiya, & Plescia, 2012; Wehner et al., 2014). Guy and colleagues reported that 20.9% of female and 6.2% of male high school students reported ever using a tanning bed (Guy, Tai, & Richardson, 2011). In adults, indoor tanning prevalence was 5.6% overall, and age-adjusted indoor tanning prevalence was higher among white women (12.9%) than white men (3.3%). The highest rates of indoor tanning (31.8% and 29.6%, respectively) are found in women aged 18-21 and 22-25 years (Hartman et al., 2012). Similarly, a comprehensive meta-analysis of indoor tanning estimated overall prevalence of ever-exposure to indoor tanning as 35.7% among adults, 19.3% for adolescents, and 55% among university students (Wehner et al., 2014). Furthermore, the same study found that prevalence of past-year use of a tanning device was 14% for adults, but 18.3% for adolescents and 43% for university students. Guy Jr. and colleagues (2011) found that white adolescents are more likely to tan than Hispanic and non-Hispanic black adolescents, with increasing prevalence every year of high school, a racial disparity that was observed among all age groups. Tanning salon density is higher in many cities than is the density of Starbucks or McDonalds (Palmer, Mayer, Woodruff, Eckhardt, & Sallis, 2002), and tanning salons are commonly found on or near college and university campuses (Pagoto et al., 2014). Additionally, universities in the South and East regions of the U.S. commonly include tanning salons among approved vendors for university-issued debit cards (Boyers et al., 2014). This study examined beliefs about UV exposure and their influence on indoor and outdoor UV exposure and protection behaviors among university students. Both indoor and outdoor UV exposure were included in this conceptualization of UV exposure. Spray tanning, self-tanning, and bronzing was not included because of the non-UV process by which the tan is generated in these tanning methods.

Significance of the Study

To date, much UV exposure research has focused on social and appearance-based motivations for intentional UV exposure. Mixed messages about the health effects of UV exposure in the past decade, however, necessitate further study of the effects of these messages on UV exposure behavior (Gilchrest, 2008). This need is particularly acute in geographical regions with high latitude, frequent cloud cover, and rainy winter seasons. This study describes the development, validation and application of the Health Beliefs About UV (HBAU) scale, a new instrument that has the potential to influence the field of skin cancer research by enabling measurement of beliefs about the health effects of UV exposure that may counteract public health efforts to promote cautious sun exposure for skin cancer risk reduction. This study offers an instrument for the measurement of beliefs that may influence individual evaluations of UV exposure risks and benefits, which may currently be either unmeasured or measured in varying ways, which leads to difficulty in comparison of results.

Communications about potential health benefits of vitamin D reflect a field that is still uncovering possible protective effects and optimal levels of vitamin D (Holick, 2007). Vitamin D production is often conflated in the media with happiness, improvement in mood, and general wellbeing (Caulfield, Clark, McCormack, Rachul, & Field, 2014), and the indoor tanning industry has consistently made unjustified vitamin D-related health claims to promote UV exposure (Autier, 2011). Seasonal affective disorder (SAD) is a form of depression that increases in severity in the winter months and remits during spring and summer, and it is more common at high latitudes (Kegel, Dam, Ali, & Bjerregaard, 2009; Levitt & Boyle, 2002).

Although oral administration of vitamin D for treatment of SAD has been studied in the general public and among people with low vitamin D (e. g., Frandsen, Pareek, Hansen, & Nielsen, 2014; Kjærgaard et al., 2012) with null results, vitamin D insufficiency has also been associated with depression (Berk et al., 2007; Bertone-Johnson, 2009). Subsequently, hypotheses have been made about a causal role of low vitamin D in SAD symptoms (Stewart, Roecklein, Tanner, & Kimlin, 2014); further research is needed to disentangle the role of vitamin D, UV exposure, and light in depression. Publications about the benefits of vitamin D have contributed to confusion about the appropriateness of UV exposure (Reichrath, 2009; Sivamani, Crane, & Dellavalle, 2009). Furthermore, the controversy about vitamin D sufficiency vis-a-vis cancer prevention is matched by messaging about the safety of sunscreen products, their ingredients, and their formulation, with some media sources suggesting that sunscreen use is itself the cause of skin cancer (Burnett & Wang, 2011). This work examines, in part, beliefs about vitamin D, SAD and sunscreen safety to identify any role these beliefs may have in determining individual skin cancer risk behaviors.

Several scales exist to measure tanning behaviors (Glanz, Yaroch, Dancel, & et al., 2008), tanning intentions and attitudes towards tanning (Cafri et al., 2008), and indoor tanning outcome expectations and beliefs (Noar, Myrick, Morales-Pico, & Thomas, 2014). Studies have also included items to determine whether participants know that UV exposure leads to vitamin D synthesis (Yoo & Hur, 2014; Youl, Janda, & Kimlin, 2009), and whether they feel that tanning lifts their mood (Noar et al., 2014; Yoo & Hur, 2014). No scale exists, however, that is designed to identify beliefs that promote UV exposure and discourage UV protection that are based in misinformation about the health effects of UV exposure. This gap in measurement may preclude the identification of key influences on skin cancer risk behaviors.

Western Oregon was the appropriate context for this study because of the region's geographical and cultural characteristics. Western Oregon has predominantly cloudy or rainy weather, with regions averaging between 39 and 88 inches of rain, and parts of the Cascades averaging up to 200 inches of rain annually ("Average Statewide Precipitation | Western U.S. States"). Furthermore, as much as half of Western Oregon's rainfall occurs during the Winter months, and rainfall between November and February averages between three and four inches per month. This study of beliefs about UV exposure, vitamin D, seasonal depression, and sunscreen use was conducted in an environmental context where the regional weather may increase the salience of messages about UV exposure and health. For this reason, and because of the prevalence of tanning among youth (Guy et al., 2011; Heckman & Coups, 2011; Holman & Watson, 2013) and college aged students (Bagdasarov, Banerjee, Greene, & Campo, 2008; Basch, Hillyer, Basch, & Neugut, 2012; Pagoto et al., 2014; Yoo & Hur, 2014), Oregon State University was an appropriate setting for this research.

Administration of the HBAU scale on a population level would enable public health officials to determine, for any geographic region, the degree to which beliefs about vitamin D, SAD, and sunscreen use impact risky UV exposure behaviors, and to tailor skin cancer prevention efforts to address those beliefs. Thus, a primary goal of this study was the development of a scale to assess aspects of UV exposure and protection behaviors that may vary geographically, but may also be particularly prevalent in Oregon.

The dual purposes of this dissertation were 1) to develop and validate a scale that measures health beliefs about UV related to health benefits of UV exposure, seasonal mood effects ,and concerns about the safety of sunscreen use, using a systematic approach to scale development; and 2) to describe the prevalence of such beliefs using the new scale, and examine the relationship of these beliefs to skin cancer risk behaviors. In preparation for the study, I generated an initial item pool and sought expert feedback to guide refinement of the items. I then piloted the selected set of items in a student population, completed item comprehension interviews and made additional revisions. Then I administered the item pool in a larger survey instrument to undergraduate students at Oregon State University (OSU) and examined the factor structure, validity and reliability of the scale. Last, I examined the prevalence of the measured constructs and the predictive validity of the scale among OSU students by examining the health beliefs and their association with behavior.

The development and application of the HBAU addresses a gap in the measurement of skin cancer risk and protection behaviors, with the long-term goal of enabling the tailoring of prevention and intervention efforts to specific risk populations. Campaigns to reduce UV exposure and promote sun protection must be informed by an understanding of all the motivational and environmental factors driving these behaviors. Thus, the current study is of public health significance in its goal of furthering skin cancer prevention.

CHAPTER 2: MANUSCRIPT 1

Development and Factor Structure of the Health Beliefs about UV (HBAU) Scale

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Title: Development and Factor Structure of the Health Beliefs about UV (HBAU) Scale

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Abstract:

Objective: Health beliefs about UV in cloudy climates may impact UV exposure behaviors. Our objective was to develop and validate a scale to measure these constructs.

Participants: Students at a large university in Oregon completed pilot and final scales online March through July, 2016. Five participants underwent cognitive interviews.

Methods: Expert feedback guided pilot item development. Cognitive interview and pilot data guided item refinement. We conducted factor analysis and invariance testing.

Results: The hypothesized three-factor solution fit the data poorly. We examined the raw correlations, removed items with poor theoretical fit, and created a fourth weather-related factor. HBAU subscales are Sunscreen Toxicity, Seasonal Effects, Health Benefits of Tanning, and Tanning Through the Winter. The final four-factor model fit well (χ^2 = 36.46; *df* = 38; RMSEA = .000, CFI = 1.000). Invariance testing supported strong invariance across gender and tanning status.

Conclusion: The resulting scale will enable more comprehensive UV exposure behavior modeling.

Keywords: Health beliefs, sunscreen, cancer prevention, measurement.

Skin cancer in the U.S. is costly both in financial and human terms (Guy, Machlin, et al., 2015), so understanding the factors that contribute to ultraviolet (UV) radiation exposure and protection behaviors is of public health significance. Annual expenditures to treat skin cancer between 2002 and 2008 rose from $3.6 billion to $8.1 billion, an increase of 126.2%, compared with a 25.1% increase in treatment cost for all other cancers over the same time period (Guy, Machlin, et al., 2015). Because solar and sunbed exposure to UV radiation is a primary modifiable risk factor for skin cancer (Berwick, Lachiewicz, Pestak, & Thomas, 2008), a deeper understanding of factors influencing UV exposure is needed. Predictors of indoor tanning include female gender; youth; the belief that a tanned appearance is attractive, sexy, or slimming; and social support for tanning (Baker, Hillhouse, & Liu, 2010; Chait, Thompson, & Jacobsen, 2015; Danoff-Burg & Mosher, 2006; Mosher & Danoff-Burg, 2005), yet these factors provide an incomplete picture of intentional UV exposure.

The primary health benefit of UV exposure is stimulation of dermal vitamin D production (Reichrath, 2009), and recent research into potential health benefits of vitamin D has resulted in positive media coverage (Caulfield et al., 2014). Frequently, however, such coverage has miscommunicated research results or suggested conclusions that extend beyond those justified by the research methodology (Hiom, 2006). In an extensive study of vitamin D-related beliefs among adults in Queensland, Australia, Youl and colleagues found that concern about vitamin D deficiency had led 21% of participants to change their sun protection behaviors, and 16% expressed the intent to change their sun protection behaviors (Youl et al., 2009). Furthermore, 14% had changed sun protective behaviors for their children out of concern for vitamin D levels. Recent research on vitamin D-related beliefs in U.S. adults found that less than 43.1% of adults believed vitamin D sufficiency can be achieved by diet and supplementation alone, and this belief was associated with increased likelihood of sun protection (Holman, Berkowitz, Guy, Lunsford, & Coups, 2017). Further, those who agreed that tanning is an effective way to get vitamin D were more likely to tan outdoors and indoors. Thus, even more so in predominantly cloudy or rainy climates, heightened concern about vitamin D deficiency may be an important determinant of UV exposure. The indoor tanning industry touts tanning as safer than solar UV exposure due to its controlled environment, framing indoor tanning as a method of sun exposure harm reduction (Autier et al., 2011). Thus, concern about vitamin D levels as a factor in UV exposure may be an important target for intervention, especially in regions where the local climate limits outdoor sun exposure.

Seasonal Affective Disorder (SAD) is a cyclic form of depression that remits during the summer months and has been hypothesized to arise in part from seasonal changes in the period of naturally occurring light and circadian rhythm disruption (Lewy, Lefler, Emens, & Bauer, 2006; Mersch, Middendorp, Bouhuys, Beersma, & van den Hoofdakker, 1999). Treatment of SAD includes pharmacotherapies such as antidepressants and Bright Light Therapy (BLT) which requires ocular exposure to bright, sometimes blue, wavelengths of light (Gordijn, Mannetje, & Meesters, 2012), and has shown consistent effectiveness (Anderson, Glod, Dai, Cao, & Lockley, 2009; Melrose, 2015). Although the devices used in BLT emit no UV light, UV exposure in a tanning bed results in a beta-endorphin release that may be interpreted as a therapeutic effect of UV exposure on depressive symptoms. Thus, conflation of BLT with UV light and the desire to avert or treat seasonal depressive symptoms may impact UV exposure behavior. Previous research indicates that mood plays a role in intentional UV exposure behaviors such as indoor tanning (Hillhouse, Stapleton, & Turrisi, 2005).

An equally important aspect of UV exposure is the failure to adopt UV protection. The belief that protection from sunlight and, specifically, that use of sunscreen for protection may have inherent risks is a third factor that may influence regional UV exposure behaviors. Sunscreen is a common, recommended, and effective method of sun protection (Buller et al., 2016; Hughes, Williams, Baker, & Green, 2013; van der Pols, Williams, Pandeya, Logan, & Green, 2006). The frequency and consistency of sunscreen use, however, may be influenced by concerns about its safety arising from desire to maintain adequate vitamin D levels (Hamilton, Cleary, White, & Hawkes, 2015) or concern about the safety of nanoscale mineral (Siegrist & Keller, 2011) and chemical photofilters themselves (Blackmun, 1998; Burnett & Wang, 2011; Jalalat, 2015). A recent qualitative study of online tanning forums (Carcioppolo, Chudnovskaya, Gonzalez, & Stephan, 2014) examined how tanners rationalize their behavior. Emergent themes included blaming risk from tanning on outside sources (in 12.7% of posts), outright denial of the association of tanning to skin cancer (in 16.7% of posts), and fatalistic beliefs about cancer (in 16.1% of posts). Several misconceptions emerged about sunscreen use, including the belief that sunscreen is toxic and that sunscreen itself is the cause of cancer (Carcioppolo, Chudnovskaya, Gonzalez, & Stephan, 2014). These findings provide further support for the current study.

No scale currently exists to measure such beliefs, which may relate to environmental or contextual factors that could influence skin cancer risk behavior. The potential of the described beliefs to increase UV exposure and diminish UV protection behaviors under the guise of healthy behavior represents significant measurement gap in skin cancer risk behavior research. The specific aim of this study was to develop and validate the Health Beliefs About UV (HBAU) scale, which measures beliefs related to vitamin D deficiency, seasonal depression, and the safety of sunscreen use.

Methods

Study context

The role of regional climate in health beliefs about UV represents an important aspect of our study design. This study was conducted in Western Oregon, which features predominantly cloudy weather and frequent precipitation. Young age and college education are associated with higher rates of risky UV exposure (Guy, Berkowitz, Watson, Holman, & Richardson, 2013; Hartman et al., 2012; Poorsattar & Hornung, 2007); thus, university students represent a population of interest for the development of our scale. The Oregon State University Institutional Review Board (IRB) approved this as an exempt study.

Item Development

We developed a preliminary set of items based on a review of the indoor tanning literature. Items were generated with the goal of tapping multiple health beliefs that support increased UV exposure related to vitamin D, seasonal depression, and sunscreen safety (see Appendix A for full item listing). An expert panel reviewed these items to gauge face validity and offer guidance on the wording, content, and clarity of the items. Experts rated items on relevance and clarity, and they offered alternative wording for potentially confusing or culturally specific terms. One expert suggested adding an item regarding concern about a dermatological reaction to sunscreen. Thus, based on expert opinion, we reworded, retained, added, or eliminated items, resulting in a 28-item pilot scale. Response options ranged from 1 (*strongly disagree*) to 5 (*strongly agree*) with a midpoint of 3 (neither agree nor disagree) and the option to respond *I don't know*.

Pilot Study

Pilot data collection. Data were collected from undergraduate students at a major university in Oregon between January and February of 2016 via an anonymous Qualtrics survey (Qualtrics, 2015). We introduced the study in all sections of courses commonly taken to fulfill core university requirements. Then, course instructors distributed the survey link to enrolled students via email. Inclusion criteria were enrollment in an eligible course, aged 18 years or older, English fluency, and U.S. nationality (because the constructs in question may be highly culturally influenced). The introduction to the survey instrument described these eligibility criteria, and students who opted to continue with the survey were assumed to have understood and met the criteria. Students who opened the survey link and did not continue to the survey were treated as having failed the eligibility screening. From the survey respondents, we further recruited five participants for cognitive interviews to identify possible misinterpretation of item wording and determine overall item comprehension.

Pilot participants. Of 378 students contacted, the initial response was 119 participants. Removal of participants who failed the eligibility screening yielded a final sample of 114 (response rate: 30%). We verified by university major that students did not disproportionately represent one discipline. Cognitive interview participants included individuals who were male and female and those who tan indoors as well as those who do not. See Table 2.1 for a summary of participant characteristics.

Pilot measures. In addition to the 28-item scale described above, we measured whether participants had ever tanned indoors, outdoors, or incidentally (defined as going outdoors without sunscreen or other sun protection, knowing that you will likely get tan), and how many times they engaged in these behaviors in the past 12 months. To test for bias due to social desirability, we included a 10-item version of the Marlowe-Crowne [M-C 1(10)] social desirability scale (Strahan & Gerbasi, 1972).

Pilot analyses. Data were screened for apparent satisficing (i.e. choosing an adequate response as opposed to selecting the optimal response). Two independent coders numerically scored each comprehension interview data for each item, and the average of these scores was used as an indicator of item comprehension. Based on item comprehension interviews and an examination of item response distributions including frequency of "I don't know" response and non-response, items were revised. A correlation matrix of the scale items was visually examined to assess dimensionality and item quality.

Pilot results. We found no significant correlations between any of the items in the scale under development and the M-C 1(10), so it was not included in the main study instrument. One item generated considerable confusion (Sunscreen can cause a bad skin reaction), and interview participants indicated they were unsure what kind of bad reaction to consider in their response. The item measuring concern about a bad skin reaction to sunscreen was revised to create two items measuring similar but distinct constructs: concern about allergic reaction to sunscreen and concern about comedogenic/acnegenic effects of sunscreen. Our final set of 27 items (see Appendix A) measured vitamin D related concerns, seasonal depression-related concerns, and sunscreen safety concerns, as well as additional items measuring health benefits of UV exposure (e.g., getting a base tan before going in the sun is protective against skin cancer).

Primary Study

The purpose of our main study was to evaluate the psychometric properties and validity of the scale. We anticipated a three-factor solution would offer the best fit to the data. As an indication of construct validity, we hypothesized that sunscreen concerns would be positively associated with a bias towards natural products and processes and negatively associated with the perception that the FDA is doing a good job of protecting consumers. We also expected that students raised in Oregon would differ from students raised in other states on SAD-related beliefs, because students from other regions may be less accustomed to the Oregon climate.

Data collection. Data collection took place between March and July of 2016 and followed the same approach as described for the pilot study. Students were recruited from on-campus and online sections of two courses offered to all students at the university as an option to fulfill core course requirements. Online students received a recruitment email worded similarly to the in-class announcement. We offered entry into a raffle for $50 gift cards to the student bookstore, with one gift card raffled for each 75 participants, as an incentive. The online survey contained 125 items and took participants, on average, 17 minutes to complete.

Participants. Out of 1406 students contacted, we received initial responses from 383 participants. We confirmed by student major area of study that the sample did not disproportionately represent one discipline. Removal of 48 participants who failed the eligibility screening from the dataset (screen fail rate: 12.5%) resulted in a final sample of 335 students (response rate: 23.8%). The main study sample resembled the pilot sample but was slightly older (see Table 2.1 for participant characteristics).

Measures. In addition to 27 final candidate scale items, we measured whether participants had ever tanned indoors or outdoors and how many times they engaged in those behaviors in the past 12 months. We also measured gender identity, year in school, parental educational attainment, Fitzpatrick skin type, and in which state participants were raised. We measured preferred formula of sunscreen, with the following response options: physical (e.g., Zinc, Titanium Dioxide), chemical (e.g., Avobenzone, Oxybenzone), I don’t use sunscreen, and I don't know. We also measured agreement with the statement: "The Food and Drug Administration (FDA) does a good job of protecting consumers." We measured bias toward natural or naturally derived products and processes with three items adapted from Levy and Maguire's Appeal to Nature Inventory (Levy & McGuire, 2012) measuring agreement with statements that natural products are preferable to or healthier than artificial ones (e.g., "I avoid purchasing products with artificial ingredients"). Responses range from 1 to 5, with higher scores indicating a stronger bias towards natural things.

Analyses. Initial analyses included data cleaning, examination of extreme cases, and review of the means and distributions of all scale items. We identified items with low variability or that participants did not understand or were unable to answer and removed these poorly performing items from analyses, as well as any items with >30% of participants responding "I don't know" (see Appendix A). We then used a combination of factor analyses and examinations of zero-order correlations to revise the item pool and expected factor structure.

We next tested the measurement invariance of the final model across gender and across two definitions of tanning status: indoor tanning (ever vs. never having tanned indoors) and recent tanning (has vs. has not indoor or outdoor tanned in the past 12 months). Each invariance test consisted of three steps. First, a test of configural invariance fit the model to two groups simultaneously and determined whether the latent variable structure was equivalent across groups. The next step was to test weak invariance by constraining the factor loadings to equivalence and comparing model fit to the configural model to determine whether the constraints significantly degraded model fit. The last step was to test strong invariance by constraining the factor loadings and their intercepts to equivalence across groups and compare the resulting model to the weak invariance model. We assessed model fit based on the following criteria: a Root-Mean Square Error of Approximation (Steiger, 1990; Steiger & Lind, 1980) of .05 for a very good fit and less than .08 for a reasonable fit (Little, Schnabel, & Baumert, 2000), a Comparative Fit Index (Bentler, 1990) greater than .95 for very good fit and greater than .90 for reasonable fit, and a Tucker-Lewis index (Tucker & Lewis, 1973) greater than .95 for very good fit and greater than .90 for reasonable fit. The χ^2 test statistic, which is not robust to sample size (Kelloway, 1995), is reported for completeness but was not used to assess model fit. We analyzed the variance-covariance matrix using Maximum Likelihood Robust (MLR) estimation in MPlus version 7.3. As indication of construct validity, we then tested the association of sunscreen concerns and 1) bias towards natural products and processes, and 2) perception that the FDA is doing a good job of protecting consumers. We further tested group mean differences to determine whether levels of SAD-related beliefs differed between students from Oregon and students from other states.

Results

We specified a three-factor solution using fixed factor identification and found a poor fit to the data (χ^2 = 403.25, *df* = 48; RMSEA = .12; CFI = .712, TLI = .646). We then examined the raw correlations, calculated corrected item-scale correlations, considered the content of the items in the three factors, and removed items that did not fit conceptually with the others representing the target factors (see Appendix A for a summary of revisions). The revised model consisted of three factors. The 3-item Factor 1 (*Sunscreen Toxicity*) measures concerns about the safety of sunscreen use. The original 6 items on Factor 2 (*Seasonal Effects)* measure beliefs about the weather negatively affecting mood or health, and the 3-item Factor 3 (*Health Benefits of Tanning)* measures beliefs about vitamin D- or health-related benefits of tanning. Examination of the *Seasonal Effects* items suggested that they represented two distinct constructs. We then separated three weather and mood-related items from *Seasonal Effects* to create Factor 4 (*Tanning Through the Winter)*, which differs from *Seasonal Effects* in that it reflects beliefs about tanning as an effective means of overcoming seasonal mood symptoms.

We then fit this four-factor model, finding good fit to the data (χ^2 = 71.48, *df* = 74; RMSEA = .038; CFI = .971, TLI = .960), and removed one item with a weak loading and potential cross loading (*Getting some sun is a good treatment for the winter blues*). The final 11 items on the four-factor solution fit well (χ^2 = 36.43, *df* = 38, RMSEA = 0.000, CFI = 1.000, TLI = 1.003). All standardized factor loadings were large and statistically significant, ranging from .55 to .85 (see Table 2.2). The subscales demonstrated acceptable to good internal consistency, indicated by McDonald's Omega (ω = 0.65 - 0.85).

Invariance Testing: Gender

We conducted gender invariance testing as described above. Individuals identifying as male or trans-male were grouped together, and participants identifying as female or trans-female were grouped together. One individual, who provided an unusable response for gender identity but whose data were otherwise valid, was not included in gender invariance testing. Invariance testing supported configural, weak, and strong invariance across gender (see Table 2.3 for a summary of invariance testing model fit). These results suggest that the scale is appropriate for use with both men and women and that these groups do not interpret the items differently (see Table 2.4 for strong gender invariance factor loadings).

Invariance Testing: Tanning

To ensure that the scale works well across multiple operationalizations of tanning, we conducted two series of invariance tests. We first tested invariance across participants who have ever or never tanned indoors (Tanning 1), which resulted in the following groups: tanners: *N* =

90; non-tanners: *N* = 243. Invariance testing supported configural, weak, and strong invariance (See Table 2.3). All factor loadings were significant at $p < .001$. (See Table 2.5 for strong tanning invariance factor loadings; Raw and standardized intercepts are presented in Table 2.6).

We then tested invariance by recent tanning status (Tanning 2), grouping those who had tanned indoors or outdoors in the past 12 months and those who have not recently tanned. This produced the following groups: Recent tanners: *N* = 256, Non-tanners: *N* = 75. The analyses supported configural, weak, and strong invariance (see Table 2.3), indicating the four-factor solution is a good fit to the data across both definitions of tanning status (see Table 2.7 for strong tanning invariance intercepts).

Tests of Validity

Independent sample t-tests indicated a difference in mean score on *Seasonal Effects* between students raised in Oregon (*M* = 3.37, *SD* = 0.91) and students raised in other U.S. states (*M* = 3.12, *SD* = 0.83) (t (268) = - 2.25, $p = .03$). Students raised in Oregon also scored higher on *Tanning Through the Winter* (*M* = 2.65, *SD* = 0.86) than students raised in other states (*M* = 3.15, *SD* = .87); (t (265) = - 4.58, $p < .001$). *Sunscreen Toxicity* scores were positively associated with bias towards natural products and processes (*r* (263) = .20, $p = .001$) and negatively associated with the belief that the FDA does a good job protecting consumers (*r* (252) = - .32, $p < .001$). Students who have tanned indoors scored higher on *Seasonal Effects* ($p < .001$) and *Tanning Through the Winter* ($p < .001$), but did not significantly differ from non-tanners on *Health Benefits of Tanning* ($p = .06$). When grouped by recent tanning, tanners scored higher on *Health Benefits of Tanning* ($p < .001$) and *Tanning Through the Winter* ($p = .03$), but did not significantly differ from non-tanners on *Seasonal Effects* ($p = .08$). As anticipated, tanners and non-tanners did not score differently on *Sunscreen Toxicity*. Although we hypothesized that the *Sunscreen Toxicity* scores would predict the use of mineral, as opposed to chemical sunscreen formulas, nearly 75% of participants did not know what formula of sunscreen they use; thus, we were not able to test this hypothesis.

Comment

Overall, we expect the HBAU will assist skin cancer prevention efforts. By measuring beliefs that legitimize intentional UV exposure as a health behavior, this scale may identify individuals and groups as well as geographic regions in need of additional education and prevention resources. The HBAU further has potential as a clinical tool to identify patients in need of sun safety counseling and information on health impacts of UV exposure. For example, the belief that getting a tan prior to vacation is protective is a motive for indoor tanning (Mayer et al., 2011; Poorsattar & Hornung, 2007), but recent research indicates that indoor tanning does not reduce risk of melanoma, independent of sunburn status (Vogel et al., 2014). Thus, the HBAU may assist clinicians in identifying individuals whose beliefs place them at elevated risk for future UV exposure behaviors.

The *Sunscreen Toxicity* subscale formed a strong factor representing beliefs about toxic ingredients, the chemical nature of sunscreen products and the general belief that sunscreens cause cancer. The *Sunscreen Toxicity* subscale will permit the measurement of consumer fears that may arise in the context of a swell in cultural preference for natural and organic products (Rozin, 2005a). Sunscreen use is the most common sun protective behavior in the U.S. (Linos et al., 2011), so sunscreen product safety concerns are a public health concern. The association of the *Sunscreen Toxicity* subscale with bias towards natural products supports the construct validity of the HBAU. We anticipated that individuals who pursue a natural lifestyle through the avoidance of artificial ingredients in their products would extend this avoidance to synthetic ingredients.

Contrary to expectations, items related to seasonal depression and impact of the weather on mood loaded onto two separate latent factors, indicating that beliefs about the impact of the climate on mood and health are complex. The first weather-related factor, *Seasonal Effects*, measures beliefs about succumbing to negative health effects of the weather. These beliefs are a critical reflection of participants' experience of their environment, and of the impact they believe the weather and climate have on their health and well-being. In contrast, *Tanning Through the Winter* taps an important extension of this construct, which is the belief that tanning and sun exposure are actions that can be taken to overcome such negative health outcomes. Although research suggests that seasonal mood variation is both genetically (Sher, 2001) and socio-culturally influenced (Kasof, 2009; Raheja et al., 2013), the belief that UV exposure provides relief of such symptoms may be a critical component of tanning behaviors in cold climates.

Health Benefits of Tanning measures beliefs that may offer a health-based justification for tanning or sun exposure. These beliefs all contain a kernel of truth. UVB exposure stimulates dermal vitamin D production which can be said to be natural. Furthermore, tanned skin is more resistant to sunburn than skin that has not been recently sun exposed. These benefits, however, do not outweigh the cancer risk associated with UV exposure (Gilchrest, 2008; Lim et al., 2005; Wolpowitz & Gilchrest, 2006).

The finding that students who were raised outside the state of Oregon scored higher on *Seasonal Effects* and *Tanning Through the Winter* has interesting implications for college student populations. Although our data did not indicate how recently these students relocated to Oregon, the young age of the sample suggests that those who report being raised in another state relocated relatively recently. Relocation to a cloudy climate may thus be a time when students are particularly vulnerable to beliefs about seasonal impact on health, and believe that UV exposure is a method of overcoming these winter blues. Further research is needed to determine how these beliefs impact UV exposure behavior and whether these beliefs vary over time.

Limitations

The HBAU scale is in the early stages of development and has limitations. Although college students are one of the highest risk populations for indoor tanning, the nature of our sample and single site of data collection may limit generalizability. Our sample was drawn from a single university which may not be reflective of universities across Oregon or in the broader Pacific Northwest region. Student eligibility (age, English fluency, etc.) was not directly verified. Our data are self-report and are thus subject to recall bias.

Conclusion

Future studies are necessary to examine the validity and utility of the HBAU in broader populations. Temperate climate may influence these UV-related beliefs, as may age. Further, cultural differences may exist in the language used to describe and understand the relationship between the weather, UV exposure, vitamin D production, mood and sunscreen use, necessitating further cross-cultural validation. Our findings suggest the scale will be useful in mixed gender samples, regardless of past or current tanning behavior, but further validation is required to ascertain its utility in skin cancer prevention efforts.

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Table 2.1. Participant characteristics

	Pilot study (N = 114)	Primary study (N = 335)
Age M (SD)	21.6 (2.64)	21.5 (4.07)
range	18-34	18-51
Gender (%)		
Men	35 (32%)	106 (33%)
Women	76 (68%)	211 (67%)
Year in school		
First	1 (<1%)	41 (13%)
Second	16 (14%)	61 (19%)
Third	53 (46%)	120 (37%)
Fourth	44 (38%)	99 (31%)
Parental educational attainment		
Less than high school diploma	5 (4%)	10 (3%)
High school graduate	17 (15%)	35 (11%)
Some college	25 (22%)	75 (24%)
College graduate	35 (31%)	135 (43%)
Graduate degree	31 (27%)	61 (19%)
Untanned skin color		
Very fair	18 (16%)	52 (16%)
Fair	46 (40%)	138 (43%)
Olive	33 (29%)	75 (24%)
Light brown	14 (12%)	50 (15%)
Dark brown	5 (3%)	4 (1%)
Very dark	0%	2 (1%)
Skin response to 1 hour in the sun		
Burns, no tan	18 (16%)	35 (11%)
Burns, then tans	21 (18%)	67 (21%)
Burns slightly, tans easily	32 (28%)	74 (23%)
Tans easily, no burn	30 (26%)	96(30%)
No change	12 (11%)	40 (13%)
I don’t go in the sun	1 (1%)	9 (3%)
Indoor tanning (Ever/Never)		
Yes	27 (24%)	90 (27%)
No	88 (76%)	245 (73%)
Indoor or outdoor tanning (past 12 months)		
Yes	95 (83%)	253 (77%)
No	20 (17%)	76 (23%)
Outdoor tanning (Ever/Never)		
Yes	95 (83%)	262 (78%)
No	20 (17%)	73 (22%)
Outdoor tanning frequency (past 12 months)		
0	28 (26%)	82 (24%)
1-2	16 (15%)	77 (23%)
3-9	26 (24%)	91 (27%)

10-19	24 (22%)	48 (14%)
20-39	11 (10%)	22 (7%)
40+	3 (3%)	15 (5%)
Raised in Oregon		
Yes	81 (74%)	195 (67%)
No	28 (26%)	98 (32%)

Note: Not all percentages may sum to 100 due to rounding.

Table 2.2. Raw and standardized factor loadings.

4- Factor Model		**Raw**	**Standardized**
Factor 1	Sunscreen ingredients are toxic.	.78	.83
Factor 1	Most sunscreen is full of harmful chemicals.	.80	.85
Factor 1	Sunscreen lotions probably cause cancer.	.67	.73
Factor 2	In Oregon, a bad mood in the winter can be because there is no sun.	.58	.58
Factor 2	The cloudy weather in Western Oregon negatively affects me.	.85	.69
Factor 2	Because of the cloudy weather in Oregon, my body probably can't produce enough vitamin D.	.60	.56
Factor 3	Tanning is a healthy treatment for low vitamin D.	.74	.70
Factor 3	Getting a base tan before going in the sun is protective against skin cancer.	.70	.63
Factor 3	Tanning is a more natural way to get your vitamin D than taking a pill.	.62	.55
Factor 4	Tanning can help you get through the Oregon winter.	.77	.79
Factor 4	Tanning can help you stay positive during the winter.	.83	.84

Note. Factor 1: Sunscreen Toxicity, Factor 2: Seasonal Effects, Factor 3: Health Benefits of Tanning, Factor 4: Tanning Through the Winter. All factor loadings were statistically significant at $p < .001$.

Table 2.3. Invariance testing model fit and scaled difference.

Model	χ^2	**Df**	**RMSEA**	**CFI**	**ΔCFI**	**TLI**	**Scaled $\Delta\chi^2$**	**$\Delta\chi^2$ *p***
Full	36.460	38	0.000	1.000	--	1.003	**--**	**--**
Gender								
Configural	90.955	76	0.035	0.980	--	0.972	--	--
Weak	95.472	83	0.031	0.984	0.004	0.978	11.097	.435
Strong	104.108	90	0.031	0.982	-0.002	0.977	8.520	.289
Tanning 1*								
Configural	95.795	76	0.040	0.974	--	0.962	--	--
Weak	77.120	83	0.000	1.000	0.025	1.00	5.309	.915
Strong	91.100	90	0.009	0.999	-0.001	0.998	14.329	.046
Tanning 2*								
Configural	85.352	76	0.027	0.988	--	0.983	--	--
Weak	98.611	83	0.034	0.980	-0.008	0.974	17.734	.088
Strong	103.087	90	0.030	0.983	0.003	0.980	4.342	.739

*Note. *Tanning 1- Tanners defined as those who have ever tanned indoors; Tanning 2: Tanners defined as those who have intentionally tanned indoors OR outdoors in the past 12 months.*

Table 2.4. Strong gender invariance model raw and standardized factor loadings.

Model	Raw		Standardized	
	Male	**Female**	**Male**	**Female**
Invariance By Gender				
Sunscreen ingredients are toxic.	.76	.76	.82	.84
Most sunscreen is full of harmful chemicals.	.79	.79	.83	.86
Sunscreen lotions probably cause cancer.	.64	.64	.67	.73
In Oregon, a bad mood in the winter can be because there is no sun.	.60	.61	.55	.59
The cloudy weather in Western Oregon negatively affects me.	.83	.83	.69	.62
Because of the cloudy weather in Oregon, my body probably can't produce enough vitamin D.	.65	.65	.65	.56
Tanning is a healthy treatment for low vitamin D.	.54	.54	.51	.75
Getting a base tan before going in the sun is protective against skin cancer.	.53	.53	.51	.66
Tanning is a more natural way to get your vitamin D than taking a pill.	.45	.45	.41	.59
Tanning can help you get through the winter.	.73	.73	.84	.78
Tanning can help you stay positive during the winter.	.81	.81	.86	.86

Table 2.5. Strong tanning invariance model raw and standardized factor loadings.

Model	Raw		Standardized	
Invariance By Tanner 1*	**Tanner**	**Non-tanner**	**Tanner**	**Non-tanner**
Sunscreen ingredients are toxic.	.73	.73	.84	.83
Most sunscreen is full of harmful chemicals.	.77	.77	.98	.81
Sunscreen lotions probably cause cancer.	.63	.63	.71	.73
In Oregon, a bad mood in the winter can be because there is no sun.	.62	.62	.51	.60
The cloudy weather in Western Oregon negatively affects me.	.90	.90	.55	.74
Because of the cloudy weather in Oregon, my body probably can't produce enough vitamin D.	.58	.58	.41	.55
Tanning is a healthy treatment for low vitamin D.	.69	.69	.76	.66
Getting a base tan before going in the sun is protective against skin cancer.	.64	.64	.69	.60
Tanning is a more natural way to get your vitamin D than taking a pill.	.58	.58	.63	.52
Tanning can help you get through the winter.	.71	.71	.76	.76
Tanning can help you stay positive during the winter.	.79	.79	.87	.82
By Tanner 2*	**Tanner**	**Non-tanner**	**Tanner**	**Non-tanner**
Sunscreen ingredients are toxic.	.76	.76	.84	.84
Most sunscreen is full of harmful chemicals.	.79	.79	.87	.80
Sunscreen lotions probably cause cancer.	.67	.67	.73	.74
In Oregon, a bad mood in the winter can be because there is no sun.	.67	.67	.56	.63
The cloudy weather in Western Oregon negatively affects me.	.99	.99	.65	.86
Because of the cloudy weather in Oregon, my body probably can't produce enough vitamin D.	.68	.68	.54	.58
Tanning is a healthy treatment for low vitamin D.	.80	.80	.67	.79
Getting a base tan before going in the sun is protective against skin cancer.	.77	.77	.60	.73
Tanning is a more natural way to get your vitamin D than taking a pill.	.68	.68	.54	.57
Tanning can help you get through the winter.	.85	.85	.78	.89
Tanning can help you stay positive during the winter.	.87	.87	.82	.82

**Tanning 1- Tanners defined as those who have ever tanned indoors; Tanning 2: Tanners defined as those who have intentionally tanned indoors OR outdoors in the past 12 months.*

Table 2.6. Strong gender invariance model raw and standardized intercepts.

Model	Raw		Standardized	
	Male	Female	Male	Female
Invariance By Gender				
Sunscreen ingredients are toxic.	2.49	2.49	2.65	2.68
Most sunscreen is full of harmful chemicals.	2.53	2.53	2.65	2.71
Sunscreen lotions probably cause cancer.	2.24	2.24	2.34	2.48
In Oregon, a bad mood in the winter can be because there is no sun.	3.28	3.28	3.04	3.47
The cloudy weather in Western Oregon negatively affects me.	2.89	2.89	2.44	2.34
Because of the cloudy weather in Oregon, my body probably can't produce enough vitamin D.	2.76	2.76	2.79	2.57
Tanning is a healthy treatment for low vitamin D.	2.55	2.55	2.28	2.57
Getting a base tan before going in the sun is protective against skin cancer.	2.62	2.62	2.39	2.37
Tanning is a more natural way to get your vitamin D than taking a pill.	3.13	3.13	2.70	2.91
Tanning can help you get through the winter.	2.91	2.91	3.21	2.94
Tanning can help you stay positive during the winter.	2.99	2.99	3.08	3.04

Table 2.7. Strong tanning invariance model raw and standardized intercepts.

Model	Raw		Standardized	
	Tanner	**Non-tanner**	**Tanner**	**Non-tanner**
By Tanner 1*				
Sunscreen ingredients are toxic.	2.43	2.42	2.59	2.65
Most sunscreen is full of harmful chemicals.	2.47	2.47	2.65	2.49
Sunscreen lotions probably cause cancer.	2.21	2.21	2.37	2.46
In Oregon, a bad mood in the winter can be because there is no sun.	3.29	3.29	3.36	3.08
The cloudy weather in Western Oregon negatively affects me.	2.87	2.87	2.30	2.48
Because of the cloudy weather in Oregon, my body probably can't produce enough vitamin D.	2.77	2.77	2.70	2.38
Tanning is a healthy treatment for low vitamin D.	2.06	2.06	1.97	2.04
Getting a base tan before going in the sun is protective against skin cancer.	2.17	2.17	1.94	2.05
Tanning is a more natural way to get your vitamin D than taking a pill.	2.72	2.72	2.50	2.27
Tanning can help you get through the winter.	2.65	2.65	2.60	2.67
Tanning can help you stay positive during the winter.	2.62	2.62	2.73	2.45
By Tanner 2*	**Tanner**	**Non-tanner**	**Tanner**	**Non-tanner**
Sunscreen ingredients are toxic.	2.43	2.43	2.59	2.65
Most sunscreen is full of harmful chemicals.	2.47	2.47	2.65	2.49
Sunscreen lotions probably cause cancer.	2.21	2.21	2.37	2.46
In Oregon, a bad mood in the winter can be because there is no sun.	3.30	3.30	3.36	3.08
The cloudy weather in Western Oregon negatively affects me.	2.87	2.87	2.30	2.49
Because of the cloudy weather in Oregon, my body probably can't produce enough vitamin D.	2.77	2.77	2.70	2.38
Tanning is a healthy treatment for low vitamin D.	2.06	2.06	1.97	2.04
Getting a base tan before going in the sun is protective against skin cancer.	2.17	2.17	1.94	2.05
Tanning is a more natural way to get your vitamin D than taking a pill.	2.72	2.72	2.50	2.27
Tanning can help you get through the winter.	2.55	2.55	2.60	2.67

Tanning can help you stay positive during the winter.	2.62	2.62	2.73	2.45

**Tanning 1- Tanners defined as those who have ever tanned indoors; Tanning 2: Tanners defined as those who have intentionally tanned indoors OR outdoors in the past 12 months.*

Appendix A. Summary of original items

FACTOR 1

Sunscreen ingredients are toxic
Most sunscreen is full of harmful chemicals
Sunscreen isn't safe to use†
Sunscreen blocks natural production of vitamin D*
Sunscreen lotions probably cause cancer
Sunscreen can cause a bad allergic skin reaction*
Sunscreen can give you acne and blackheads*
Most of the year, sun protection isn't necessary in Western Oregon⅄

FACTOR 2

The cloudy weather in Western Oregon negatively affects me
Sun exposure is therapy for the winter blues✧
Tanning is a way to prevent feeling sluggish in the winter✧
Because of the cloudy weather in Oregon, my body can't produce enough vitamin D
In Oregon, a bad mood in the winter can be because there is no sun

FACTOR 3

I probably can't produce enough vitamin D in Oregon✧
Tanning is a healthy treatment for low vitamin D
Tanning is a natural way to get your vitamin D✧
Getting some sun is healthy†
UV exposure is necessary for good health*✧
Tanning reduces risk of cancer†
Getting a base tan before going in the sun is protective against cancer
Vitamin D is the "happy vitamin"*⅄
Lying in the sun is a more natural way to get your vitamin D than taking a pill✧
Tanning is a more natural way to get your vitamin D than taking a pill
Maintaining healthy vitamin D levels reduces risk of cancer*

FACTOR 4

Tanning is a way to stay positive during the winter
Tanning can help you get through the Oregon winter
Getting some sun is a good treatment for the winter blues♦

Note. *Deleted due to high rates of *I don't know* response. ✧Deleted because a similar item was better. †Deleted due lack of variability. ♦ Deleted due to crossloading. ⅄Conceptually dissimilar to other items.

CHAPTER 3: MANUSCRIPT 2

Health Beliefs about UV and Skin Cancer Risk Behaviors

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Title: Health Beliefs about UV and Skin Cancer Risk Behaviors

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Abstract:

Beliefs about ultraviolet (UV) radiation exposure, sunscreen, and health may influence tanning and sun protection behaviors. Our purpose was to describe the prevalence of beliefs about UV exposure and sunscreen use among college students using the Health Beliefs About UV (HBAU) scale and examine the relationship of these health beliefs to skin cancer risk behaviors in a cloudy climate. Online survey participants (N = 334) were recruited from a large university in Oregon. After fitting an initial measurement model, we fit a structural equation model including HBAU subscales (*Health Benefits of Tanning*, *Seasonal Effects*, *Tanning Through the Winter* and *Sunscreen Toxicity*), outcome variables sunscreen use and indoor and outdoor tanning, and covariates of tanning and sunscreen use. A minority of students held the beliefs represented by three HBAU subscales, but beliefs about negative health effects of the local weather were common. The measurement and adjusted models provided good fit to the data (χ^2 = 157.43; p = .13; *df* = 139; RMSEA = .02; CFI = .981; TLI = .959). After adjusting for covariates, *Sunscreen Toxicity* predicted reduced sunscreen use (β = -.12, p = .021), *Health Benefits of Tanning* predicted outdoor tanning (β = .43, p < .001), and *Tanning Through the Winter* predicted indoor tanning (β = .31, p = .02). Beliefs related to health benefits of sun exposure, the regional weather, and safety of sunscreen may play a role in skin cancer risk behaviors.

Keywords: Health beliefs, sunscreen, tanning, cancer prevention, measurement.

Introduction

Intentional exposure to ultraviolet (UV) radiation is popular among young white adults, despite the associated risk of skin cancer, cataracts and premature aging (Poorsattar & Hornung, 2007). Projected incidence of melanoma is 87,110 in 2017 (Siegel, Miller, & Jemal, 2017), and skin cancer treatment expenditures have increased in recent decades (Guy, Machlin, et al., 2015). Consistent sunscreen use is low, especially among young adults and men (Buller et al., 2011). Despite recent reductions in indoor tanning in the U.S. (Guy, Berkowitz, Holman, & Hartman, 2015), intentional UV exposure remains a challenge for skin cancer prevention. Therefore, an improved understanding of factors that influence UV exposure and protective behaviors is a public health priority.

From an ecological perspective, prevailing weather may influence beliefs about UV exposure (i.e., the belief that UV exposure has health benefits such as treating vitamin D deficiency). The indoor tanning industry cites the benefit of UV-induced vitamin D production to counteract public health messages about tanning risks (U.S Congress, 2012). Australian researchers documented the influence of concern about vitamin D production on UV exposure behaviors (Youl et al., 2009), and vitamin D-related messaging may be even more salient in cloudy environments. A recent study of vitamin D-related beliefs in U.S. adults found that only 43.1% of adults believed vitamin D sufficiency is possible by diet and supplementation alone. This belief was associated with increased likelihood of sun protection, whereas the belief that tanning effectively increases vitamin D was associated with increased indoor and outdoor tanning (Holman, Berkowitz, Guy Jr, Lunsford, & Coups, 2017). Further, Hillhouse and colleagues (2005) found symptoms of seasonal depression in 80% of frequent indoor tanners. In regions with seasonally varying natural light, the belief that cloudy weather is detrimental to mood or health and that sun exposure is therapeutic for seasonal depression may influence UV exposure behaviors.

Sunscreen is a primary sunburn and UV damage prevention tool (Hughes et al., 2013; van der Pols et al., 2006). Failure to adopt sun protection strategies compounds the challenge of preventing risky UV exposure. Barriers to sunscreen use—such as cost, smell, and inconvenience—have been documented (Abroms, Jorgensen, Southwell, Geller, & Emmons, 2003). A societal shift toward preference for natural products, however, may portend the belief that sunscreen contains harmful ingredients as an emerging reason for disuse of sunscreen.

North American consumers associate natural origin with positive attributes such as health (Rozin, 2005a; Rozin, Fischler, & Shields-Argelès, 2012), and natural-inspired personal care products include sunscreens free from organic photofilters and gluten. Indeed, Consumer Reports recently found that almost half of sunscreen buyers desire a "natural" product (Calvo, 2016). Further, European researchers found nanotechnology in sunscreen was perceived by laypeople as highly risky (Siegrist, Keller, Kastenholz, Frey, & Wiek, 2007), and that nanotechnology labelling on sunscreen reduced perceived benefits of sunscreen and increased perceived risks (Siegrist & Keller, 2011). Thus, although the literature suggests that UV exposure is partly motivated by a desire for improved appearance (Cafri, Thompson, Jacobsen, & Hillhouse, 2009; Hillhouse & Turrisi, 2012), beliefs about health benefits of sun exposure and concerns about sunscreen safety may also influence intentional UV exposure and sunscreen disuse.

The aims of this study were to describe the prevalence of UV-related health beliefs and examine their relationship with UV exposure and sunscreen use among college students using a new measure, the Health Beliefs About UV scale (HBAU). We hypothesized that 1) the HBAU constructs will be positively associated with tanning, and 2) concern about the safety of sunscreen use will be negatively associated with sunscreen use frequency. Cloudy or rainy regions and populations with risky UV exposure (Guy, Berkowitz, et al., 2015; Poorsattar & Hornung, 2007) are important to the study of health beliefs about UV exposure. Thus, Oregon college students are an appropriate population for our study.

Methods

Participants

Students were recruited from online and campus sections of undergraduate courses commonly taken to fulfill core requirements at a large university in Oregon. Students' major area of study was collected to ensure a representative sample. Out of 1406 students contacted, 383 participants attempted the survey. Eligibility criteria were enrollment in a course section, aged 18 years or older, English fluency, and U.S. nationality; these criteria were explained at the beginning of the online survey. Students who did not continue past the eligibility criteria (n= 48) were excluded (final response rate: 23.8%).

Data Collection

Data were collected online from March through July of 2016 using a Qualtrics survey. As an optional incentive to participate, one $50 gift card was raffled for every 75 participants. A pilot study informed development of the online, English-language survey, which contained 125 items and took, on average, 17 minutes to complete. The Oregon State University Institutional Review Board (IRB) approved this protocol as an exempt study.

Measures

Health beliefs about UV scale (HBAU). The eleven-item HBAU scale measures health beliefs that may increase skin cancer risk behaviors by justifying increased UV exposure and reduced sunscreen use. Response options range from 1 (*strongly disagree*) to 5 (*strongly agree*). The HBAU subscales *Sunscreen Toxicity* (3 items), *Health Benefits of Tanning* (3 items), *Seasonal Effects* (3 items), and *Tanning Through the Winter* (2 items) have demonstrated acceptable to good internal consistency (McDonald's Omega ω = 0.65 - 0.85).

UV exposure and sunscreen use. UV exposure was measured in two ways: indoor tanning (lifetime ever/never) and outdoor tanning (past 12-month frequency). Sunscreen use frequency was measured on a scale ranging from 1 (*never*) to 5 (*always*), or "I don't go in the sun," which was treated as missing (NHIS, 2010). In addition, we measured the following non-sunscreen forms of UV protection: wearing sunglasses, wearing a wide-brimmed hat, wearing long-sleeve shirt, and using an umbrella.

Physical appearance and sociocultural reasons to tan. We measured appearance motivation to tan with the attractiveness subscale of the Physical Appearance Reasons to Tan Scale (PARTS; Cafri et al., 2008). The subscale, which had excellent internal consistency (α = .91 - .95), identifies reasons to tan related to attractiveness or sex appeal (e.g., "I tan because it makes me look better"). Sociocultural reasons to tan were measured with the media subscale of the PARTS (e.g., "I wish I were as tan as the people in magazines") (α = .89).

Potential covariates. Susceptibility and severity of skin cancer were measured with participants' level of agreement with the statements "I am likely to be diagnosed with skin cancer" and "It would be very bad to be diagnosed with skin cancer". Response options ranged from 1 (*strongly disagree*) to 5 (*strongly agree*), or I don't know (treated as missing). Sociodemographic variables included gender (male, female, trans male, trans female, queer/gender non-conforming and other); responses were recoded such that trans men were categorized as male and trans women were categorized as female. The gender of the single participant not identifying as male or female was treated as missing. We measured skin type (6-point Likert scale, Fitzpatrick 1988) and skin response to one hour in the sun. Response options were: burns, no tan; burns then tans; burns slightly, tans; tans easily, no burn; no change; and "I don't go in the sun," which was treated as missing. Parental educational attainment was measured on a scale from 1 (*less than high school diploma*) to 5 (*advanced degree*).

Analyses

We examined item and subscale frequency distributions and conducted a preliminary confirmatory factor analysis to fit the measurement model. We then added structural elements to model indoor tanning, outdoor tanning, and sunscreen use. The following covariates were included: gender identity, parental education, skin color, perceived susceptibility and severity of skin cancer, appearance-related and sociocultural reasons to tan, and non-sunscreen UV protection behaviors. Model fit was assessed based on the following criteria: a Root-Mean Square Error of Approximation (RMSEA; Steiger & Lind, 1980, as cited by Steiger, 1990) of .05 for a very good fit and less than .08 for a reasonable fit (Little et al., 2000), and a Comparative Fit Index (CFI; Bentler, 1990) and Tucker-Lewis index (TLI; Tucker & Lewis, 1973) greater than .95. The χ^2 test statistic, which is sensitive to sample size (Kelloway, 1995), is reported for completeness but was not used to assess model fit. We then trimmed three paths that were hypothesized a priori to be non-significant, conducting a $\chi^2 \Delta$ test after each deletion to check impact on model fit. We conducted latent analyses using Robust Weighted Least Squares (WLSMV) parameter estimation in MPlus version 7.1 (Muthen & Muthen, 2010). Polychoric correlations were calculated using Stata 12.1 (StataCorp, 2013).

Results

Participant characteristics are presented in Table 3.1. Student scores on the HBAU subscales indicated, on average, low endorsement of sunscreen toxicity concerns (see Table 3.2). As shown in Table 3.3, 10%-16% of participants believed that sunscreen ingredients are toxic and probably cause cancer. Additionally, 20% believed that tanning before sun exposure is protective against skin cancer, and nearly 40% believed tanning is a more natural source of vitamin D than supplementation. Beliefs that the weather has negative effects in general (34%), on vitamin D production (38.5%), and on personal mood (56.9%) were common.

The measurement model revealed significant loadings for all scale items and an excellent model fit (χ^2 = 156.43; p = 0.11; *df* = 136; RMSEA = .021; CFI = .979; TLI = .954). Next, the structural elements of the model were added, incorporating the four-factor scale, UV exposure and protection outcome variables, and known covariates. This model presented identical fit to the data (χ^2 = 156.43; p = .11; *df* = 136; RMSEA = .021; CFI = .979; TLI = .954). After removal of non-significant paths between *Health Benefits of Tanning, Seasonal Effects*, and *Tanning Through the Winter* based on *a priori* hypothesis, our final model fit the data well (χ^2 = 157.43; p = .13; *df* = 139; RMSEA = .02; CFI = .981; TLI = .959), and the revision did not significantly impact model fit (see Table 3.4).

In the final model, *Sunscreen Toxicity* predicted reduced sunscreen use (β = -.12, *p* = .021), *Health Benefits of Tanning* predicted outdoor tanning (β = .43, p < .001), and *Tanning Through the Winter* predicted indoor tanning (β = .31, *p* = .02). Standardized path coefficients and standard errors for the final model are presented in Table 3.5.

Discussion

The current work developed and validated the HBAU scale which measures beliefs about UV consisting of four subscales. The *Seasonal Effects* and *Health Benefits of Tanning* subscales include concepts that have been identified in previous literature, such as tanning with the goal of improving mood. This scale is unique in that it addresses beliefs related to health impact of local climate and weather in that may influence UV exposure. Further, the role of beliefs about sunscreen ingredient safety as a deterrent to UV protection has, to our knowledge, not been investigated in the UV exposure literature.

In this study, endorsement of HBAU beliefs such as those on the Sunscreen Toxicity subscale and the belief that tanning can be protective against cancer, were low overall. Beliefs about negative impacts of the weather were most commonly endorsed, and nearly two thirds of students believed that Oregon weather negatively affects mood. Belief about tanning being a more natural way to get vitamin D than supplements and tanning to overcome the effect of winter weather were endorsed by approximately a third of the sample. Individuals who hold such views, while in the minority, may be an important focus for future sun safety campaigns.

Beliefs about the local climate and health impact of UV exposure were associated with risky UV-related behaviors, even after adjusting for gender, skin type, appearance and sociocultural motives to tan and risk perception. Further study is, however, necessary to examine how these relationships differ by indoor and outdoor UV exposure context. The belief that tanning has inherent health benefits (such as reducing skin cancer risk or being a "natural" way of achieving vitamin D sufficiency) was associated with increased outdoor tanning but not indoor tanning. In contrast, the belief that tanning can help one overcome the health and mood-related effects of a rainy winter was associated with increased indoor tanning but was unrelated to outdoor tanning behaviors. Thus, our hypothesis that HBAU constructs would be associated with increased tanning was partially supported, a finding that agrees with high levels of seasonal depressive symptoms found among high-frequency indoor tanners (Hillhouse et al., 2005).

Study of such constructs, however, requires careful consideration of design and sampling. Further research should examine whether students experiencing seasonal mood disruption begin indoor tanning to assuage these symptoms.

Our results suggest that concerns about sunscreen ingredients being toxic, harmful or carcinogenic are related to less frequent sunscreen use, even after adjustment for various potential confounders, confirming our second hypothesis. Further, no relationship emerged between these concerns and non-sunscreen UV protection such as umbrella use, which suggests that among the behaviors included, no compensatory protection measures are being taken. Boon and colleagues (2013) found that consumers value natural health product efficacy less than perceived naturalness and lack of side effects. Individuals who are concerned about toxic sunscreen ingredients may thus disuse sunscreen products altogether, select less effective or untested formulations (Boon et al., 2013), or apply sunscreen so stringently as to render it ineffective. Most sunscreen users fail to apply adequate product to achieve the advertised protection (Novick, Anderson, Miller, Allgeier, & Unice, 2015; Petersen, Datta, Philipsen, & Wulf, 2013), so this possibility is troubling. Thus, individuals concerned about sunscreen safety may be an important target for sun safety interventions.

This study has several limitations. The small student sample and single data collection site limit generalizability. The cross-sectional nature of our data limit causal inference. Furthermore, unmeasured covariates of tanning and sunscreen use may potentially confound these findings. Our measure of indoor tanning does not capture potential differences in frequency and occasion of tanning, nor between current and former tanning. These differences may influence HBAU constructs. Additionally, seasonal variation during data collection may have biased the detection of effects towards the null. For instance, Adams documented differential reporting of sun exposure behavior in winter and summer months (Adams, Mayer, Bowen, & Ji, 2009). Despite its limitations, this study offers new insights into skin cancer risk behaviors, accounts for many known covariates of UV exposure, and suggests potential avenues for future research.

The factors measured by the HBAU merit further study among college students and in more representative samples. Our results indicate that some health beliefs about UV are associated with increased intentional tanning and decreased sunscreen use, but are not associated with compensatory UV protection efforts such as wearing a long-sleeved shirt. These findings are consistent with those of Holman and colleagues (in press) and suggest a role of HBAU constructs in skin cancer risk behavior. Future validation studies should further examine the observed relationships. Geographic variation in the role of HBAU constructs is likely, so an important future direction is the examination of geographic differences in HBAU constructs, with HBAU items revised to reflect the climate of the region under study. Our study suggests that beliefs about health benefits of UV exposure and concern about the safety of sunscreen have implications for skin cancer risk behaviors.

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Table 3.1. Participant characteristics (N = 335).

Age M (SD)	21.5 (4.07)
range	18-51
Gender (%)	
Men	106 (33%)
Women	211 (67%)
Year in school	
First	41 (13%)
Second	61 (19%)
Third	120 (37%)
Fourth	99 (31%)
Parental educational attainment	
Less than high school diploma	10 (3%)
High school graduate	35 (11%)
Some college	75 (24%)
College graduate	135 (43%)
Graduate degree	61 (19%)
Untanned skin color	
Very fair	52 (16%)
Fair	138 (43%)
Olive	75 (24%)
Light brown	50 (15%)
Dark brown	4 (1%)
Very dark	2 (1%)
Skin response to 1 hour in the sun	
Burns, no tan	35 (11%)
Burns, then tans	67 (21%)
Burns slightly, tans easily	74 (23%)
Tans easily, no burn	96(30%)
No change	40 (13%)
I don’t go in the sun	9 (3%)
Indoor tanning (Ever/Never)	
Yes	245 (73%)
No	90 (27%)
Indoor or outdoor tanning (past 12 months)	
Yes	253 (77%)
No	76 (23%)
Outdoor tanning (Ever/Never)	
Yes	262 (78%)
No	73 (22%)
Outdoor tanning frequency (past 12 months)	
0	82 (24%)
1-2	77 (23%)
3-9	91 (27%)

10-19	48 (14%)
20-39	22 (7%)
40+	15 (5%)

Note: Not all percentages may sum to 100 due to rounding.

Table 3.2. Subscale and item means and standard deviations.

HBAU Item	**M (*SD*) Overall**
Subscale- Sunscreen toxicity	**2.36 (.81)**
1. Sunscreen ingredients are toxic	2.55 (.93)
2. Most sunscreen is full of harmful chemicals	2.49 (.94)
3. Sunscreen lotions probably cause cancer	2.19 (.92)
Subscale- Seasonal effects	**3.21 (.85)**
4. In Oregon, a bad mood in the winter can be because there is no sun	3.50 (1.01)
5. The cloudy weather in Western Oregon negatively affects me	3.17 (1.23)
6. Because of the cloudy weather in Oregon, my body can't produce enough vitamin D	2.98 (1.06)
Subscale- Health benefits of tanning	**2.52 (.84)**
7. Tanning is a healthy treatment for low vitamin D	2.28 (1.05)
8. Getting a base tan before going in the sun is protective against skin cancer	2.36 (1.11)
9. Tanning is a more natural way to get vitamin D than taking a pill	2.92 (1.12)
Subscale- Tanning through the winter	**2.82 (.89)**
10. Tanning can help you get through the Oregon winter	2.77 (.97)
11. Tanning can help you stay positive during the winter	2.86 (.99)

Note. Range for all items was 1-5. Scale scores were calculated as the average of the items on the scale. Seasonal Effects and Tanning Through the Winter observed range: 1 - 5, and Sunscreen Toxicity and Health Benefits of Tanning observed range: 1 - 4.67.

Table 3.3. Frequency distribution of HBAU items.

HBAU item	**Strongly Disagree** (%)	**Disagree** (%)	**Neither Agree Nor Disagree** (%)	**Agree** (%)	**Strongly Agree** (%)
Sunscreen ingredients are toxic	12.8	47.1	24.6	14.1	1.4
Most sunscreen is full of harmful chemicals	12.1	47.1	24.1	15.1	1.6
Sunscreen lotions probably cause cancer	23.1	45.9	20.8	9.5	.7
In Oregon, a bad mood in the winter can be because there is no sun	3.0	17.6	17.6	50.1	11.6
The cloudy weather in Western Oregon negatively affects me	8.3	28.7	15.4	32.4	15.1
Because of the cloudy weather in Oregon, my body probably can't produce enough vitamin D	5.7	34.4	22.1	31.9	6.0
Tanning is a healthy treatment for low vitamin D	25.4	38.8	19.3	15.0	1.5
Getting a base tan before going in the sun is protective against skin cancer	24.3	38.2	17.4	17.4	2.8
Tanning is a more natural way to get your vitamin D than taking a pill	11.7	27.5	23.6	32.0	5.2
Tanning is a way to get through the Oregon winter	8.3	34.5	31.6	23.3	2.2
Tanning can help you stay positive during the winter	7.3	33.1	27.4	30.6	1.6

Table 3.4. Summary of model fit indices and likelihood ratio test results.

Model	χ^2	*p*	$\chi^2\Delta$	$\chi^2\Delta$ *p*	*df*	RMSEA	CFI	TLI
Adjusted model	156.43	0.11	--	--	136	.021	.979	.954
Trim 1	156.92	0.12	.490	.484	137	.021	.980	.955
Trim 2	157.37	0.12	.450	.502	138	.020	.980	.957
Final model	157.43	0.13	.060	.806	139	.020	.981	.959

Table 3.5. Final model standardized path coefficients and standard errors.

	Indoor Tanning		Outdoor Tanning		Sunscreen Use	
	Coeff.	SE	Coeff.	SE	Coeff.	SE
1. Sunscreen Toxicity	.016	.098	-.082	.059	-.123*	.053
2. Seasonal Effects	-.01	.117	-.074	.079	--	--
3. Health Benefits of Tanning	-.005	.182	.428***	.116	--	--
4. Tanning Through the Winter	.312*	.141	-.035	.098	--	--
5. Susceptibility to skin cancer	.077	.077	.020	.057	.082	.051
6. Severity of skin cancer	-.011	.074	.057	.046	-.072	.058
7. Appearance motivation to tan	.244**	.086	.420***	.059	.024	.058
8. Sociocultural motivation to tan	.013	.080	.-.069	.062	-.114	.063
9. Alt. protection: Wear hat	.003	.085	-.073	.055	.160**	.051
10. Alt. protection: Wear shirt	.025	.081	-.114**	.046	.031	.053
11. Alt. protection: Umbrella	-.085	.074	-.100*	.050	.187***	.046
12. Alt. protection: Wear shades	.063	.081	.133**	.053	.179***	.044
13. Parental education	-.143	.083	.006	.051	.168***	.046
14. Skin color	-.086	.097	.029	.058	-.040	.041
15. Gender	.362***	.092	.237***	.067	.256***	.049

Note. * $p < .05$; ** $p < .01$; *** $p < .001$.

CHAPTER 4: INTEGRATIVE DISCUSSION

The problem of skin cancer is both highly complex and extraordinarily simple. A majority of keratinocyte skin cancers (KSC) are caused by a single environmental exposure: ultraviolet (UV) radiation (Armstrong & Kricker, 2001). Generally, carcinogenesis is a multifactorial process that can occur in individuals with no risk factors. Few cancers have such a unidimensional cause. Thus, the prevention of skin cancer should, in theory, be as simple as preventing risky UV exposure behavior such as intentional tanning and failure to adopt sun protection strategies. Skin cancer prevention is complicated, however, by the complexity of human behavior. High-risk behavior has been documented among individuals who are aware of the cancer-causing potential of UV (Hiom, 2006). Reducing the burden of disease from skin cancer is challenging, despite abundant information about the risk associated with UV exposure (Hobbs, Nahar, Ford, Bass, & Brodell, 2014). The considerable gap between knowledge and behavior seen in many preventable health conditions is likewise a challenge for skin cancer prevention. Although intentional UV exposure and failure to use sunscreen are clearly multifactorial behaviors, these findings suggest that the beliefs measured by the Health Beliefs About UV (HBAU) scale may encourage or provide additional justification for these risky behaviors. Thus, this dissertation represents a critical step toward the public health goal of reducing excessive UV exposure.

The current work focuses on identifying and measuring beliefs about UV exposure that may help explain the discrepancy between skin cancer knowledge and behavior. Skin cancer prevention efforts may focus on risk reduction by offering information about outcomes associated with UV exposure such as premature aging and carcinogenesis and offering sun protection resources and strategies. If the information about risks of sun exposure must compete with positive perceptions of sun exposure and a concern about sunscreen's safety that deters its use, however, such prevention efforts may be ineffective. Further, this challenge may be particularly problematic in a climate that is cloudy most of the year. The development of the HBAU scale is expected to enable the measurement of an additional aspect of skin cancer risk: health beliefs about UV in sun exposure and protection.

The overarching goal of this dissertation was to 1) develop an instrument to assess health beliefs about UV that may increase risky UV exposure and reduce sunscreen use, and 2) advance public understanding of skin cancer risk behaviors by examining these beliefs in Oregon college students. This dissertation has achieved its goals by developing the HBAU scale and demonstrating its relationship to skin cancer risk behavior outcomes of interest. I expected that UV exposure and sunscreen use would be related to the beliefs measured by the HBAU, and an examination of these behaviors supports my general hypotheses. These findings are consistent with recent studies of vitamin D-related beliefs (Holman et al., 2017) and indoor tanning in Canada (Qutob et al., 2017). Although the purpose of this study was not to build or test theory, I anticipate the HBAU will further be used in testing theoretical models of skin cancer behavior.

Health Beliefs About UV Among Oregon College Students

During the conceptualization and item pool development phases of this study, I anticipated this scale would have three subscales representing beliefs about vitamin D, seasonal depression and sunscreen safety, and that these scales would have good internal consistency. I found, however, that the beliefs in question are interrelated and the meaning of the subscales did not reflect these terms. Thus, I revised the factor names to more accurately reflect the subscale content, and the final four-factor scale includes two factors related to impact of the season on health and mood. The first reflects the endorsement of seasonal weather-related effects on mood, vitamin D sufficiency and general wellbeing, and the second reflects belief in tanning as an effective way to overcome the negative effects of the weather.

The emergence of both positive and negative factors related to the local weather, while unexpected, is a critical aspect of the HBAU structure. In retrospect, beliefs about the weather harming health and the belief that tanning can help prevent or reduce these harms are distinct and offer different information about an individual's experience of the environment. The positive association observed between beliefs supporting tanning to get through a cloudy winter and indoor tanning suggests a role of these beliefs in skin cancer risk. Indeed, indoor tanners scored higher on *Seasonal Effects* and *Tanning Through the Winter* subscales, recent tanners scored higher on *Health Benefits of Tanning,* and outdoor tanners scored higher on *Health Benefits of Tanning,* confirming my expectations. A positive relationship between the revised Appeal to Nature Inventory (Levy & McGuire, 2012) and *Sunscreen Toxicity* subscale confirmed my hypothesis that sunscreen safety concerns would be associated with preference for natural products and processes. The negative association between concerns about the safety of sunscreen and sunscreen use provide additional support for the role of HBAU constructs in UV exposure. Although I hypothesized that individuals with high levels of sunscreen toxicity concerns would demonstrate a preference for mineral sunscreen, due to the quality of the data about sunscreen formula, I was unable to perform this hypothesis. Overall, these findings offer confirmation of the contributing role of the measured health beliefs in skin cancer risk behavior.

When examined at the item level, participant responses overall on the HBAU subscales were somewhat encouraging. Students averaged less than 3.0 on 9 out of the 11 HBAU items, indicating that more students disagreed with the items than agreed with them. This is consistent with Noar and colleagues' (2014) findings on the *Mood Enhancement* and *Health Improvement* subscales of their Comprehensive Indoor Tanning Expectations scale (CITE). The *Mood Enhancement* subscale, which is scored similarly to HBAU subscales, contains items such as "Tanning would be enjoyable" and "Tanning would be relaxing." The *Health Improvement* subscale includes items regarding general improvement of health (e.g. "Tanning would be healthy for me" and "Tanning would be good for my skin"). An important difference between the Noar et. al. study and the current work is the more general wording of the items and Southeastern origin of the student sample. Noar and colleagues' study contributes significantly to the literature in its comprehensiveness, and the current work advances the literature by addressing the influence of local climate to UV exposure outcomes.

Recent research supports the importance of beliefs about vitamin D such as those on the HBAU in skin cancer risk behaviors. A large online survey of U.S. adults examined endorsement of beliefs about vitamin D (Holman et al., 2017). The belief that it is not possible to achieve vitamin D sufficiency through dietary sources was associated with lower sun protective behaviors, and individuals who endorsed the belief that tanning is an effective way to get vitamin D were more likely to indoor and to outdoor tan (Holman et al., 2017). In my sample, 37% endorsed the statement that the cloudy weather prevents them from producing enough vitamin D, but this result was not associated with skin color, as would be expected if participants were judging vitamin D production capacity based on skin biology. This finding contrasts with those of Holman and colleagues that non-Hispanic blacks were most likely to believe that sun protection put them at risk of vitamin D insufficiency (Holman et al., 2017).

Two HBAU items on which the participant mean score was above 3.0 were both on the *Seasonal Effects* subscale. Over half of the sample (62%) endorsed the statement "In Oregon, a bad mood in the winter can be because there is no sun," and 47% endorsed "The cloudy weather in Western Oregon negatively affects me." Further, based on HBAU subscale scores, female students believed in the seasonal effect of the weather on their health more strongly than did male students. In addition, although the *Seasonal Effects* subscale did not significantly predict exposure in the adjusted model, the high proportion of participants in the study who reported perceived seasonal effects on health has implications for college health in cloudy climates. Particularly, students with high scores on *Seasonal Effects* and *Tanning Through The Winter* may benefit from additional psychosocial support and counseling about non-UV approaches to relieving their symptoms.

The proportion of participants that agreed with the statements "Lying in the sun is a healthy treatment for low vitamin *D"* (17%) and *"*Getting a base tan before going in the sun is protective against skin cancer*"* (17%) are higher than the proportion of adults believing that tanning is an effective way to get vitamin D (5.1%) found by Holman et al. (2017). Holman found these individuals were more likely to be outdoor and indoor tanners, which is consistent with my findings. The higher level of this belief in my sample may be due to the college age or the geographic location of the sample. Nonetheless, a subgroup of Oregon college students hold beliefs that may place them at heightened risk for skin cancer via increased sun exposure. Further, a very recent analysis of indoor tanners in the Canadian Community Health Survey (Qutob et al., 2017), 62% of respondents reported getting a protective base tan as their reason for indoor tanning. This reason was more common than aesthetic purposes (21%) relaxation (15.8%) or for immune-boosting and vitamin D-related purposes (8.9%). Furthermore, 35% of respondents agreed or strongly agreed with the statement "Tanning is a more natural way to get your vitamin D than taking a pill." Endorsement of this statement was associated with higher frequency of outdoor sun exposure, further corroborating Holman's findings. Future longitudinal studies are needed to examine the nature of this relationship in greater depth, determine whether the observed association represents a causal relationship and identify potential moderators of this belief on UV exposure.

Participants predominantly disagreed with statements about sunscreen toxicity, but 10%-17% of participants agreed or strongly agreed with items stating that sunscreen probably causes cancer, that sunscreen ingredients are toxic, or that sunscreen is full of harmful chemicals. These sunscreen toxicity concerns were negatively associated with sunscreen use and unassociated with non-sunscreen forms of sun protection. This finding suggests that individuals who are concerned about the safety of sunscreen products use them less frequently. Furthermore, three of the four HBAU subscales were negatively associated with the following non-sunscreen forms of UV protection: wearing a hat, wearing a long-sleeved shirt, and staying under an umbrella or otherwise seeking shade. The additional finding that sunscreen use was positively associated with other non-sunscreen forms of sun protection, in the context of the other associations, suggests that disuse of sunscreen is not associated with compensatory adoption of other types of sun protection behavior. The absence of association between the HBAU constructs and wearing wraparound sunglasses is likely because sunglasses are often associated with fashion as opposed to cataract prevention (Vogel, 2002). While not indicative of a causal relationship, these findings overall indicate that sunscreen toxicity concerns are associated with a generally risky profile of low UV protection behavior.

The beliefs measured on the HBAU relate to the local climate, and many items refer to Oregon weather, but recent research suggests HBAU constructs may exist in other regions with extended cloudy winters. A recent print media content analysis of 2,103 skin cancer, tanning and vitamin D-related articles in Germany and Switzerland found that 26.8% of the articles included misleading or false statements, some of which support the beliefs reflected on the HBAU (Reinau, Meier, Blumenthal, & Surber, 2015). For example, in that content analysis, statements about vitamin D production that were erroneous or misleading were found in 21.3% of vitamin D-related articles. The following statement is an example: “Due to vitamin D being produced in the skin, sunbathing at the beach or in the garden is highly recommendable. In winter the solarium is an alternative.” Further, Reinau and colleagues included the following exemplar erroneous statement about sunscreen: “Traditional sunscreens contain chemicals that are known to be toxic.” Researchers found such statements in 11.9% of articles they reviewed. Reinau and colleagues’ findings suggest that the U.S. may not be the only region in which HBAU constructs exist. Research to identify sources of information that form the basis for these beliefs is needed in the United States.

According to Rozin (2005), the preference for naturalness that has emerged in the late 20th century is both moral and instrumental in origin. The term *chemical* may be understood as the inverse of natural and synonymous with unhealthy, synthetic, artificial, and toxic. Rozin found that individuals who preferred *natural* medicines over *chemical* ones continued to hold this preference irrespective of the comparative efficacy of the chemical equivalent and the structural identity of the compound. This finding is confirmed by Boon and colleagues (2013), who found that the naturalness of a product and the associated perceived lack of side effects was more important than product efficacy, except in special cases where efficacy was deemed essential. Because of the daily nature of UV exposure and cumulative risk of skin cancer, popular belief that sunscreens contain harmful chemicals may be problematic for skin cancer prevention over time.

The sunscreen toxicity beliefs I measured cannot be divorced from their context. Emergent lifestyle trends currently govern behaviors ranging from dietary restrictions to personal care product preference. Avoidance of chemicals and the consumption of superfoods are hallmarks of an era in which what one puts in and on the body is imbued with moral overtones (Shotwell, 2016). Individual decisions such as whether to lie in the sun or take a daily multivitamin in order to achieve vitamin D sufficiency, whether to take antidepressants for seasonal mood disturbance, or whether to apply sunscreen that contains synthetically derived compounds, now occur in a context of heightened awareness of environmental exposures (Sutton, Giudice, & Woodruff, 2016). Overall, the constructs measured by the HBAU may offer insight into potential avenues of skin cancer risk reduction among Oregon college students.

UV Exposure and Protection Among Oregon College Students

Rates of ever exposure to indoor tanning in the current sample (27%) were similar to rates observed in other collegiate samples (Cottrell, McClamroch, & Bernard, 2005) and among college-aged adults in some studies (Hartman et al., 2012; Watson et al., 2013). A recent analysis of national data that defined tanning as I defined recent tanning (at least one exposure in the past year), however, found considerably lower rates among 18-29 year old adults (Guy, Berkowitz, et al., 2015). Outdoor tanning in my sample (78%) and incidental tanning (87%) further illustrate the popularity of risky UV exposure in Oregon college students. The season of exposure was not measured, but because of the weather pattern common to Oregon, I expect that the reported outdoor and incidental tanning occurred during the hot summer months. In the past 12 months, 70% of participants had been badly sunburned, and 44% had been burned twice or more.

Regular sunscreen use (defined as often or always use) in this sample was low, which is consistent with recent findings on sunscreen use among U.S. adults (Holman et al., 2015) and college athletes (Hobbs et al., 2014). In gender-stratified analyses, I observed higher rates of sunscreen use overall among women, which is likewise consistent with the extant sunscreen use literature (Holman et al., 2015). Although national surveys such as the NHIS generally do not differentiate between warm sunny days and most days (NHIS, 2014), the more common use of sunscreen on hot sunny days than on most days (34% vs. 9%) that I observed suggests that Oregon college students may benefit from additional information about the risk of UV damage on cloudy days. Infrequent sunscreen use on a warm sunny day (defined as rarely or never use) was reported by only 34% of participants, compared to 56.7% of participants 18-29 in a national survey (Holman et al., 2015). This lower rate of disuse on warm days may be due to the education level of the sample. Conversely, over half of participants reported the belief that is it too cloudy for sunscreen where they live as a reason for not using sunscreen, and 31% agreed that sunscreen is not necessary in Oregon, which may explain these patterns. These findings suggest that Oregon's climate may generate a false sense of security regarding skin cancer risk, and although hot weather serves for most students as a cue to use sunscreen, the perceived need for sun protection is reduced on cool or cloudy days.

The scale development process, while focused on identifying ideal scale items, revealed important information about the behavioral outcomes that have broader implications for survey measurement of UV exposure and protection. Although nearly all participants embraced outdoor sun exposure in general, it became clear that measures that address indoor and outdoor tanning may require a more nuanced approach than originally anticipated. The term *tanning* may carry a stigma associated with indoor tanning, and thus use of this term may influence responses to questions about tanning outdoors. Interview data suggested that outdoor tanning was more acceptable when it could be dismissed as incidental to an outdoorsy lifestyle or active social life. Phrasing such as “getting some sun” and “lying out” may better capture attitudes toward outdoor solar UV exposure.

As the final form of the HBAU scale emerged, it became clear that some aspects of students’ health beliefs about UV would not be reflected on the final scale, despite their interesting nature. For example, the item *Getting some sun is healthy* was cut from consideration for the scale due to lack of variability. However, the very high level of agreement with this item (94%) highlights the broad acceptance of sun exposure as beneficial to health and further illustrates the importance of wording in eliciting beliefs about sun exposure. Furthermore, the negligible level of disagreement with this item (1.5%) suggests that at least when it comes to solar UV, cultural beliefs about the health benefits of exposure may be outweighing sun protection messaging. Historical associations of sun with invigoration and wellbeing persist. The proportion of participants who outdoor tanned, however, did not significantly differ between those who strongly agreed with the statement (82%) and to those who agreed (77%). The prevalence of outdoor tanning in my sample suggests a potential ceiling effect may have obscured an effect of this belief on behavior.

A further interesting result that emerged during validation analyses was the strikingly high proportion of participants who do not know what formula of sunscreen they use. I originally hypothesized that individuals with high sunscreen toxicity concerns would prefer mineral formula sunscreens to chemical formulas, but responses to the item about participants’ sunscreen formulas used prevented us from completing this analysis. The majority of participants (75%) responded that they do not know what type of sunscreen they use, and an additional 8% replied that they do not use sunscreen, and thus could not report their preferred formula.

Participants who scored high on sunscreen toxicity concerns were no more likely to be aware of their sunscreen formula than those who scored low on the scale. This additional finding suggests that beliefs that sunscreen contains harmful ingredients are formed either a) based on information that does not include detail about sunscreen formulations and their characteristics or b) with inattention to detail about the formulations. The implications of these findings are twofold. First, the general concern about sunscreen safety is not based on information participants have gathered about the formulation of sunscreen and the characteristics of the photofilters themselves either in personal research or during product purchase; were that the case, participants would be able to report the type of sunscreen they use based on product labelling. Second, because participants with high levels of sunscreen toxicity beliefs were no more able to report the type of sunscreen they use than those with low levels of these beliefs, I can conclude that the concerns they report are not leading to actions such as information-gathering about different sunscreen formulations. As demonstrated, however, these beliefs are associated with lower use of sunscreen. In light of these findings, future research should attempt to describe and characterize people who report high sunscreen toxicity beliefs and their cognitive and behavioral responses to these beliefs by examining these beliefs in a larger and more diverse sample.

In general, concerns about sunscreen containing toxic chemicals may be part of a broader mindset. The negative association between sunscreen toxicity concerns and the belief that the FDA does a good job at protecting consumers may offer some insight into other characteristics of these individuals who believe sunscreen contains toxic ingredients. Indeed, some health-related beliefs may cluster in ways that are informative for intervention research. I did not measure participants' beliefs about risks associated with vaccination or the belief that ingredients in vaccines are toxic, but these beliefs resemble sunscreen safety concerns in that they represent distrust in products and processes that are intended to preserve the public's health. Further research should examine the origin and covariates of sunscreen toxicity concerns.

The broader work of developing the HBAU and examining its relationship to UV exposure represents progress towards understanding the impact of local environment on skin cancer risk behaviors. In rainy or cloudy climates, identifying and addressing these beliefs in college students may present an important step toward reducing risky UV exposure behaviors. This work demonstrates that beliefs about positive health effects of UV exposure play a role in UV-related behavior, and this study is a step in the pursuit of a deeper understanding of UV exposure in Oregon. My findings require replication in a larger and more representative sample, and HBAU constructs should be assessed in varying climates to determine their geographic variability, both in the U.S. and internationally. Reinau and colleagues' analysis of German and Swiss media communications related to skin cancer, indoor tanning, and vitamin D discovered that misleading or erroneous information was widespread (Reinau et al., 2015), and many HBAU beliefs were reflected in these articles. Researchers did not measure penetration of these messages in terms of popular acceptance, but an examination of information sources that underlie the formation of the HBAU constructs may illuminate potential avenues for future skin cancer risk reduction strategies.

Implications for Public Health Policy and Practice

Findings of the current study have implications for cancer risk communication policy. Analysis of newsprint articles in the U.S. in 2009 demonstrated an emphasis on the use of sunscreen with infrequent mention of alternative risk reduction methods (Cokkinides, Kirkland, Andrews, Sullivan, & Lichtenfeld, 2012). Furthermore, although the U.S. Surgeon General's Call to Action to prevent skin cancer (2014) highlights the importance of sun safety efforts that promote the adoption of a variety of complimentary sun protection behaviors as opposed to sunscreen use alone, reliance on sunscreen to the exclusion of other methods of sun protection is a problem both in the U.S. and abroad (Koch, Pettigrew, Strickland, Slevin, & Minto, 2016; Linos et al., 2011). For this reason, concerns about sunscreen safety must be measured and addressed to overcome this barrier to sun protection. Sunscreen toxicity concerns should be evaluated in a broader study of sun protection behaviors to determine, in cases of sunscreen disuse, whether any alternative methods of sun protection are being adopted, and whether those methods are effective. The association of sunscreen toxicity concerns with preference for natural products observed raises a potentially challenging area of behavior change. If, as previous findings suggest (Boon et al., 2013; Rozin, 2005b; Rozin et al., 2004) individuals who prefer natural products prefer them regardless of the effectiveness of the product, these individuals may be uniquely likely to use untested, home-formulated or ineffective sun protection products.

The current study also has implications for policy at the state and local level. In regions with predominantly cloudy weather, public health attention to perceptions of seasonal effects on mood may be warranted. Furthermore, greater attention to the wording of skin cancer, seasonal depression and vitamin D deficiency risk communications may reduce perceptions that UV exposure is therapeutic in cloudy climates. In the university setting, students who have recently relocated to a cloudy climate may require additional resources to manage the perceived impact of the weather on their mood, and to ensure that risky UV exposure is not adopted as a coping strategy. New program content tailored to address student beliefs about UV exposure, their mood, vitamin D sufficiency and the local climate may help student health professionals address the needs of their student populations.

Clinicians may play a critical role in the identification of populations at high risk for skin cancer. The advent of computer-assisted surveys in the medical setting and electronic medical records enables healthcare providers to gather important and up-to-date behavioral and socio-cognitive data about patients before an appointment begins, and this approach is already being used in many clinics (Ferrari, Ahmad, Shakya, Ledwos, & McKenzie, 2016). A tool such as the HBAU may help clinicians identify clients whose beliefs may lead to risky sun exposure. When used in student health clinics, dermatology practices and general practice as a pre-appointment screening tool, the HBAU may identify young patients who believe that they are at high risk for vitamin D deficiency due to the local weather patterns. Such patients might benefit from a discussion with a healthcare provider about their vitamin D levels, possible screening for vitamin D deficiency and, in the case of deficiency, counselling about food sources of vitamin D and supplementation. In this setting, the HBAU may assist primary care providers to refer patients with these beliefs to needed sun safety resources, in a manner similar to that currently used in mental health screening among youth (Honigfeld, Macary, & Grasso, 2017). Furthermore, the repeated use of the measure at regular appointments would generate information about HBAU constructs over time, enabling the examination of the temporal stability of these beliefs. The HBAU requires additional validation in older and younger populations prior to use in a clinical setting.

Limitations

This study has several limitations. First, the sample is from a single university in Oregon, so findings are not generalizable to the U.S. population, or to college student populations in other regions. For example, students attending universities in Eastern Oregon may differ in their health beliefs about UV; thus, the HBAU requires validation in more diverse samples. Second, the cross-sectional nature of the data also limit the conclusions that can be drawn about the relationship between HBAU constructs and sun exposure and protection behaviors. For example, UVB exposure produces a short-term beta-endorphin release, which may be interpreted as having a therapeutic effect on seasonal mood symptoms. Thus, beliefs on the *Tanning Through the Winter* subscale may increase UV exposure, but experiences with positive feelings after UV exposure may also drive the belief that tanning is a way to survive a cold winter. Longitudinal research examining the temporal relationship between HBAU beliefs and sun exposure is needed to examine whether the association between HBAU constructs and behaviors is causal in nature.

An additional limitation of the current study is the measurement of potential confounders. Measuring socioeconomic status presented a challenge in this college student sample. Some measures of SES such as personal income were inappropriate because of the transitional nature of the college experience and the fact that income at this time may not be reflective of a student's overall SES either before, during, or after college. Parental income was likewise not appropriate because students a) may not know or be able to accurately report their parents' income and b) may no longer be supported by parents. Personal education level was also not useful because of the source of the sample. So, as a proxy for socioeconomic status, the highest education level achieved by either parent was recorded. A potential avenue of future research may examine whether sunscreen toxicity beliefs influence sunscreen use differently in high and low SES populations.

An additional challenge for this study was achieving adequate sample size considering the nature of tanning as an outcome. Grouping participants by whether or not they had ever engaged in indoor tanning was necessary, but ideally I would have achieved a sample with enough recent indoor tanners to conduct analyses based on this conceptualization of tanning. Additionally, outdoor tanning is qualitatively different from indoor tanning and is a less precisely defined behavior. Because of the high rate of outdoor tanning, future studies should consider measurement of outdoor tanning, what frequencies or intensities or this behavior represent important behavioral categories and whether intent should be a factor in determining whether outdoor activity is considered tanning.

Finally, data collection spanned multiple seasons, so the context of season of measurement may have impacted these findings. The measurement of sun exposure behavior may be influenced by the immediate seasonal context. Adams and colleagues found season of interview differences on reported exposure behaviors such as sunscreen use on a warm sunny day and non-sunscreen UV protection behaviors, using NHIS and BRFSS data. Thus, additional variability in reporting of the outcome and UV protection covariates may have biased findings towards the null. Although Adams et al. did not assess differences in beliefs related to UV exposure, this limitation may also apply to the HBAU constructs themselves. Additional research is needed to examine seasonal and geographic stability of these constructs. I further did not measure the timing of outdoor tanning, so I was unable to tell whether the outdoor tanning reported is part of the risky pattern of intermittent intense sun exposure associated with skin cancer. Outdoor tanning in Oregon is less likely to occur outside of the intensely sunny summer season, however, because of the cool climate ("Average Number of Cloudy Days - Western Regional Climate Center," 2015). Despite its limitations, the current study offers a new instrument to more comprehensively measure beliefs related to UV exposure. These findings offer interesting insight into UV exposure behavior in Oregon and raise new avenues of future research.

Future Directions

Building on this dissertation, a further study will examine geographic patterns in beliefs about UV. It is possible that students raised in Oregon differ from students who have relocated to Oregon on HBAU constructs. A research question related to this topic is whether recent relocation is associated with higher scores on HBAU subscales related to weather, mood, and benefits of tanning. Additional studies underway will examine in greater depth the meaning behind beliefs about sunscreen toxicity, differences between indoor and outdoor tanning (and potential stigma against these words that may influence response patterns), and levels of participant knowledge about HBAU-related constructs. The relative importance of effectiveness and naturalness in relation to sunscreen toxicity concerns may offer important insight into the role of these beliefs in sunscreen use. My item comprehension interviews raised interesting questions about participant understanding of the relationship between UV exposure and health, and the importance of exposure context in determining risk. Participants drew a distinction between tanning outdoors and engaging in physical activity outdoors without sun protection, although the UV exposure level involved should be similar. If lying by a pool in the sun to get tan is stigmatized or perceived as unhealthful, but floating down the river in similar attire is not, these contextual aspects of UV exposure may have implications for prevention messaging. Additional in-depth interviews will be conducted to explore, among other things, what distinction students draw between the terms *sun exposure* and *tanning* and what contexts might cause risky UV exposure behaviors to be considered low-risk.

Future studies are needed to validate the HBAU in other age groups, geographic regions and racial/ethnic groups, as well as to examine correlates of the constructs measured on the HBAU. Research is also needed to provide information about the origin of the beliefs measured by the HBAU, regions in which they are most common, whether they are stable, and how they may evolve over time. For example, higher endorsement of tanning for a protective base tan in a Canadian population-based sample than in my Oregon student sample may be related to local climate (Qutob et al., 2017). Qutob also observed rates of tanning to achieve vitamin D or immune-boosting effects that were lower than I observed but higher than those found by Holman in a representative U.S. sample (Holman et al., 2017). It is likely that tanners differ geographically in their reasons for tanning, and in future studies the HBAU may help identify geographic regions where health beliefs have an important role in skin cancer risk.

Conclusion

The dual purposes of the present study were to develop and validate a psychometrically sound scale to measure specific health beliefs about UV exposure and, using this scale, to examine the prevalence of these beliefs and their role in UV exposure in a college student sample. These findings support and extend recent research into skin cancer risk behavior, provides additional insight into UV exposure behaviors among Oregon college students, and suggests next steps for additional research on the etiology and behavioral impacts of these beliefs. My results are consistent with findings of recent studies in the field of UV exposure behaviors research. Next steps include the administration of the HBAU at a larger number of college campuses and additional interviews to identify possible mechanisms through which HBAU constructs may be reversed. The health beliefs measured on the HBAU may be relevant not only to the skin cancer risk of young adults, but also more generally to the health of students concerned about the impact of the environment on their mood. Thus, this dissertation has achieved its goal of advancing the literature on UV exposure and protection.

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Appendix A: Literature Review

The literature related to the current study spans several fields, so the relevant literature from each will be summarized below. To clarify the purpose of the study, indoor tanning, vitamin D, seasonal depression, sunscreen formulation, and measurement of UV exposure behaviors will be briefly reviewed. The relevance of the Oregon context to the proposed study is highlighted throughout.

Historical Context

Intentional exposure to UV light has an interesting medical and cultural history. Aside from its biological role (Jablonski, 2004), skin color has also been the foundation of social constructions of beauty and class worldwide (Hunt, Augustson, Rutten, Moser, & Yaroch, 2012). During eras when preference in the U.S. and Europe was for fair skin and the canon of beauty was porcelain and unblemished, avoidance of the sun was, for women in particular, critical beauty maintenance (Segrave, 2005). The avoidance of sun exposure and the associated pigmentation of the skin was rooted in classist bias; only the wealthy could afford to be indoors and, thus, to have the revered complexion (Fitzpatrick, 2014; Hunt et al., 2012). Tanned skin was associated with outdoor labor and lower class. Nonetheless, the health benefits of UV exposure were noted in the medical profession; the therapeutic effects of sun exposure for treatment of rickets and tuberculosis, as well as some dermatological conditions, led to the use of solaria and relocation to higher latitudes for health benefits (Hunt et al., 2012).

The medical community began prescribing UV exposure for a broadening array of ailments including diabetes, hypertension, hypotension, constipation, and gastric ulcers (Albert & Ostheimer, 2003). UV exposure was prescribed as a preventive health approach as well, and it was thought to offer benefits as broad as improvement of overall well-being, boosting immune function, and improving cognition, hemoglobin levels, angina pectoris, and circulation (Albert & Ostheimer, 2003). Public sentiment prizing pale skin changed in the 1920s when Coco Chanel popularized sunbathing and advertisements for women's swimwear depicted unprotected sun exposure as healthy (Andrieu, 2009). Beliefs about the health benefits of UV light led to public health efforts to increase sun exposure and influenced a change in fashion towards loosely woven materials and increasingly revealing bathing suits (Albert & Ostheimer, 2003). Tanning outdoors gained increasing popularity with media depictions associating bronzed skin with health, vitality, and sex appeal; and the manufacture of tanning lamps emitting UV light gave rise to an industry (Hunt, Augustson, Rutten, Moser, & Yaroch, 2012).

Sun protection in the early part of the 20th century primarily consisted of gradual increases in length of sun exposure to reduce the chance of sunburn (Hunt et al., 2012), but the 1940s brought the commercial availability of topical sunscreens (Segrave, 2005). Pioneered by Coppertone, the industry of sunscreen marketed their products as tanning aids that would maximize a deep tan while reducing sunburn. Using exhortations such as "Don't be a Paleface," and "Tan- Don't burn! Coppertone" sunscreen advertising promoted UV exposure. A year-round tan was further popularized by celebrities who could afford to travel to tropical climates, and the idea of tanning safely was used to sell sun care products as well as increase UV exposure in general (Hunt et al., 2012).

After the discovery in 1928 that UV exposure causes cancer in rodents (Albert & Ostheimer, 2003), awareness in the medical community of the risks of UV exposure grew throughout the mid-20th century. Public health campaigns to increase sun protection and press coverage of skin cancer increased public awareness of the risks associated with UV exposure but failed to keep pace with popular preference for a tanned look (Hunt et al., 2012). The discovery that UVB rays are responsible for sunburn led to the design and manufacture of tanning beds in the late 1970s that filtered out UVB which were marketed as a "safe" tan because they did not emit burning rays (Hawk, 1983). Despite their marketing as a low-risk route to a dark tan, however, these beds emitted UVA and UVB rays, and presented a considerable risk of cancer, skin damage and cataracts (Hawk, 2000). Public appeal for tanning expanded through the media and popular press (Segrave, 2005). Between 1979 and 1983, Mattel manufactured the *Sun Lovin,' Beach Party, Sunsational*, and *SunGold Malibu* Barbie models. These dolls came with bikinis and tan lines (D'Amato, 2009). Positive messages about a tanned appearance being sexy, attractive, and upper-class have persisted in the media through the promotion of spray tanning, and the popularity of a tanned appearance remains strong (Cokkinides, Weinstock, Lazovich, Ward, & Thun, 2009).

Frameworks for Indoor Tanning, Sunbathing and Sunscreen Use

Researchers interested in health risk and health protective behaviors such as indoor tanning and the use or disuse of sunscreen have employed various models to understand the behaviors' environmental, cognitive and socio-behavioral determinants. Hillhouse and Turrisi (2012) note that few studies have attempted to apply behavioral models in their entirety to tanning behavior. Danoff-Burg and Mosher applied Jaccard's (1981) Behavioral Alternatives Model to address indoor tanning (Danoff-Burg & Mosher, 2006), theorizing that the decision to indoor tan arises from a lack of appealing alternatives to achieve the appearance enhancement, relaxation and social goals fulfilled by indoor tanning. UV exposure research has often emphasized continuum-based models of behavior change such as the Behavioral Alternatives Model (BAM) (Jaccard, 1981), the Health Belief Model (Cummings, Jette, & Rosenstock, 1978), Azjen's (1985) Theory of Planned Behavior (TPB), and Social-Cognitive Theory (Bandura, 2004). Interventions using such behavioral models generally focus on manipulating modifiable cognitive and socio-behavioral variables theorized to impact the likelihood of a health behavior. Although full models of the TPB and BAM have each been fit in studies to UV exposure behaviors (Danoff-Burg & Mosher, 2006; Hillhouse, Adler, Drinnon, & Turrisi, 1997; Hillhouse & Turrisi, 2002; Hillhouse, Turrisi, & Kastner, 2000), most theories or behavioral models are only represented in part in indoor tanning studies. The use of hybrid behavioral models is common in UV exposure research, and for this reason, Hillhouse and Turrisi argue that a more comprehensive examination of the HBM and social cognitive theory (SCT, Bandura, 1986), as well as exploration of the Transtheoretical Model (TTM) should be undertaken (Hillhouse & Turrisi, 2012, pg. 82).

Hybrid models of tanning behavior have frequently included constructs from the HBM (Becker, 1974) such as perceived risk, perceived susceptibility and perceived severity of negative outcomes of a health risk behavior (or outcomes of not initiating a health protective behaviors), as well as perceived benefits and barriers to behavior change. Perceived threat of a behavior, the HBM construct determined by perceived susceptibility and severity of health outcomes, has not consistently predicted UV exposure behavior. Under the HBM, perceived threat of a behavior should increase the likelihood that the behavior is discontinued or that a protective counter-measure is adopted. Hillhouse and Turrisi (2012) suggest that the varied results obtained in studies measuring perceived threat may be due to increased salience of skin cancer risk information among people who engage in high risk UV-related behavior. It may also be the case that those who tan have high threat perceptions because they are aware of the risk their behavior involves, but the risk is inadequate to motivate change.

Constructs from Social Cognitive Theory such as behavioral self-efficacy and outcome expectations (Noar et al., 2014) have been included as predictors of UV exposure behavior. In UV exposure models, self-efficacy would be the individual's perceived competence to carry out a health behavior (i.e., consistent sunscreen use, sun avoidance, tanning cessation, etc.). Outcome expectations are beliefs about what the outcome of a behavior will be, for example the belief that achieving a tan will increase one's sexual attractiveness. Other socio-cultural influences commonly included are the role of peer and family subjective norms (beliefs about what one's peers or family do or prefer). Peer norms, particularly the perception that most peers prefer to look tan and that a high percentage of peers engage in tanning, have been consistently found to predict tanning behavior and behavioral intentions (Hoerster et al., 2007; Jackson & Aiken, 2000; Stapleton, Turrisi, & Hillhouse, 2008). The proposed study will employ constructs from the HBM and SCT to understand the influence of beliefs on UV exposure and sunscreen use. These constructs are described below.

Factors Influencing UV Exposure and Protection

Female gender and youth. Under the HBM, demographic characteristics such as age and sex are factors that impact risk and susceptibility perceptions. Studies of indoor tanning prevalence demonstrate that this form of intentional UV exposure is more common in females than males at all ages (Hartman et al., 2012; Wehner et al., 2014). Tanning is furthermore increasingly promoted in the educational and academic settings with tanning salons advertising and offering coupons in high school newspapers (Freeman, Francis, Lundahl, Bowland, &

Dellavalle, 2006) and partnering with universities as vendors for sponsored debit cards (Boyers et al., 2014). Tanning generally is promoted to women as a mode of appearance improvement, and advertisements of tanning and tanning-related products often target females and young adults by linking tanning to fashion, celebrities and popularity (Greenman & Jones, 2010). Gender is a predictor of frequency of skin cancer risk behaviors such as indoor tanning, intentional tanning in general, and low sunscreen use (Coups & Phillips, 2011; Heckman & Coups, 2011; Holman et al., 2015; Holman & Watson, 2013). In the U.S., however, sun care products are marketed towards women more aggressively than they are to men (Lee et al., 2006), and sunscreen use is a cornerstone of the anti-aging industry as well as the skin cancer prevention field. The frequent, intentional UV exposure and use of sun care products as tools for anti-aging seen among women can be viewed through the lens of objectification theory (Fredrickson & Roberts, 1997), whereby women internalize messages about their comparative attractiveness and begin to self-objectify, valuing the appearance-enhancing effects of both these behaviors.

Social/environmental influences on UV exposure. Social determinants of tanning and sun protection behaviors have also been identified. Behavioral modeling, a construct arising from Social Cognitive Theory (1986) explains the impact of parental behavior on adolescents who tan. Having parents who tan or who hold positive attitudes about tanning (Cokkinides, Weinstock, O'Connell, & Thun, 2002; Coups & Phillips, 2011) increases risky UV exposure among youth, as does parental approval of tanning (Hoerster et al., 2007). Modeling of tanning behaviors by the maternal or female caregiver strongly increases odds of adolescent tanning (AOR: 3.2) as does maternal permissiveness (AOR: 9.1) and lack of gatekeeping or monitoring (AOR: 1.7) (Stryker et al., 2004). Peers are similarly influential in tanning behavior. Having peers who tan or who hold positive attitudes about tanning increase tanning behavior among adolescents (Andreeva, Reynolds, Buller, Chou, & Yaroch, 2008; Holman & Watson, 2013). The role of norms and social learning in tanning behavior is clear from studies of tanning-related behaviors and attitudes among youth; identification with a popular peer group in college students was associated with past year use and intention to use tanning salons in the future (Stapleton et al., 2008). Furthermore, Hoerster and colleagues (2007) found that the perception that many of one's peers hold pro-tanning attitudes increased odds of tanning behavior (AOR: 1.7). Parental modeling of tanning behaviors and perceived peer norms and behaviors are all predictors of indoor tanning.

Appearance motivation. Alteration of appearance by attaining a tan is a common motive for UV exposure. Intentional tanning, either in a tanning bed or outdoors, is highly correlated with positive personal and peer attitudes about tanning, and the belief that tanned skin is more attractive, appealing or sexy (Holman & Watson, 2013; Robinson et al., 2008). The appeal of tanned skin also often extends to the impression that tanned skin is healthier than pale skin (Robinson et al., 2008). Parental approval of tanning and perceived peer and partner belief that tanned skin is attractive have also been associated with tanning bed use (Weinstein, Yarnold, & Hornung, 2001). The value placed on appearance, however, has also been used to reduce tanning and increase sunscreen use (Cornelis, Cauberghe, & De Pelsmacker, 2014; Hillhouse, Turrisi, Stapleton, & Robinson, 2008; Olson, Gaffney, Starr, & Dietrich, 2008; Tuong & Armstrong, 2014). Notably, messaging about the impact of UV exposure on premature aging has decreased indoor tanning behaviors and intentions both among indoor tanners in general and tanners with low information (Hillhouse et al., 2008), and it has increased sunscreen use intentions among high school students (Tuong & Armstrong, 2014). In contrast, positive attitudes toward indoor tanning, positive outcome expectations of tanning, and positive beliefs about tanning increase UV exposure behavior (Coups & Phillips, 2011).

Cafri and colleagues have considerably advanced the measurement of appearance-based tanning motivation (Cafri et al., 2006, 2008, 2009)They developed the Physical Appearance Reasons to Tans Scale (PARTS) and revealed that appearance motives are multidimensional, with motives that are related to general appearance (i.e., looking better overall) and motives that are specific (i.e., improvement of acne or concealment of cellulite)(Cafri et al., 2006). They continued their work by confirming the factor structure of a scale of reasons to tan and not tan in a sample of 589 female and 335 male college students at a university in South Florida (Cafri et al., 2008). Using key constructs from the Theory of Reasoned Action (Fishbein & Azjen, 1975), the HBM (Becker, 1974), and the body image literature, their study included three higher-order factors: *sociocultural reasons to tan*, *appearance reasons to tan*, and *appearance reasons not to tan*. Lower-order sociocultural reasons to tan were *friends*, *family*, *significant others,* and *media*; appearance reasons to tan were *general, acne,* and *body shape*; and appearance reasons not to tan were *skin aging* and *immediate skin damage*. Cafri and colleagues confirmed the scale factor structure and noted that some items related to appearance produced gender invariance. Thus, items written about constructs that may be differentially relevant to men and women should be written with attention to avoid language that may only be relevant to one sex. Therefore, Cafri et al.'s Appearance Reasons to Tan and Not Tan scale captures both general and specific appearance reasons to tan and not tan, and measures the influence of peer, family, significant others and media in sociocultural influences on tanning.

Knowledge. Information about the health risks of UV exposure is an important motivator of UV avoidance behaviors. Knowledge about the necessity and correct use of sun protective methods is also critical to their adoption (Cercato et al., 2014; Janssen, Kann, de Vries, Lechner, & van Osch, 2015). Under the Health Belief Model (Becker, 1974), UV exposure and protection behaviors are influenced by an individual's level of knowledge or education on the topic of sun safety as a determinant of the perceived susceptibility and severity of the health outcomes of UV exposure. Lack of information on the risks of UV exposure predicts risky UV exposure in collegiate athletes (Hobbs et al., 2014), in adult women (Hobbs et al., 2014) and youth (Andreeva et al., 2008). Although information about the risk of skin cancer inherent in UV exposure is a component of most models of UV exposure/protection behavior (Hillhouse & Turrisi, 2012), indoor tanning and poor UV protection do not arise from a lack of information about cancer risk (Robinson, Rademaker, Sylvester, & Cook, 1997; Sven Schneider, Zimmermann, Diehl, Breitbart, & Greinert, 2009).

Risk perception. One construct of interest to UV exposure research is risk perception. Many behavior theories, such as the Health Belief Model (Becker, 1974) and the Protection Motivation Theory (Rogers, 1975), acknowledge the role of the perceived risk of a behavior in determining the adoption of health protective counter-measures. As discussed above, the Health Belief Model posits that the decision to engage in a health behavior is based on an individual's evaluation of the threat of a negative outcome associated with continuation of a risky behavior, balanced against the benefits of that behavior. The perceived threat is influenced by the individual's perceived vulnerability to the negative outcome (the likelihood that a negative outcome, such as cancer, will happen to them) and perceived severity of the outcome (how undesirable the outcome, such as premature skin damage, is). Generally, skin cancer research has framed UV exposure as a risk behavior, and has assessed perceived risk of skin cancer or premature aging (Cornelis et al., 2014; Heckman, Wilson, & Ingersoll, 2009; Hillhouse, Thompson, Jacobsen, & Cafri, 2009) as primary deterrents of the behavior, although the predictive validity depends on how risk perception is measured (Eva Janssen, van Osch, de Vries, & Lechner, 2011). In the proposed study, perceived susceptibility and severity of vitamin D deficiency, seasonal mood symptoms, health effects due to sunscreen use, premature aging and skin cancer will be measured as determinants of UV-related behaviors.

Health beliefs. Under the HBM (Becker, 1974), an individual's perceived threat of a behavior (or failure to initiate a protective behavior) is influenced by perceived susceptibility and severity of negative outcomes of the behavior. Perceived susceptibility and perceived severity are influenced by the individual's knowledge about the behavior. A person lacking knowledge about the risks of the behavior will perceive less risk and be less likely to engage in behavior change to avoid the risk. Likewise, health beliefs about a behavior influence perceived susceptibility and severity. For example, a young person who believes that skin cancer only occurs in older adults, or that skin cancer is not fatal, will be less likely to initiate skin cancer risk reducing behaviors. Likewise, a person who sees few risks to UV exposure and believes that sunscreen contains toxins that cause cancer may be unwilling to use sunscreens. As discussed above, skin cancer research has generally framed UV exposure as a risk behavior and UV protection as a protective behavior (e.g., Crane et al., 2012; Hillhouse & Turrisi, 2002; Olson et al., 2008), but it is possible that beliefs about the benefits of UV exposure and possible risks of sunscreen use lead young people to conceive of UV exposure as a health protective behavior, and sunscreen use as a risk. The sections below explain the risk/benefit equation, framing UV exposure as a risk behavior and as a protective behavior.

Risks of UV Exposure/Benefits of UV Protection

Public health messaging about sun exposure has increasingly emphasized the negative health effects of UV exposure and promoted UV protection (Hunt et al., 2012, pp. 23-25). Beliefs about negative health consequences of UV exposure and the health benefits to be gained from UV protection are theorized to suppress risky UV behaviors and increase UV protection. Public beliefs about what negative outcomes to expect from UV exposure and the benefits of UV protection derive from family upbringing, peer norms and public health awareness campaigns (Jackson & Aiken, 2000). From the public health perspective, UV protection is an effective method of reducing risk of sunburn, photoaging, and skin cancer (Autier, 2004; Heckman & Manne, 2012)

Melanoma and non-melanoma skin cancer. Exposure to UV radiation has long been associated with increased risk of both melanoma and non-melanoma skin cancer (NMSC), and UV radiation (UVR) is now classified as a known carcinogen ("IARC Monographs-Classifications," 2014). The sun emits a spectrum of wavelengths of light, some of which are visible, and some of which are not. The invisible ultraviolet wavelengths are classified as UVA, UVB, and UVC and Vacuum UV (100-200nm). UVC, the most harmful class of UV wavelength (220-280 nm), are dispersed by the Earth's atmosphere. UVB (280-320 nm) and UVA (320-400nm) have both been implicated in human carcinogenesis. The skin penetration of UV rays is dependent on wavelength; shorter UVB are responsible for the reddening and inflammation of the skin after prolonged exposure (the *erythemal response*), as well as acute and chronic skin damage (O'Leary, Diehl, & Levins, 2014). UVA rays penetrate deeper into the dermis, and although they produce a darkening of the skin, they do not induce erythema. Both UVA and

UVB rays are absorbed by DNA, causing DNA damage and mutation, and both are implicated in carcinogenesis of the skin (Armstrong & Kricker, 2001; Coelho & Hearing, 2010; Leiter & Garbe, 2008; Mason & Reichrath, 2013). Although mortality from NMSC is decreasing, a rising incidence of basal cell carcinoma and squamous cell carcinoma is attributed to increased UV exposure, outdoor activity, increased longevity and ozone depletion (Leiter & Garbe, 2008).

The amount and type of UVR varies by altitude, latitude, season, and time of day, as well as with local cloud cover, ozone level (Engelsen, 2010). The effect of an hour of outdoor UV exposure is highly variable, and this variability has led to tanning industry claims that indoor tanning is safer than solar UV exposure (U.S Congress, 2012). One effect of indoor or outdoor exposure to UV rays is burning of the skin, although it is possible to incur skin damage without erythema.

Premature aging. Another outcome of UV exposure over time is early photoaging of the skin. The term *photoaging* refers to changes in the skin induced by cumulative UV exposure (Rabe, Mamelak, McElgunn, Morison, & Sauder, 2006). Typical changes observed in skin that has been exposed to UV rays compound the effects of chronological aging on appearance. Although 1980s-era tanning marketing promoted tanning beds high in UVA as a safe tan, both UVA and UVB are now implicated in the photoaging process (Armstrong & Kricker, 2001; Coelho & Hearing, 2010). Photoaging generally presents as loss of elasticity, dryness, uneven pigmentation and patchiness, often with wrinkles and actinic keratoses (Green, Hughes, McBride, & Fourtanier, 2011). Absorption of UVB causes skin damage primarily by generating DNA mutations in dermal cells, and to a lesser degree, by producing reactive oxygen species (ROS), also known as *free radicals*. The deeper dermal penetration of UVA wavelengths directly damages DNA and collagen, and indirectly harms the skin by generating ROS. Both these routes of damage ultimately lead to skin elastosis, thickening of the epidermis, wrinkling and discoloration (Hughes et al., 2013). Because the sun protection factor (SPF) of a sunscreen is determined based on the minimal dose of UV required to induce erythema, this metric is not a good indicator of a sunscreen's ability to prevent photoaging (Rabe et al., 2006).

Benefits of UV exposure/Risks of UV protection.

Vitamin D-related benefits of UV exposure. Synthesis of vitamin D is the primary known benefit of UV exposure (Webb & Holick, 1988). Discussion of beliefs motivating UV exposure and protection behaviors in the tanning literature have focused primarily on popularity, sex appeal, appearance, and looking healthy (Cafri, Thompson, Jacobsen, & Hillhouse, 2009; Hillhouse et al., 2009), distinct from the belief that UV exposure represents a behavior with biological outcomes that are beneficial to human health. Several plausible health beliefs that may motivate tanning or reduce sun protection such as beliefs about risk of vitamin D deficiency are, however, commonly covered in the popular press (Caulfield et al., 2014) and may underlie intentional UV exposure, particularly in low latitude regions due to the higher risk of vitamin D deficiency in these areas (Holick, 2006). Although research is increasing our understanding of tanning behavior, health beliefs that possibly motivate UV exposure behaviors have not been as widely studied as appearance-related motives and social influences. This avenue of research is critical to skin cancer prevention efforts because pursuit of positive health outcomes of sun exposure among people in low UV regions may lead to indoor tanning and sun-seeking that motivates intermittent acute sun exposure, which may play a bigger role in cancer etiology than cumulative exposure (Gandini et al., 2005).

UV exposure and vitamin D synthesis. The topic of UV exposure and the appropriate amount of sunlight for ideal health is currently controversial (Gilchrest, 2008), because UV exposure increases cancer risk (Reichrath, 2009). Sun exposure also confers some health benefits that are mediated by cutaneous Vitamin D production triggered by exposure to the UVB spectrum of radiation (Reichrath, 2009; Webb & Holick, 1988). UVA exposure, on the other hand, is implicated in skin damage and aging but does not lead to vitamin D synthesis. The public health goals of skin cancer reduction and vitamin D sufficiency have been framed as adversarial in the media and in some scientific publications (Gilchrest, 2008; Lim et al., 2005; Wolpowitz & Gilchrest, 2006). Though some of the health claims made about vitamin D lack sufficient evidence (e.g., breast cancer prevention, treatment of hypertension, general cancer treatment), it is undisputed that vitamin D is crucial to human health. The ideal dosage, appropriate measurement, and definition of terms such as deficiency and insufficiency of vitamin D, however, are still in dispute in the scientific community (Thienpont, Stepman, & Vesper, 2012). The impact of this state of the literature on skin cancer prevention is problematic and controversial. Hiom (2006) discusses the public health challenge presented by public awareness of vitamin D’s real or possible health benefits for skin cancer prevention in the UK and reviewed British attitudes about sun exposure and tanning. She found that rare sunny days and high latitude led to a general perception that sunscreen was not necessary; that intermittent, intense sun exposure was not particularly risky; and that sunny days and vacations in sunny climes needed to be “made the most of” (Hiom, 2006). Such observations may have important implications for UV exposure behaviors in climates such as that in Oregon, which is the location for the proposed research.

Vitamin D health claims. UV exposure has been identified as a human carcinogen, but cutaneous UVB exposure also results in vitamin D-mediated health benefits. Chronic vitamin D insufficiency causes rickets, as well as increased risk of osteoporosis (Gilchrest, 2008), and maintaining vitamin D sufficiency is critical to skeletal health. In the past decade several studies have suggested that vitamin D is beneficial beyond bone health, although an evidence-based analysis of the clinical utility of vitamin D testing conducted by the medical advisory for the Ontario Ministry of Health concluded that no high-quality or moderate quality evidence exists for the effectiveness of Vitamin D in prevention or treatment of non-bone related outcomes such as cancer, cardiovascular disease or all-cause mortality (Ontario, Ministry of Health and Long-Term Care, Medical Advisory Secretariat, & Ontario Health Technology Advisory Committee, 2010). Although diet and endogenous production are the two main sources of vitamin D for humans, the diet only provides approximately 10% of necessary vitamin D (Holick, 2007), and sun exposure and vitamin supplementation are the alternative sources of this nutrient. Because of the recent media attention given to the possible health protective effects of vitamin D, the decision to tan indoors or outdoors may be influenced by the belief that this behavior is necessary for good health.

The link between UV exposure and vitamin D production has been exploited by the indoor tanning industry through marketing campaigns targeting young adults that have been likened to the advertising methods of the tobacco industry (Greenman & Jones, 2010). The tanning industry, which is a considerable driver of the messaging promoting UV exposure and vitamin D for health is focused, not on the elderly, who are at increased risk of vitamin D deficiency, nor on populations with high dermatological melanin (Clemens, Henderson, Adams,

& Holick, 1982; Gilchrest, 2008). These messages target fair skinned people, the individuals who are *least* likely to be vitamin D deficient (Greenman & Jones, 2010).

Local latitude, weather, and vitamin D production. The amount of UV light that reaches the Earth varies geographically, and high latitude regions have reduced levels of UVB rays during the Winter months (Kimlin, Olds, & Moore, 2007). The actual amount of vitamin D produced in response to sun exposure also varies individually, based on skin pigmentation and other factors (Holick, 2007). In contrast to vitamin D-generating UVB rays, however, UVA rays are not affected by cloud cover, do not vary by season or hour of the day, and can cause overexposure and DNA damage that is less predictable by weather (Coelho & Hearing, 2010; Webb, Kline, & Holick, 1988). Cloudy or rainy weather in places like Oregon may contribute to the perception that it is not possible to produce adequate vitamin D, and that sunscreen is not necessary in the absence of visible sun. Questions about sunscreen use in national surveys such as the National Health Information Survey (NHIS) preface questions about sunscreen use with the instruction that participants should consider their behavior on a warm, sunny day ("NHIS Survey Description," 2010). Under the HBM, warm sunny weather serves as a cue to action for sun protective behaviors (Becker, 1974), and lower frequency of warm sunny days in Oregon may further impact UV exposure and protection. Furthermore, Oregon is at a relatively high latitude, with population hubs at latitudes ranging from 42.12 N in Ashland to 45.32 N in Portland ("USA Latitude and Longitude Map," n.d.). Local latitude and weather may increase the salience of the vitamin D-health messaging and impact tanning behaviors all the more in this region.

Media coverage of vitamin D. Popular media streams' translations of vitamin D health studies have led to a surge in coverage of vitamin D promoting the "happy vitamin" or the "sunshine vitamin," suggesting positive health and mood effects. Because of these messages, intentional UV exposure has likely gained acceptance (Wolpowitz & Gilchrest, 2006), particularly among individuals who prefer a tanned appearance. Studies suggest that the general public does not frequently consult original scientific studies in seeking information about natural health products and complementary medicine (Ferrucci, McCorkle, Smith, Stein, & Cartmel, 2009; Tsui, Boon, Boecker, Kachan, & Krahn, 2012). Rather, lay people consult their healthcare providers, the popular press, Internet, blogs and other secondary sources of information, so the accuracy and tone of information in such sources is of concern. A recent media content analysis of articles, print ads, and images covering vitamin D supplementation in U.S. newspapers sought to identify health benefits associated with vitamin D (Caulfield et al., 2014). Caulfield and colleagues found that claims about the health benefits of vitamin D were poorly supported by research and varied from cancer prevention to cardiovascular benefits. They noted that articles commonly framed vitamin D sufficiency as difficult to achieve through diet alone (Caulfield et al., 2014). Most importantly, 40% of newspaper articles discussing vitamin D referred to one or more scientific studies and positioned these studies as evidence of health benefits, and further that 35% of those made statements that extended beyond the conclusions of the study. Although Caulfield and colleagues studied vitamin D supplementation and did not investigate messages promoting sun exposure for vitamin D production, the perceived value derived from vitamin D due to UV exposure is likely to promote UV exposure for vitamin D synthesis as well. Messages about the benefits of vitamin D may impact UV exposure both directly and through social learning. To determine the roots of insufficient levels of sun protection offered to young children by their parents (Klostermann & Bolte, 2014), Hamilton and colleagues (Hamilton et al., 2015) studied parental beliefs about sun protection, examining perceived advantages and disadvantages as well as benefits and barriers to the behavior. Notably, prevention of vitamin D synthesis was a common perceived disadvantage of sun protection. Thus, parental beliefs about vitamin D may influence child UV exposure by reducing parental insistence on sun protection during youth, as well as by socially learned behaviors that persist in adulthood.

The tan as sun protection. Skin response to UV exposure varies by skin type, which is usually measured on the Fitzpatrick Scale (Fitzpatrick, 1988). Darker-skinned individuals are at reduced risk of sunburn and skin cancer, although when melanoma is diagnosed among African Americans, mortality rates are higher than among whites (Agbai et al., 2014). The tanning effect produced by UV exposure increases melanin in the upper layers of the dermis, which reduces risk of sunburn, with the effect of a sun protection factor (SPF) of 2-4 (Gange, Blackett, Matzinger, Sutherland, & Kochevar, 1985). This protective effect is also a reason that individuals may frame UV exposure as a health protective behavior, and the mechanism is referenced by the tanning industry as a reason to indoor tan and as a criticism of topical sunscreens (“Base Tan Versus Chemical Sunscreens,” 2011). The Indoor Tanning Association website claims that their purpose is “promoting sunburn prevention,” clearly misrepresenting the science on UV exposure. The words flash across an image of a young woman indoor tanning without the required eye protection (“Theita - ITA,” n.d.). The only study to our knowledge that assessed the belief that a tan offers protection from sunburn found it to be positively correlated with tanning (Mackay, Lowe, Edwards, & Rogers, 2007).

Mood-related Benefits of UV exposure. Another factor that may fuel the belief that intentional UV exposure yields health benefits is awareness of Seasonal Affective Disorder (SAD). In the past two decades, scientific investigation of this mental health condition have determined geographical patterns of distribution and have identified a current standard of treatment, although exact etiology and neurological mechanism of treatment are not understood.

SAD etiology, diagnosis and treatment. SAD is characterized by cyclic depressive symptoms that change seasonally. SAD is theorized to result from circadian rhythm disruption that occurs with seasonally changing patterns of daylight that are particularly striking at high latitudes. The most commonly used SAD diagnostic tool is the Seasonal Patterns Assessment Questionnaire (SPAQ), which consists of scales that assess impact on mood, appetite, sleep patterns, weight, energy and social behavior. In a validation study, the SPAQ demonstrated good specificity (94%) but low sensitivity (44%). Studies validating the SPAQ and other proposed scales for measuring seasonality have generated inconsistent results (Mersch et al., 2004; Murray, 2003; Thompson & Cowan, 2001; Young, Blodgett, & Reardon, 2003), with some suggesting that the scale has a high rate of false positives; thus, accurate screening for SAD remains challenging (Magnusson, 1996; Mersch et al., 2004). Currently, the predominant therapy for SAD symptoms is Bright Light Therapy (BLT), which requires daily exposure of the retinas to a bright wavelength of light intended to mimic morning light (Hsu, Moskowitz, & Young, 2014). Studies of seasonal symptoms suggest that SAD may fall on a latitude gradient, with higher rates of symptoms at high latitudes. BLT lamps, also known as Happy Lamps or Light Boxes, are the most common treatment for SAD (Roecklein, Schumacher, Miller, & Ernecoff, 2012). Seasonal depression may be a motivator for UV exposure, particularly in the winter months, as suggested by Hillhouse and colleagues (2005) who found an association between seasonal symptoms and high frequency indoor tanning (Hillhouse et al., 2005). Findings of that study were limited by its use of the SPAQ as opposed to clinical interview for identification of SAD cases.

Hillhouse et al. (2005) state in their rationale for their study that BLT is the common therapy for SAD and this may be a reason to tan, an argument which ignores a basic difference between indoor tanning beds and BLT as prescribed for seasonal symptoms. Although light therapy boxes are widely produced, the type considered safe for ocular exposure for treatment of SAD emit intense white or blue light (Glickman, Byrne, Pineda, Hauck, & Brainard, 2006) and negligible UV light. This characteristic is crucial because intense retinal exposure to UV light would cause extreme and possibly irreversible eye damage (Cullen, 2002). A critical distinction between SAD therapy devices and indoor tanning beds is that SAD therapy has its effect via retinal exposure, not cutaneous exposure. Bright light boxes are commonly confused with sunlamps, which emit invisible or UV spectrum light (Hunt et al., 2012). Sunlamp use is, in some cases, prescribed for treatment of skin conditions such as psoriasis, but carries risk of skin damage and is not indicated for SAD treatment (Roecklein et al., 2012). Furthermore, although vitamin D (whether ingested or generated by cutaneous exposure to UVB light) has been associated with depression incidence and severity (Bertone-Johnson, 2009), the current literature is insufficient to support recommendation of oral vitamin D as a treatment for depression (Bertone-Johnson, 2009; Parker & Brotchie, 2011; Shaffer et al., 2014; Wolpowitz & Gilchrest, 2006), let alone UV exposure for the purpose of vitamin D generation to treat depression.

SAD in the media. Conflation of SAD with vitamin D deficiency, and of BLT with UV exposure, is common in the media and may promote risky UV exposure and discourage UV protection (Gilchrest, 2008). Seasonal depression may particularly be a motivator of risky UV exposure in the winter months, as suggested by Hillhouse and colleagues (2005). In the context of mass media, seasonal depression treatments are referred to as bright light or blue light therapy, with inadequate detail as to the types of light emitted by various phototherapeutic lamps (e.g., "Bright light therapy eases bipolar depression for some," 2008; "Bright light therapy in evening may reduce sleep disturbances," 1992; "Is bright light therapy sufficient for seasonal affective disorder?" 2004; "Nature Bright Company," 2014; "Study suggests that three weeks of bright light therapy will lift winter depression.," 1999; Waldman, 2002). The resulting impression may be that cutaneous UV exposure is an effective treatment for SAD, and that UV exposure is a preventive measure against seasonal depression.

Sunscreen Concerns and UV Protection. The belief that protection from UV light and, specifically, use of sunscreen for this protection may have inherent risks is another related factor that may influence regional UV exposure and protection behaviors. Although sunscreen use is a common, recommended, and effective skin cancer- and aging-prevention method questions about its ingredients, the effects of its use on vitamin D levels, and the technology used in its formulation have led to popular media coverage of sunscreen products with a decidedly alarmist tone (Gilchrest, 2008). A recent study conducted by Consumer Reports indicated that over a third of sunscreens do not achieve the SPF advertised, a finding that may reduce its use ("Sunscreen Buying Guide," 2015).

Sunscreen use and Vitamin D. Sunscreen use is generally considered health protective, but when framed by trade groups promoting tanning or vitamin D, it is a threat to health via potential vitamin D deficiency. Studies of actual sunscreen use have, however, determined that average consumers are highly unlikely to put themselves at risk for deficiency by using sunscreen for several reasons. First, Peterson and Wulf demonstrated that sunscreen application by consumers is rarely adequate to produce the sun protection factor advertised; to confer the advertised SPF, application thickness should be 2.0 mg/cm^2 (Food and Drug Administration, HHS, 2012) but average application is 0.39 to 1.0 $mg/cm,^2$ which considerably reduces protection (Petersen & Wulf, 2014). Second, consumers often fail to apply sunscreen 20 minutes prior to sun exposure, as recommended, and instead apply the product when already in the sun or shortly before, reducing sunscreen effectiveness. Last, the application does not cover all exposed skin, and reapplication of sunscreen does not meet the frequency and thickness necessary to maintain protection; thus, typical use of sunscreen is unlikely to cause vitamin D deficiency. In light of the considerable gap between consumer sunscreen use and the ideal applications on which sunscreen recommendations are based, Teramura and colleagues (2012) recently recommended a double application of sunscreen to obtain the advertised SPF, although this recommendation has not been adopted by the FDA. Furthermore, because foods fortified with vitamin D are widely available on the U.S. market, and vitamin D is available in various supplement forms, the fear of vitamin D deficiency should not dissuade sunscreen use (Lim et al., 2005). The perception that sunscreen blocks the generation of a vitamin critical to physical health and mental wellness may nonetheless impact its use. In the Pacific Northwest, where UV intensity is reduced during the winter, and cloud cover is prevalent for most of the year ("Average Number of Cloudy Days - Western Regional Climate Center," 2015), this potential effect on sunscreen use is of particular interest.

Sunscreen formulations and consumer concerns. Sunscreen ingredients approved for use in the U.S. are classified in two broad categories: Inorganic and organic. Inorganic sunscreens such as titanium dioxide (Ti02) and zinc oxide (Zn0), are mineral-based filters that block light by reflecting or scattering UV rays on the skin's surface. Organic sunscreens, such as avobenzone, octocrylene and homosalate, react chemically in the skin and either absorb or scatter UV light. The FDA currently considers 21 sunscreen compounds as Generally Recognized As Safe (GRAS), although their classification is based on external use on unbroken skin ("Sunscreen Drug Products: OTC," 1999).

Inorganic sunscreens Ti02 and Zn0 are minerals that were the most commonly used ingredients in early formulations, and are memorable for their use in 1980s-era sunblocks that were thick, opaque, and available in bright colors ("American Melanoma Foundation, Facts About Sunscreen," 2000). Despite early popularity among downhill skiers as a nose-cover, the opacity of such formulations limits their practicality for everyday sun protection, and their use has also been impacted by their tendency to leave a white pallor. To formulate a product that is transparent on application to the skin and improve consumer acceptance of inorganic sunscreens, micronized forms of Zn0 and Ti02 have been developed ("Sunscreen Drug Products: OTC," 1999), and nanoscale particles are now common in inorganic sunscreen formulations (Nohynek, Antignac, Re, & Toutain, 2010; Nohynek, Lademann, Ribaud, & Roberts, 2007). Products containing these minerals are considered safe on intact skin (Bronfenbrener, 2014), although animal studies have raised concerns about their potential to penetrate into living tissues (Bonner et al., 2013; Chen et al., 2013). Some cosmetic brands such as PeterThomasRoth, Colorescience, and Jane Iredale currently sell powdered and aerosolized Ti02 for application to the face and scalp, but these products have not been tested for inhalation safety ("Sunscreen Drug Products: OTC," 1999).

Studies of systemic effects of organic sunscreen ingredients have had mixed results, with in vitro studies and rodent models suggesting potential endocrine disruption at high doses (Kim, Jung, Kho, & Choi, 2014), but generalizability of these studies to human use of sunscreens has some limitations. Critics point out that the oral or intravenous dosages studied do not reflect transdermal exposure in humans (Jalalat, 2015). Furthermore, the doses studied that generated the negative effects are not achievable by humans using sunscreen as recommended, in fact it has been estimated that nearly 300 years of full-body application of sunscreen would be necessary to achieve the doses via transdermal absorption (Burnett & Wang, 2011). Nonetheless, concern about transdermal absorption of sunscreen ingredients and possible health outcomes has led to fear about the use of sunscreen products and considerable media attention (Burnett & Wang, 2011; Jalalat, 2015; Lodén et al., 2011).

Questions have likewise been raised about the safety of inorganic sunscreen ingredients Zn0 and TiO2 in vitro (Ambalavanan et al., 2013; Chen et al., 2013; Ghosh, Chakraborty, & Mukherjee, 2013), although mineral sunscreens are globally used and are considered safe based on pre-market safety data ("Food and Drug Administration meeting of the Nonprescription Drugs," 2014). Their use is approved in liquid, gel and cream formulations of sunscreen, but powdered and aerosol forms have not been evaluated for inhalation safety. Given this state of the science, some media coverage of the ingredients has taken a decidedly alarmist tone. A popular medical television show has used the title "Your Sunscreen Might Be Poisoning You" to garner viewership and promote homeopathic products, but televised medical talk shows are very rarely supported by accurate research (Korownyk et al., 2014). Similarly, naturopath Dr. Mercola's website demands "Are You Subjecting Your Skin to a Potentially Toxic Chemical Concoction?" and warns of "contamination" with "risky chemicals lurking in your sunscreen," and simultaneously advertises his own brand of "non-toxic" sunscreen ("Non-Toxic Sunscreen Lotion | Sunburn Protection," n.d.). Media coverage raising concern about the safety of both categories of sunscreen and a recent study questioning the role of sunscreen in skin cancer reduction has evolved into a controversy paralleling that currently stirring in the UV exposure field (Burnett & Wang, 2011; Lodén et al., 2011).

Concerns about the safety of sunscreens arise in an important cultural context. Increasing popularity of organic foods and products (Dimitri & Greene 2002) and rising adoption of naturopathic and holistic approaches to health and medicine among non-minority adults in the U.S. (Su & Li, 2011) reflect a worldview or set of values that increasingly prioritize a natural lifestyle. Siahpush (1998) commented that this shift toward trusting and embracing nature represents a postmodern value system that includes perspectives on nature, science and technology, health, and consumerism. These "postmodern values" often accompany a reorientation toward nature and health, establishing nature as safe, kind, and benevolent. Bakx (1991) argues that postmodern values are reflected in the adoption of a "green culture" that aligns the health of the body with nature, that rejects additives or preservatives, and that views the consumption of such products as parallel to pollution of the environment with toxic chemicals. The belief that natural or naturally derived products and processes are inherently superior to man-made or artificial ones simply due to their natural origin is referred to as *Appeal to nature*, a logical fallacy. Appeal to nature may be associated with an increased belief in the potential harm of using sunscreens that are said to contain toxic chemicals. Individuals who believe that natural things are inherently good may be more likely to seek out or attend to messages about the safety of sunscreen formulations and to avoid some forms of sunscreen due to these concerns.

Sunscreens and nanotechnology. Sunscreen use behaviors may further be impacted by postmodern rejection of science and technology. Many current mineral sunscreen formulations employ nanotechnology to create a product that is transparent and more appealing for application to the skin (Schilling et al., 2010). Although use of nano-size Ti02 and ZnO particles has been common for decades, fear about absorption of the micronized ingredients and about nanotechnology in general has led to additional consumer alert (Nohynek et al., 2007; Wilson, 2006). Nanoparticle size is a critical part of effective sunscreen formulation because larger particle size increases visibility on the skin, but also increases reflectivity whereas smaller particles are necessary for a transparent product but can more easily penetrate the skin (Schilling et al., 2010). These nanoparticles are also coated to reduce contact between the mineral and human tissue in case of transdermal absorption, but the materials used in coating vary (Carlotti et al., 2009). Sunscreen manufacturers are not required to advertise nanoparticle size and coating formulations, which leaves consumers wondering about the safety and effectiveness of the products (Burnett & Wang, 2011; Jalalat, 2015; Lodén et al., 2011). Furthermore, Consumer Reports (2015) recently stated that "Products that contain the active ingredients titanium dioxide and zinc oxide may contain nanoparticles, especially if they go on clear or nealy [sic] so. These compounds have been linked to reproductive and developmental effects in animals." Such statements, while common, mischaracterize both the state of the science and the essence of nanotechnology by ignoring study limitations and conflating nanoscale particle size with compound toxicity. For individuals with a personal philosophy that leads them to avoid Western medicine may likewise be averse to exposure to nanotechnology. Indeed, according to the Environmental Working Group, a non-profit that is a vocal critic of many FDA-approved sunscreen compounds ("Nanoparticles in Sunscreens | EWG's 2015 Guide to Sunscreens,") several sunscreen companies have begun promoting their sunscreen formulations as "non-nano." As early as 1994, Kurz noted the popular rise of anti-science sentiment and suspicion or rejection of scientific results in areas such as biomedicine, bioengineering, and environmental science (Kurtz, 1994). For individuals holding distrust in modern technology, arguments about the risk of using high-tech sunscreens may influence sunscreen use.

Marketing of UV exposure. Promotion of a tanned appearance as attractive is common in U.S. media (Cho, Hall, Kosmoski, Fox, & Mastin, 2010; McWhirter & Hoffman-Goetz, 2015), and emphasis on tanning as a means of appearance improvement is found in various types of media (Cho et al., 2010; Fogel & Krausz, 2013; Poorsattar & Hornung, 2008). Some research indicates the 2009 IARC reclassification of indoor tanning as a *known carcinogen* has not impacted media messaging about tanning and skin cancer risks. More specifically, content analysis of North American magazines before and after the reclassification found that text coverage of fair skin as a risk factor for skin cancer increased, as did text and image coverage of higher SPF sunscreen use, but that images promoting a tanned appearance and promoting indoor tanning *also* increased over the study period (McWhirter & Hoffman-Goetz, 2014).

Since the design of bulbs emitting primarily UVA light in the late 1970s, tanning salons have long marketed the use of tanning beds as safer when compared to solar UV exposure, arguing that the beds filter out "burning rays," or UVB rays (Hunt et al., 2012). As discussed above, the tanning response is secondary to DNA damage and, thus, any tan is reflective of skin damage (Rabe et al., 2006). Furthermore, the intensity of UVA rays emitted by tanning beds has been found to be as high as 10-15 times that of midday sun (Autier, 2004).

The indoor tanning industry's marketing strategies have been systematically compared to approaches used historically by the tobacco industry (Greenman & Jones, 2010). Greenman and Jones identified the following commonalities between the two industries: 1) mitigating health concerns by associating the product with athleticism, health, and vitality; 2) associating the product with fashion and celebrity; 3) emphasizing mental effects of product use such as relaxation; and 4) targeting specific population segments such as women and teenagers. Of specific relevance to this study are the first, third and fourth advertising strategies. As Greenman and Jones (2010) point out, the tanning industry has used physicians as allies and cited research to support its claims; in addition, the industry has suggested that the regulation of tanning (as opposed to an outright ban) is evidence that the practice is not harmful (Greenman & Jones, 2010). Autier and colleagues (Autier et al., 2011) argue, however, that regulating the use of a carcinogenic product does not render it safe, yet the tanning industry promotes tanning as not only safe but healthy and vital to life. This "risk reduction" approach has been used frequently by the indoor tanning industry in order to ease concerns about the health effects of their product; salon operators have been found to commonly promote tanning as protective against cancer via vitamin D synthesis (Greenman & Jones, 2010; U.S Congress, 2012). Recent research attention to possible health benefits of vitamin D have spurred widespread marketing with salons using "Got vitamin D?" as a slogan ("Ariel's global travels chasing sunshine & vitamin D," n.d.), clearly borrowed from a popular mass media campaign promoting milk consumption that officially ended in 2014 ("'Got Milk' ads retired after 20 years of milk moustaches," n.d.).

The tanning industry also appeals to tanners' intelligence; the International Smart Tan Network ("Tanning Certification, Sales Training, Product Info and Tanning News | Smart Tan," n.d.) refers to indoor tanning as a "smart tan," claiming that sunbeds allow customers to control their exposure while maximizing their tan, and that salon staff are highly skilled and trained to tailor exposure to skin type, which research has demonstrated is not the case (U.S Congress, 2012). A recent report requested by ranking members of the Committee on Energy and Commerce revealed a pattern of consistently dishonest advertising and claims among indoor tanning salons and their staff. Investigators found that 90% of salons contacted denied the known risks of indoor tanning, and 78% claimed health benefits of indoor tanning, with many salons promoting tanning for cancer prevention. The main health claims made were that tanning increases vitamin D, treats depression and low self-esteem, treats or prevents arthritis and fibromyalgia, prevents osteoporosis, promotes weight loss, and reduces cellulite.

These claims, along with the tanning industry's targeting of adolescent and college age women are evidence of harmful, deceptive and misleading marketing. The tanning industry targets women and youth specifically, selling tanning as a quick way to alleviate body image concerns and achieve slenderness, sexiness, and confidence (Greenman & Jones, 2010). By advertising in women's magazines and associating tan appearance with fitness, the industry capitalizes on societal pressure for women to be thin and attractive and to maintain an aura of youth (O'Riordan et al., 2006). Salons were also found in 2006 to advertise in 48% of high school newspapers (Freeman et al., 2006) and although many states have since banned indoor tanning among minors (Pan & Geller, 2015), salons still advertise and offer tanning coupons in college papers and flyers. These promotions often include unlimited tanning sessions for a specific period of time, "upgrading" to a higher intensity bed, and other offers that increase the likelihood of overexposure, especially in new customers (Hornung et al., 2003; U.S Congress, 2012). Hornung and colleagues found that in 2003, FDA limits on UV exposure were being exceeded by 95% of tanning salon patrons, with 33% of clients initiating indoor tanning at the maximum exposure dose (2003). Nearly a decade later, the tanning industry was still consistently ignoring FDA recommendations for UV dosage (U.S Congress, 2012). As an industry-targeted population and one that is commonly found to intentionally tan, college students are an appropriate population for UV exposure research.

The indoor tanning industry is not alone in its use of scientific findings to promote unhealthy behaviors. The inaccurate or intentionally false communication of science in the media is truly a cause for public health concern. According to Weinstein (2001), 254 parents attending pediatric clinics rated television and magazines as their top sources of sun protection information, suggesting that media play a considerable role in skin cancer prevention. Furthermore, a study that randomly sampled episodes of internationally syndicated medical or health talk shows found that over half of the advice given was either unsupported or in direct conflict with scientific evidence (Korownyk et al., 2014). Drs. Mehmet Oz and Mercola, whose public audience has earned them celebrity status, have been investigated by Congress and the FDA respectively for making false statements about the safety and efficacy of the products they promote (U.S Congress, 2012). Additionally, after investigation by the Federal Trade Commission, Lindsey Duncan (a frequently featured guest on the Dr. Oz show) agreed to a $9 million fraud settlement for a scheme to sell dietary supplements. Representatives of the Dr. Oz show reported no prior knowledge about the arrangement. The FTC's discovery of multiple similar setups intended to promote sale of supplements using poorly vetted experts, however, in combination with the work of Krorwnyk and colleagues (2014) demonstrates a lack of media oversight and standards for health claims. The proposed study represents a critical step in addressing the effects of such misunderstood or misleading messages by developing a scale to assess beliefs that result from presentation of UV exposure science to support regulation of health claims in the media.

Measurement of UV-related health beliefs

The Comprehensive Indoor Tanning Expectations Scale. The most comprehensive scale to date assessing constructs related to UV exposure is the Comprehensive Indoor Tanning Expectations scale (also known as "CITE") (Noar et al., 2014). Researchers' goal in developing the CITE was to generate a multi-dimensional scale assessing a broad range of indoor tanning outcome expectations. In a volunteer sample of 708 sorority sisters attending a university in North Carolina, researchers administered a scale intended to encompass positive and negative outcomes of indoor tanning. Factor analysis of the CITE identified eleven factors; six of which were positive outcome expectations, and five of which were negative outcome expectations. The positive factors identified are as follows: *appearance benefits, convenience, mood enhancement, health improvement, social approval,* and *parental approval*. Negative factors are *health threat, psychological harm, appearance harm, social disapproval,* and *parental disapproval*. The *health improvement* subscale measures participant endorsement of items such as "tanning would be healthy for me" and "tanning would be good for my skin." Assessment of expected mood effects included items such as "[tanning] would lift my spirits" and "[tanning] would be healthy for me" but these items are not worded to identify the reasoning behind these expectations. Such items may identify general expectations about outcomes of indoor tanning, but are not worded to identify beliefs that are rooted in participants' understanding of current health science, such as the belief that one is at risk of vitamin D deficiency without intentional UV exposure, or the belief that UV is therapeutic for seasonal mood disturbance. Specifically because of their scientific basis, such beliefs are likely to challenge behavior modification efforts.

The measurement gap. The expectations measured by the CITE are important theoretical factors in indoor tanning behavior, but the scale is not worded to identify vitamin D deficiency and seasonal affective disorder-related beliefs, nor does it evaluate beliefs about the safety of sunscreen as a determinant of UV exposure behavior. Furthermore, the CITE is a measure of outcome expectations about indoor tanning, as opposed to UV exposure and protection. Because exposure to messages about vitamin D deficiency, SAD and sunscreen risks can lead to risky outdoor UV exposures and lack of UV protection, particularly in regions with cloudy weather and high latitude, a scale is needed that applies to UV exposure and protection in general. Thus, the proposed scale will refine current approaches in tanning research, use wording that targets beliefs founded in published science, and will expand the conceptualization of the risk behavior to all UV exposure, as opposed to strictly indoor tanning.

In another study of indoor tanning attitudes recently conducted in the U.S. that considered vitamin D-related beliefs as an influence on UV exposure, Yoo and Hur (2014) asked participants to agree or disagree with the statement “Tanning provides vitamin D.” This question was one of three items intended to measure health-related attitudes about tanning. The other two were “Tanning makes me look more active” and “A tanned body is healthy.” In a sample of 208 college students, authors tested a model of tanning that included appearance-related attitudes, health-related attitudes, and emotion-related attitudes, controlling for age, height, and weight. The health-related attitudes were not a significant predictor of tanning; this finding is not surprising for multiple reasons. The study sample was predominantly white with only 7.7% of respondents of African American race. In addition, the sample was drawn from the undergraduates of a university in central Texas, a region with relatively sunny, hot weather. Because vitamin D deficiency is of greater concern for people with very dark skin or people living in high latitudes and regions with consistent cloud cover (Webb & Holick, 1988, pp. 384-386), vitamin D synthesis would be an unlikely reason for intentional tanning in this region. Additionally, the goal of the Yoo and Hur (Yoo & Hur, 2014) study was the examination of body tanning attitudes, which was defined as indoor or outdoor tanning, spray or self-tanning or bronzing. The authors did not determine if UV exposure was affected by beliefs about vitamin D deficiency, seasonality, depression, or mood, nor if the measured attitudes impacted sunscreen use. In light of the gap in measurement of health beliefs about vitamin D, seasonal depression, and sunscreen safety, the proposed study will develop and evaluate a tool for assessing a potentially key factor in UV exposure behaviors.

In one of the most extensive studies of vitamin D related beliefs to our knowledge, Youl and colleagues (2009) explored the effects of vitamin D-related media messaging in UV exposure behaviors in a sample of 2,001 adults in Queensland, Australia. To determine whether mixed messages regarding vitamin D were leading to increased UV exposure, the researchers measured information and attitudes about vitamin D and UV protection, specifically asking if participants believed that practicing UV protection would cause low vitamin D levels. The authors found that concerns about vitamin D were leading to reduced UV protection behaviors, and that the belief that sun protection use increased risk for vitamin D deficiency was most common among older adults. They observed that the belief that sun protection would lead to insufficient vitamin D levels increased from 17% to 32% from 2004 to 2009. Furthermore, approximately one third of participants though that a fair-skinned adult and a fair-skinned child require 30 minutes of summer sun to maintain vitamin D levels. These findings are intriguing, because the Queensland region of Australia has high levels of year-round UV radiation, and some of the highest rates of skin cancer in the world (Australian Institute of Health & Welfare, 2015). The salience of messages related to vitamin D deficiency in regions with higher latitudes and cooler climes is likely even greater than in Australia, which underscores the need for the current study.

The basis for the proposed research is further evident from the work of Carcioppolo, Chudnovskaya, Gonzalez and Stephan (2014) who conducted a qualitative examination of the content of an online indoor tanning forum to clarify how risk perceptions relate to indoor tanning behavior, and how indoor tanners rationalize their behavior. They found that the majority of posts (69.7%) recognized a link between indoor tanning and cancer. Thematic analysis revealed several common themes: questioning or uncertainty about risk from indoor tanning (in 4.5% of posts), fatalistic beliefs about cancer (in 16.1% of posts), blaming outside sources for cancer risk associated with indoor tanning (in 12.7% of posts) and outright denial of cancer risk (in 16.7% of posts). Carcioppolo and colleagues used Powe and Finnie's (2003) conceptualization of cancer fatalism, which manifested in comments such as: "Nope it didn't affect me […] everything can cause cancer so probably in my lifetime I will get some kind of cancer sooner or later."

Carcioppolo and colleagues further found that tanners commonly blamed factors such as genetics for cancer causation (Carcioppolo et al., 2014). Notably, they also identified a common belief that sunscreens and lotions are the true cause of cancer, which demonstrates consumer concerns about sunscreen safety. Last, posts which outright denied the connection between indoor tanning and cancer were often written in scientific language, were strongly worded, and claimed that UV exposure treats or prevents cancer, or argued for the cancer-fighting potential of UV exposure via vitamin D synthesis. These arguments were often logic-based arguments, and highlighted strongly held views questioning the legitimacy of the link between UV exposure and skin cancer. Overall, the study findings illustrate the role of belief in positive health outcomes of UV exposure in the justification of continued tanning behavior.

Conceptual Framework of the Study

The proposed study incorporates constructs from SCT into a modification of the HBM to understand the role of health beliefs about vitamin D, seasonal depression, and sunscreen safety in determining UV exposure and sunscreen use in Oregon college students. In this conceptual framework, the primary outcomes of interest, UV exposure and sunscreen use, are influenced by health beliefs about UV exposure and risks of sunscreen use, via the perceived susceptibility to and severity of negative outcomes of these behaviors. Additionally, socio-cultural variables (family, friend, peer and media influences) as well as physical appearance motivators such as improvement of body appearance influence UV-related behavior.

Summary and Specific Aims

Current measures of UV exposure motivation, especially Cafri and colleagues' well-validated Appearance Reasons to Tan and Not Tan scale, robustly assess many socio-cultural and individual factors motivating indoor tanning (Cafri et al., 2008). This work, however, does not consider that the decision to UV expose or protect may be influenced by health beliefs founded in uncertain science. Noar and colleagues' CITE is a general measure of indoor tanning outcome expectations and assesses general perceptions of tanning as a healthy or behavior, but likewise does not probe beliefs about UV exposure that may be derived from secondary sources of vitamin D, SAD, and sunscreen research. Furthermore, the impact of such beliefs on UV exposure may be sharpened in a climate where awareness of the risk of seasonal mood changes and the importance of adequate vitamin D is heightened by regional weather and cultural factors. From the findings of Youl et al. (2009), Yoo and Hur (2014), and Carccioppolo et al. (2014), it is evident that ill-informed beliefs about the risks and benefits of UV exposure and sunscreen are impacting UV exposure and protection behaviors in some populations, yet no validated scale exists to measure these constructs.

This study focuses on health beliefs about UV exposure and protection as primary modifiable variables in the determination of perceived threat of UV exposure. Oregon college students' UV-related behavior may be particularly influenced because of marketing, media exposure, and regional weather. Tanning for prevention of vitamin D deficiency, prevention or self-medication for seasonal depression, or fears of negative health impacts of sunscreen use may contribute to an individual's decision to engage in intentional UV exposure (or to avoid sunscreen use), and the field lacks a valid and reliable measure of these variables. The literature reviewed provides strong evidence for a role of beliefs about a) the vitamin D-related health benefits of UV exposure, b) the beneficial seasonal mood effects of UV exposure and c) the safety of sunscreen use in determining exposure and protection behavior. A validated scale measuring these constructs would advance the science of skin cancer prevention considerably.

In light of these gaps in the literature, the current study has the following specific aims:

Aim 1: Develop and pilot a scale that measures: a) vitamin D-related beliefs about UV exposure, b) seasonal mood-related beliefs about UV exposure, and c) beliefs about the safety of sunscreen use.

Aim 2: Assess the psychometric properties of the scale. Hypotheses related to this aim are:

Hypothesis 1: The resulting scale will have subscales related to health beliefs about a) vitamin D, b) seasonal mood effects of UV exposure, and c) safety of sunscreen use.

Hypothesis 2: The items measuring each factor will have high internal consistency.

Hypothesis 3: As an evaluation of construct validity, we expect that participants who tan will have a higher mean score on vitamin D-related beliefs and SAD-related beliefs than will those who do not tan.

Hypothesis 4: With regards to construct validity, we further expect that participants who value natural products will have greater concerns about sunscreen safety than will those who do not.

Hypothesis 5: We expect that, among participants who use sunscreen, sunscreen safety concerns will be positively associated with mineral sunscreen use.

Aim 3: Examine the scale's performance in the greater student population by a) describing health beliefs about UV exposure among local college students and b) examining the relationship between the measured constructs and UV-related behaviors. Research questions related to this aim include: 1) How prevalent are vitamin D-related and SAD-related UV beliefs among local college students? 2) To what extent are college students concerned about the safety of sunscreen?

An additional hypothesis related to this aim is:

Hypothesis 6: Sunscreen safety concerns will be negatively associated with sunscreen use.

The successful completion of this study will produce a scale that is a reliable and valid measure of the described health beliefs related to UV exposure. Anticipated next steps will be to validate the measure in a broader sample of the Oregon population and examine the mechanism of action by which the measured constructs influence behavior. This investigation of UV-related health beliefs and UV exposure and protection is expected to clarify the role of understudied variables in determining skin cancer risk in Oregon college students.

Appendix B. Gender-stratified frequency distribution of HBAU items.

HBAU item	Strongly Disagree (%) M / F	Disagree (%) M / F	Neither Agree Nor Disagree M / F	Agree (%) M / F	Strongly Agree (%) M / F
Sunscreen ingredients are toxic	10.5 / 12.8	48.4 / 46.0	25.3 / 25.1	14.7 / 14.4	1.0 / 1.6
Sunscreen is full of harmful chemicals	12.8 / 10.2	44.7 / 47.9	27.7 / 23.1	12.8 / 17.2	2.10 / 1.6
Sunscreen probably causes cancer	22.1 / 22.8	40.0 / 50.0	22.1 / 19.0	14.7 / 7.6	1.1 / <1.0
The cloudy weather in Western Oregon negatively affects me	11.0 / 6.3	35.0 / 26.1	14.0 / 16.4	29.0 / 32.9	11.0 / 18.4
Because of the cloudy weather in Oregon, my body can't produce enough vitamin D	8.7 / 3.0	39.4 / 31.8	26.9 / 19.7	23.0 / 36.9	1.9 / 8.6
In Oregon, a bad mood in the winter can be because there is no sun	4.8 / 1.9	23.8 / 14.4	21.0 / 15.9	40.0 / 55.8	10.5 / 12.0
Tanning is a more natural way to get your vitamin D than taking a pill	9.80 / 12.0	20.6 / 30.2	25.5 / 23.4	38.2 / 29.7	5.9 / 4.7
Lying in the sun is a healthy treatment for low vitamin D	17.3 / 28.6	35.6 / 40.8	24.0 / 16.5	22.1 / 12.6	1.0 / 1.5
Getting a base tan before going in the sun is protective against skin cancer	10.9 / 31.1	40.2 / 37.8	28.3 / 11.1	15.2 / 18.3	5.5 / 1.7
Tanning can help you stay positive during the Winter	5.0 / 8.0	29.3 / 34.1	34.3 / 24.6	29.3 / 31.7	2.0 / 1.5
Tanning is a way to get through the Oregon Winter	4.2 / 9.0	31.3 / 37.0	35.4 / 30.0	28.1 / 21.0	1.0 / 3.0

Appendix C. Inter-factor correlations and standard errors.

Factor	1	2	3	4
1. Sunscreen Toxicity	1.0	.08	.07	.07
2. Seasonal Effects	.20*	1.0	.08	.08
3. Health Benefits of Tanning	.30**	.28**	1.0	.06
4. Tanning Through the Winter	.28**	.34**	.74**	1.0

Note. Correlations are below the diagonal and standard errors are above the diagonal. * p <.01, ** p < .001

Appendix D. Overall and gender-stratified subscale and item means and standard deviations.

Item	***M* (*SD*)**		
	Overall	**Men**	**Women**
Subscale- Sunscreen toxicity	**2.36 (.81)**	**2.39 (.83)**	**2.35 (.81)**
1. Sunscreen ingredients are toxic	2.55 (.93)	2.44 (.93)	2.46 (.95)
2. Most sunscreen is full of harmful chemicals	2.49 (.94)	2.49 (.94)	2.52 (.94)
3. Sunscreen lotions probably cause cancer	2.19 (.92)	2.19 (.92)	2.13 (.87)
Subscale- Seasonal effects**	**3.21 (.85)**	**2.96 (.86)**	**3.36 (.81)**
4. The cloudy weather in Oregon negatively affects me	3.17 (1.23)	3.17 (1.23)	3.31 (1.21)
5. In Oregon, a bad mood in the winter can be because there is no sun	3.50 (1.01)	3.17 (1.01)	3.62 (.94)
6. Because of the cloudy weather in Oregon, my body can't produce enough vitamin D	2.98 (1.06)	2.98 (1.06)	3.16 (1.06)
Subscale- Health benefits of tanning**	**2.52 (.84)**	**2.76 (.74)**	**2.42 (.85)**
7.Lying out in the sun is a healthy treatment for low vitamin D	2.28 (1.05)	2.28 (1.05)	2.17 (1.03)
8. Getting a base tan before going in the sun is protective against cancer	2.36 (1.11)	2.36 (1.11)	2.22 (1.13)
9. Tanning is a more natural way to get vitamin D than taking a pill	2.92 (1.12)	2.92 (1.13)	2.84 (1.12)
Subscale- Tanning through the winter	**2.82 (.89)**	**2.90 (.85)**	**2.80 (.91)**
10. Tanning can help you get through the Oregon winter	2.77 (.97)	2.77 (.97)	2.72 (.99)
11. Tanning can help you stay positive in the winter	2.86 (.99)	2.85 (.98)	2.84 (1.01)

Note. ** $p <$ .01 Range for all items was 1-5. Scale scores were calculated as the average of the items on the scale. Seasonal Effects and Tanning through the winter observed range: 1 - 5, and Sunscreen toxicity and Health benefits of tanning observed range: 1 - 4.67.