



# Association of Skin Cancer Risk and Protective Behaviors with Health Literacy Among Young Adults in the USA

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## Abstract

**Background** The goal of this study was to investigate the association of health literacy with skin cancer risk and protective behaviors among young adults at moderate to high risk of skin cancer, the most common cancer.

**Method** A US national sample of 958 adults, 18–25 years old, at moderate to high risk of developing skin cancer, completed a survey online. Behavioral outcomes were ultraviolet (UV) radiation exposure (e.g., indoor and outdoor tanning, sunburn) and protective (e.g., sunscreen use, sunless tanning) behaviors. Multivariable regression analyses were conducted to determine whether health literacy (a four-item self-report measure assessing health-related reading, understanding, and writing) was associated with behavioral outcomes while controlling for demographic factors.

**Results** Higher health literacy was independently associated with less sunbathing, odds ratio (OR) = 0.77, 95% confidence interval (CI) = 0.60–0.98; less indoor tanning, OR = 0.38, CI = 0.31–0.48; and less use of tanning oils, OR = 0.54, CI = 0.43–0.69. However, health literacy was also associated with a lower likelihood of wearing long pants, OR = 0.76, CI = 0.58–0.99, or a hat, OR = 0.68, CI = 0.53–0.87, when outdoors. On the other hand, higher health literacy was associated with higher incidental UV exposure, OR = 1.69, CI = 1.34–2.14, and a greater likelihood of ever having engaged in sunless tanning, OR = 1.50, CI = 1.17–1.92.

**Conclusion** Interestingly, higher health literacy was associated with lower levels of intentional tanning yet also higher incidental UV exposure and lower skin protection among US young adults. These findings suggest that interventions may be needed for young adults at varying levels of health literacy as well as populations (e.g., outdoor workers, outdoor athletes/exercisers) who may be receiving large amounts of unprotected incidental UV.

**Keywords** Health literacy · Skin cancer · Prevention · Young adults · Risk behaviors

## Introduction

Skin cancer (keratinocyte carcinomas and melanomas) is the most common cancer, with nearly five million diagnoses made annually in the USA, and it has been increasing in incidence for several decades [1–5]. Major risk factors for skin

cancer include personal or family history of skin cancer, fair skin, and ultraviolet radiation (UV) from the sun and/or indoor tanning [3, 6–10]. It is common for young adults in the USA to expose themselves to large amounts of UV and protect their skin poorly [11–14]. Numerous correlates of UV exposure and skin protective behaviors among young adults have been

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investigated. These include demographic, phenotypic, cognitive, and interpersonal variables [13, 15–19]. Surprisingly, one potential correlate that has garnered only minimal attention is health literacy.

Health literacy is “the degree to which individuals have the capacity to obtain, process, and understand basic health information and services needed to make appropriate health decisions” [20]. Health literacy is an important determinant of health-related behaviors such as adherence to medical recommendations [21–25]. More specifically, health literacy is associated with cancer prevention and detection attitudes and behaviors. For example, low health literacy has been found to be associated with lower information seeking, avoiding information about diseases one does not have, fatalistic attitudes toward cancer, less accuracy in identifying the purpose of cancer screening tests, lower self-efficacy for cancer screening, and avoiding doctor’s visits [23, 26]. Individuals with low health literacy have been found to be less likely to be adherent with recommendations for colorectal cancer screening [23, 25], cervical cancer screening [21, 22], and breast cancer screening [24]. Numerous studies including systematic reviews and large national studies have reported that many Americans have a low level of health literacy, which is not adequate to comprehend many existing health intervention materials [27–29].

Only a few prior studies have assessed the association between health literacy and skin cancer risk and/or protective behaviors. One relevant study was conducted with fair-skinned adults with or without skin cancer recruited from hospitals in eight countries in Europe [30]. The authors found that in univariable analyses, higher health literacy was associated with greater sunscreen and sunbed use. Positing that either indoor tanners are aware of the risks and tan anyway or that they are not aware of the risks, the authors provided evidence for both arguments. However, in multivariable analysis, higher health literacy was associated only with greater sunscreen use [30]. A follow-up with this sample found that outdoor workers reported higher occupational and leisure UV exposure, lower sunscreen use, and lower health literacy compared to indoor workers [31]. Finally, a study on vitamin D supplementation among older Chinese adults found that health literacy was associated with higher sunlight exposure [32].

The purpose of the current study was to investigate the association of skin cancer risk (sun exposure, indoor tanning) and protective (skin protection, sunless tanning) behaviors with health literacy in a US sample of young adults, which is a different population from prior research. In addition, the current study includes a greater variety of measures of skin cancer-related behaviors including UV exposure and sunless tanning (temporary bronzing of the skin using UV-free lotion or spray) as well as additional sociodemographic variables (skin pigmentation, receiving public assistance, and perceived ability to live on income) that could be associated with health literacy or skin cancer risk and protective behaviors. Based on

the findings of the prior studies, it was hypothesized that health literacy would be positively associated with skin protection. However, due to the mixed and counter-intuitive findings of these prior studies, there was no hypothesis for the direction of the association between health literacy and outdoor and indoor UV exposure. Individuals who engage in sunless tanning tend to have higher levels of education and income than non-users [33, 34], demographic variables that tend to be associated with health literacy. Therefore, it was expected that sunless tanning would be associated with higher health literacy. This topic is important because the public is barraged with public health news and messages and commercial marketing efforts (e.g., by the indoor tanning industry) and likely has difficulty interpreting the large amounts of often conflicting information. Study findings might suggest whether sun safety behaviors should be addressed differently for individuals with lower versus higher health literacy.

## Materials and Methods

### Participants

Eligible participants were 18–25 years old, had never had skin cancer, and were at moderate to high risk of developing skin cancer based on the 9-item Brief Skin Cancer Risk Assessment Tool (BRAT, see “[Measures of Interest](#)”) [35].

### Measures of Interest

**BRAT [35]** BRAT skin cancer risk items included personal skin cancer history (ineligible), hair and skin color, sensitivity to burning and tanning, number of moles and freckles, lifetime sunburn history, and climate of childhood residence. The nine items are weighted, resulting in a 0–78 score. The BRAT authors recommend a cutoff of  $\geq 27$  to denote moderate to high skin cancer risk. Internal and test–retest reliability compare favorably to those reported in the literature for similar items/scales [35]. Cronbach’s alpha in the current sample was 0.76.

**Demographics** Standard demographic items assessed age, sex, and education (less than a standard 4-year college degree vs. at least a standard 4-year college degree). Self-rated fair/very fair skin versus olive, light brown, medium brown, dark brown/black (from the BRAT [35]), climate of geographic region (Southern USA/Hawaii vs. Northern USA), receiving public assistance (yes vs. no), and perceived ability to live on income (1 = not hard at all, 5 = extremely hard or impossible) were also assessed. Items, other than from the BRAT, were written by the authors.

**Health Literacy** Problems with understanding written health information (e.g., instructions, pamphlets) and confidence in

filling out medical forms independently were assessed using three items adapted from Chew and colleagues [36]. Responses ranged from 0 (always) to 4 (never), with two items reverse-scored. This is a well-validated measure of health literacy [36]. One item was adapted for a young healthy population by changing “your medical condition” to “your health”. A self-rating of reading ability item from Jeppesen and colleagues [37] was also added to the other items. The scale had a Cronbach’s alpha of 0.72 in the current sample. Higher scores indicate better health literacy. A brief, subjective measure that could be completed online was selected to minimize participant burden.

**Exposure and Protective Behaviors** Participants who reported being outdoors for more than a few minutes at a time during the past month (all but 8.7%,  $n = 84$ ) were queried about the frequency of engagement in seven *skin protection* behaviors (e.g., sunscreen use, clothing, hat, shade, sunglasses) in the past month using items adapted from Glanz and colleagues [38] and Ingledew and colleagues [39]. Responses ranged from 0 (never) to 4 (always), which were dichotomized (0 and 1 = lower, 2 to 4 = higher). *UV exposure* behaviors were also assessed. The number of days per week of *sunbathing* and *incidental sun exposure* (time spent in the sun when not trying to get a tan, e.g., working) in the past month were reported separately and dichotomized as zero versus one or more days. Also assessed were the number of *sunburns* and frequency of *indoor tanning* in the past month [38, 40], which were recoded dichotomously as did not occur versus did occur (0 or 1). An item adapted from Ingledew and colleagues [39] asked about frequency of use of *tanning products* that facilitate a faster or deeper tan (i.e., tanning oils). Responses ranged from 0 (always) to 4 (never) and were also dichotomized (0 and 1 = lower, 2 to 4 = higher). Finally, ever engaging in *sunless tanning* [40] was assessed (no = 0, yes = 1). Several studies have demonstrated the reliability and validity of self-report questionnaires of UV exposure and protection compared to observation and objective measures with no systematic bias identified among various populations [41–43].

## Procedures

**Recruitment and Screening** Participants were recruited nationally online by a consumer research company, Survey Sampling International (SSI) [19, 44], using their US consumer opinion panel and partnerships with other panels and online communities. Internet panel-based research is becoming more widespread, and research samples recruited from Internet panels have been found to be representative of the US population [45–47]. SSI panelists were exposed to brief Web banner ads about a skin cancer prevention study from which they could click to enter the study Web site. Once at the study Web site, interested candidates were asked to complete the study

screeener (i.e., age, skin cancer history, and the BRAT), which was scored automatically. Forty-eight percent of individuals who submitted a screening form were deemed eligible.

**Consent and Survey** Eligible participants were automatically directed to the online informed consent form, which could be signed using a computer mouse. Seventy-two percent of eligible participants submitted consent forms. After submitting a consent form, participants were automatically directed to the online survey. Seventy-two percent of participants who consented to participate completed the survey during the spring season (March–June). For more procedural details, please see earlier reports [48, 49].

**Analyses** Descriptive statistics and univariable analyses (independent sample *t* tests and Pearson’s correlations) were conducted. Multivariable regression analyses were conducted separately to determine whether health literacy was associated with each UV exposure and skin protection outcome. Linear regressions were used for continuous outcomes (overall UV exposure, skin protection), and logistic regressions for dichotomized outcomes (indoor tanning, incidental UV exposure, sunburns, sunbathing, sunless tanning). All models controlled for age, gender, skin color, southern or northern climate, education, use of public assistance, and ability to live on income. For each model, cases with missing data were excluded.

## Results

Descriptive statistics for the 958 eligible participants who consented and completed the health literacy items are provided in Table 1. The average health literacy score of the sample was 3.35 (SD = 0.67) on a scale of 0 to 4.

Based on univariable analyses (Tables 1 and 2), the demographic variables that were significantly associated with higher health literacy were older age, female sex, fair skin, living in the Northern USA, and having at least some college education. In terms of UV exposure and protection behaviors, health literacy was significantly associated with wearing sunscreen, pants, or a hat, not having indoor tanned, not having sunburned, and also with receiving incidental sun exposure (e.g., getting a tan while playing a sport rather than intentionally sunbathing), and use of tanning oils or sunless tanners. Health literacy was not associated with other sun protective behaviors or sunbathing in univariable analysis.

In multivariable analyses (Table 3), higher health literacy was independently associated with less sunbathing, odds ratio (OR) = 0.77, 95% confidence interval (CI) = 0.60–0.98; less indoor tanning, OR = 0.38, CI = 0.31–0.48; and less use of tanning oils, OR = 0.54, CI = 0.43–0.69. However, higher health literacy was also associated with a lower likelihood of wearing long pants, OR = 0.76, CI = 0.58–0.99, or a hat,

**Table 1** Demographic descriptives and univariable associations with health literacy

Variable (possible range)	<i>N</i> missing	<i>M</i> (SD)	<i>r</i>	<i>N</i> (%)	Health literacy <i>M</i> (SD)	<i>t</i>
Health literacy (0–4)	0	3.35 (0.67)				
Age in years (18–25)	0	21.84 (2.16)	0.15**			
Ability to live on income (1–5)		2.40 (1.11)	0.05			
Sex	0					
Male				323 (33.72)	3.15 (0.77)	6.65**
Female				635 (66.28)	3.44 (0.59)	
Fair/very fair skin	0					
Yes				131 (13.67)	3.38 (0.65)	4.33**
No				827 (86.33)	3.11 (0.74)	
Geographic location	0					
Lives in Southern USA/Hawaii				321 (33.51)	3.28 (0.69)	2.19*
Lives in Northern USA				637 (66.49)	3.38 (0.66)	
Education	1					
Less than a 4-year college degree				409 (42.74)	3.29 (0.67)	2.10*
At least a 4-year college degree				548 (57.26)	3.39 (0.66)	
Receives public assistance	35					
Yes				173 (18.74)	3.35 (0.70)	0.33
No				750 (81.26)	3.37 (0.63)	

\* $p < 0.05$ ; \*\* $p < 0.01$ 

OR = 0.68, CI = 0.53–0.87, when outdoors. On the other hand, higher health literacy was associated with higher incidental UV exposure, OR = 1.69, CI = 1.34–2.14, and a greater likelihood of ever having engaged in sunless tanning, OR = 1.50, CI = 1.17–1.92. In multivariable analyses, health literacy was no longer significantly associated with sunburn or sunscreen use but was associated with sunbathing.

## Discussion

This is one of the few studies investigating the association of health literacy and UV risk and protective behaviors and appears to be the first conducted with an American population. The authors are not aware of any prior studies examining the association of health literacy and sunburns or sunless tanning. As hypothesized, higher health literacy was associated with ever having engaged in sunless tanning. Contrary to the hypothesis and data from European studies on sunscreen use [30, 31], higher health literacy was associated with lower skin protection, specifically wearing long pants or a hat when outdoors. Higher health literacy was also associated with less sunbathing, not having indoor tanned, and less use of tanning oils, yet more incidental UV exposure. Notably, neither sunburn nor wearing sunscreen on one's body was associated with health literacy among the young adults once other covariates such as skin fairness was taken into account.

Overall, higher health literacy was associated with lower intentional UV exposure, which is consistent with prior European data focusing on outdoor exposure [31]. The higher the health literacy, the more cognizant one would likely be of the dangers of UV, thus motivating avoidance of excessive UV exposure. Of course, risk awareness does not always predict UV exposure behavior [50]. The current study findings with regard to intentional UV exposure stand in contrast to the univariable findings of Altsitsiadis and colleagues [30], who found that higher health literacy was associated with greater indoor tanning among European adults recruited from hospitals.

The associations of higher health literacy with lower skin protection and higher incidental UV exposure are more surprising and concerning. Many skin cancers are caused by chronic incidental UV exposure, and protective behaviors such as wearing clothing may help prevent these cancers. Although young adults with high health literacy may be generally aware of the dangers of sunbathing and indoor tanning, as evidenced by decreasing rates of indoor tanning in recent years [51], they may be less aware of the dangers of chronic incidental UV exposure without burning or even noticeable tanning such as one might experience while playing sports or exercising outdoors without using skin protection. Indeed, higher health literacy has been associated with higher levels of exercise in older US adults [52]. It is interesting that higher health literacy was associated with a lower likelihood of only the protective behaviors of wearing pants or hats, when

**Table 2** Descriptives and univariable associations of behaviors with health literacy

Variable (refers to past month unless otherwise specified)	<i>N</i> missing	<i>N</i> (%)	Health literacy <i>M</i> (SD)	<i>t</i>
Sunburned	4			
At least one sunburn		514 (53.88)	3.30 (0.73)	2.03*
No sunburns		440 (46.12)	3.40 (0.58)	
Indoor tanned	3			
Some indoor tanning		300 (31.41)	3.05 (0.78)	9.57**
No indoor tanning		655 (68.59)	3.48 (0.56)	
Sunbathed	13			
1 or more days per week		220 (23.28)	3.28 (0.73)	1.66
0 days per week		725 (76.72)	3.37 (0.64)	
Incidental UV exposure	29			
1 or more days per week		693 (74.60)	3.43 (0.62)	−6.52**
0 days per week		236 (25.40)	3.11 (0.77)	
Used sunless tanners (ever)	0			
Yes		411 (42.90)	3.51 (0.57)	6.48**
No		547 (57.10)	3.22 (0.71)	
Used products that help me get a faster or deeper tan (like tanning oils)	1			
Low use		687 (71.8)	3.42 (0.62)	5.19**
High use		270 (28.2)	3.17 (0.76)	
Wore sunscreen with SPF of 15 or more on your face	78			
Low use		386 (43.9)	3.42 (0.61)	1.162
High use		494 (56.1)	3.37 (0.64)	
Wore sunscreen with SPF of 15 or more on other parts of your body	81			
Low use		418 (47.7)	3.45 (0.60)	2.281*
High use		459 (47.9)	3.36 (0.65)	
Wore a shirt with sleeves that cover your shoulders	80			
Low use		188 (21.4)	3.46 (0.67)	1.489
High use		690 (78.6)	3.38 (0.62)	
Wore long pants	78			
Low use		259 (29.4)	3.48 (0.62)	2.271*
High use		621 (64.8)	3.37 (0.63)	
Wore a hat	78			
Low use		551 (62.6)	3.48 (0.55)	4.846**
High use		329 (37.4)	3.27 (0.72)	
Wore sunglasses	84			
Low use		263 (30.1)	3.42 (0.63)	0.672
High use		611 (69.9)	3.39 (0.63)	
Stayed in the shade (like under a tree or umbrella)	75			
Low use		233 (26.4)	3.40 (0.64)	0.039
High use		650 (73.6)	3.40 (0.62)	

\* $p < 0.05$ ; \*\* $p < 0.01$ 

controlling for other potential correlates related to socioeconomic status. These protective behaviors may be more consistent with those of outdoor workers as opposed to intentional exercisers. However, outdoor workers are also known to have inadequate levels of skin protection in general [53].

Additionally, young adults with higher health literacy are likely ambivalent about tanning versus protecting their skin [54] and may manage this ambivalence by not tanning intentionally but also not protecting their skin during incidental exposure, which they may perceive as less dangerous. Moreover, there is a

**Table 3** Associations between health literacy and UV exposure and protection behaviors: multivariable models

Variable (refers to past month unless otherwise specified)	Odds ratio (95% confidence interval)
UV exposure	
Incidental UV exposure	<i>1.69 (1.34–2.14)</i>
Sunburn	0.86 (0.69–1.06)
Indoor tan	<i>0.38 (0.31–0.48)</i>
Sunbathe	<i>0.77 (0.60–0.98)</i>
Tanning oils	<i>0.54 (0.43–0.68)</i>
Skin protection	
Sunscreen $\geq 15$ on face	0.90 (0.71–1.14)
Sunscreen $\geq 15$ on body	0.79 (0.62–1.00)
Shirt covering shoulders	0.89 (0.66–1.19)
Long pants	<i>0.76 (0.58–0.99)</i>
Hat	<i>0.68 (0.53–0.87)</i>
Sunglasses	0.89 (0.69–1.16)
Shade	1.00 (0.77–1.30)
Sunless tanner (ever)	<i>1.52 (1.19–1.94)</i>

Each model controlled for age, sex, fair skin, geographic location, education, receiving public assistance, and ability to live on income. Odds ratios that are significant at  $< 0.05$  are italicized

\* $p < 0.05$ ; \*\* $p < 0.01$

possibility that some individuals with high health literacy are seeking vitamin D via incidental UV exposure and not protecting their skin. This is consistent with Leung and colleagues' [32] findings that health literacy was associated with higher sunlight exposure in their study on vitamin D supplementation, albeit with older Chinese adults. Finally, these data were collected mostly in the spring (March–June) rather than the summer when people may be more likely to minimize sun exposure and protect their skin from UV.

Strengths of the study include the relatively large sample size and the variety of items used to try to help expand on prior conflicting and confusing study findings. Study limitations include the cross-sectional nature of the study, the use of a convenience sample, the brevity of the measures, and the limited variability of health literacy scores, which may have created a ceiling effect. Some of the current results differ from prior findings. However, the samples, measures, and levels of health literacy differed among the studies. For example, in the Leung and colleagues' study [32], sun exposure in the last 7 days was coded as sufficient or not (30–60 min) for producing adequate vitamin D levels in older Chinese individuals. Additionally, the European studies involved a case-control design, thus including many older adults with skin cancer. Health literacy was assessed using similar, but not identical, items across studies. The current study had the highest levels of health literacy and the youngest participants. Of course, in all studies of self-reported health literacy, it is likely overestimated by study participants. More research addressing

these study limitations is needed to confirm and explain the findings more fully in order to inform potential future interventions.

The results of this study suggest that US young adults with lower health literacy may be putting themselves at risk of skin cancer by sunbathing and/or indoor tanning. Although young adults with high health literacy may be aware of the dangers of intentional tanning, they may benefit from more nuanced messages about the dangers of not protecting one's skin from the sun, particularly behaviors such as wearing hats and long pants and skin protection during incidental sun exposure. This could include addressing ambivalence about tanning versus skin protection or clarifying recommendations about vitamin D. Thus, interventions might target young adults with lower health literacy as well as outdoor workers (e.g., lifeguards, public service workers [55, 56]) and/or outdoor athletes/exercisers who may be receiving large amounts of unprotected incidental UV. For example, less health-literate individuals could be educated about sunless tanning as an alternative to UV exposure. As noted in the extant literature, interventions designed for individuals with low health literacy should be focused, simple, and utilize multimedia approaches [57]. Another concern is widespread misinformation, for example, tanning salons not complying with federal advertising regulations [58]. Given that young adults are probably not actively seeking skin cancer prevention information, public health professionals face an uphill battle attempting to proactively correct misinformation clearly and simply, particularly among individuals with low health literacy. Finally, theoretically informed interventions aimed at increasing self-efficacy and perceived benefits of (e.g., enhancing and protecting one's appearance now and in the future) and decreasing barriers to sunless tanning and skin protection (e.g., using a daily moisturizer with SPF) during incidental exposure could be useful [49].

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## Compliance with Ethical Standards

**Ethical Standards** All procedures performed in the study involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. This article does not contain any studies with animals performed by any of the authors.

**Conflict of Interest** The authors declare that they have no conflict of interest.

## References

- Donaldson MR, Coldiron BM. No end in sight: the skin cancer epidemic continues. *Semin Cutan Med Surg.* 2011;30:3–5.
- Gordon R. Skin cancer: an overview of epidemiology and risk factors. *Semin Oncol Nurs.* 2013;29(3):160–9. <https://doi.org/10.1016/j.soncn.2013.06.002>.
- Nikolaou V, Stratigos AJ. Emerging trends in the epidemiology of melanoma. *Br J Dermatol.* 2014;170(1):11–9. <https://doi.org/10.1111/bjd.12492>.
- Tuong W, Cheng LS, Armstrong AW. Melanoma: epidemiology, diagnosis, treatment, and outcomes. *Dermatol Clin.* 2012;30(1):113–24, ix. <https://doi.org/10.1016/j.det.2011.08.006>.
- US Department of Health and Human Services. The surgeon General's call to action to prevent skin cancer. Washington, DC: US Dept of Health and Human Services; 2014. p. 2014.
- Goldberg MS, Doucette JT, Lim HW, Spencer J, Carucci JA, Rigel DS. Risk factors for presumptive melanoma in skin cancer screening: American Academy of Dermatology National Melanoma/Skin Cancer Screening Program experience 2001–2005. *J Am Acad Dermatol.* 2007;57(1):60–6. <https://doi.org/10.1016/j.jaad.2007.02.010>.
- Lazovich D, Vogel RI, Berwick M, Weinstock MA, Anderson KE, Warshaw EM. Indoor tanning and risk of melanoma: a case-control study in a highly exposed population. *Cancer Epidemiol Biomark Prev.* 2010;19(6):1557–68. <https://doi.org/10.1158/1055-9965.epi-09-1249>.
- Markovic SN, Erickson LA, Rao RD, McWilliams RR, Kottschade LA, Creagan ET, et al. Malignant melanoma in the 21st century, part 1: epidemiology, risk factors, screening, prevention, and diagnosis. *Mayo Clin Proc.* 2007;82(3):364–80. <https://doi.org/10.4065/82.3.364>.
- Psaty EL, Scope A, Halpern AC, Marghoob AA. Defining the patient at high risk for melanoma. *Int J Dermatol.* 2010;49(4):362–76. <https://doi.org/10.1111/j.1365-4632.2010.04381.x>.
- Qureshi AA, Zhang M, Han J. Heterogeneity in host risk factors for incident melanoma and non-melanoma skin cancer in a cohort of US women. *J Epidemiol.* 2011;21(3):197–203.
- Buller DB, Cokkinides V, Hall HI, Hartman AM, Saraiya M, Miller E, et al. Prevalence of sunburn, sun protection, and indoor tanning behaviors among Americans: review from national surveys and case studies of 3 states. *J Am Acad Dermatol.* 2011;65(5 Suppl 1):S114–23. <https://doi.org/10.1016/j.jaad.2011.05.033>.
- Coups EJ, Manne SL, Heckman CJ. Multiple skin cancer risk behaviors in the U.S. population. *Am J Prev Med.* 2008;34(2):87–93. <https://doi.org/10.1016/j.amepre.2007.09.032>.
- Heckman CJ, Coups EJ, Manne SL. Prevalence and correlates of indoor tanning among us adults. *J Am Acad Dermatol.* 2008;58(5):769–80. <https://doi.org/10.1016/j.jaad.2008.01.020>.
- Stanton WR, Janda M, Baade PD, Anderson P. Primary prevention of skin cancer: a review of sun protection in Australia and internationally. *Health Promot Int.* 2004;19(3):369–78. <https://doi.org/10.1093/heapro/dah310>.
- Coups EJ, Phillips LA. A more systematic review of correlates of indoor tanning. *J Eur Acad Dermatol Venereol.* 2011;25(5):610–6; author reply 7–8. <https://doi.org/10.1111/j.1468-3083.2011.03996.x>.
- Coups EJ, Stapleton JL, Medina-Forrester A, Natale-Pereira A, Tortolero-Luna G. Sun protection behaviors among Puerto Rican adults. *JAMA Dermatol.* 2014;150(8):899–901. <https://doi.org/10.1001/jamadermatol.2013.8852>.
- Heckman CJ, Coups EJ. Correlates of sunscreen use among high school students: a cross-sectional survey. *BMC Public Health.* 2011;11:679–87. <https://doi.org/10.1186/1471-2458-11-679>.
- Heckman CJ, Darlow S, Cohen-Filipic J, Kloss JD, Manne SL, Munshi T, et al. Psychosocial correlates of sunburn among young adult women. *Int J Environ Res Public Health.* 2012;9(6):2241–51. <https://doi.org/10.3390/ijerph9062241>.
- Manne S, Lessin S. Prevalence and correlates of sun protection and skin self-examination practices among cutaneous malignant melanoma survivors. *J Behav Med.* 2006;29(5):419–34. <https://doi.org/10.1007/s10865-006-9064-5>.
- Ratzan SCP, R. M. Introduction. In Selden, C.R., Zorn, M., Ratzan, S.C., & Parker, R.M. (Eds.), National Library of Medicine current bibliographies in medicine: health literacy. NLM Pub. No. CBM 2000–1. Bethesda, MD: National Institutes of Health, U.S. Department of Health and Human Services. 2000.
- Bellinger JD, Brandt HM, Hardin JW, Bynum SA, Sharpe PA, Jackson D. The role of family history of cancer on cervical cancer screening behavior in a population-based survey of women in the Southeastern United States. *Womens Health Issues.* 2013;23(4):e197–204. <https://doi.org/10.1016/j.whi.2013.03.003>.
- Garbers S, Chiasson MA. Inadequate functional health literacy in Spanish as a barrier to cervical cancer screening among immigrant Latinas in New York City. *Prev Chronic Dis.* 2004;1(4):A07.
- Morris NS, Field TS, Wagner JL, Cutrona SL, Roblin DW, Gaglio B, et al. The association between health literacy and cancer-related attitudes, behaviors, and knowledge. *J Health Commun.* 2013;18(Suppl 1):223–41. <https://doi.org/10.1080/10810730.2013.825667>.
- Pagan JA, Brown CJ, Asch DA, Armstrong K, Bastida E, Guerra C. Health literacy and breast cancer screening among Mexican American women in South Texas. *J Cancer Educ.* 2012;27(1):132–7. <https://doi.org/10.1007/s13187-011-0239-6>.
- Sentell T, Braun KL, Davis J, Davis T. Colorectal cancer screening: low health literacy and limited English proficiency among Asians and Whites in California. *J Health Commun.* 2013;18(Suppl 1):242–55. <https://doi.org/10.1080/10810730.2013.825669>.
- von Wagner C, Good A, Wright D, Ratchet B, Obichere A, Bloom S, et al. Inequalities in colorectal cancer screening participation in the first round of the national screening programme in England. *Br J Cancer.* 2009;101(Suppl 2):S60–3. <https://doi.org/10.1038/sj.bjc.6605392>.
- Herndon JB, Chaney M, Carden D. Health literacy and emergency department outcomes: a systematic review. *Ann Emerg Med.* 2011;57(4):334–45. <https://doi.org/10.1016/j.annemergmed.2010.08.035>.
- Paasche-Orlow MK, Parker RM, Gazmararian JA, Nielsen-Bohlman LT, Rudd RR. The prevalence of limited health literacy. *J Gen Intern Med.* 2005;20(2):175–84. <https://doi.org/10.1111/j.1525-1497.2005.40245.x>.
- White S, Chen J, Atchison R. Relationship of preventive health practices and health literacy: a national study. *Am J Health Behav.* 2008;32(3):227–42. <https://doi.org/10.5993/AJHB.32.3.1>.
- Altsitsiadis E, Undheim T, de Vries E, Hinrichs B, Stockfleth E, Trakatelli M. Health literacy, sunscreen and sunbed use: an uneasy association. *Br J Dermatol.* 2012;167(Suppl 2):14–21. <https://doi.org/10.1111/j.1365-2133.2012.11082.x>.
- Trakatelli M, Barkitzki K, Apap C, Majewski S, De Vries E. Skin cancer risk in outdoor workers: a European multicenter case-control study. *J Eur Acad Dermatol Venereol.* 2016;30 Suppl 3:5–11. <https://doi.org/10.1111/jdv.13603>.
- Leung AY, Cheung MK, Chi I. Supplementing vitamin D through sunlight: associating health literacy with sunlight exposure behavior. *Arch Gerontol Geriatr.* 2015;60(1):134–41. <https://doi.org/10.1016/j.archger.2014.10.005>.
- Cokkinides VE, Bandi P, Weinstock MA, Ward E. Use of sunless tanning products among US adolescents aged 11 to 18 years. *Arch Dermatol.* 2010;146(9):987–92. <https://doi.org/10.1001/archdermatol.2010.220>.
- Stryker JE, Yaroch AL, Moser RP, Atienza A, Glanz K. Prevalence of sunless tanning product use and related behaviors among adults

- in the United States: results from a national survey. *J Am Acad Dermatol.* 2007;56(3):387–90. <https://doi.org/10.1016/j.jaad.2006.08.051>.
35. Glanz K, Schoenfeld E, Weinstock MA, Layi G, Kidd J, Shigaki DM. Development and reliability of a brief skin cancer risk assessment tool. *Cancer Detect Prev.* 2003;27(4):311–5.
  36. Chew LD, Bradley KA, Boyko EJ. Brief questions to identify patients with inadequate health literacy. *Fam Med.* 2004;36(8):588–94.
  37. Jeppesen KM, Coyle JD, Miser WF. Screening questions to predict limited health literacy: a cross-sectional study of patients with diabetes mellitus. *Ann Fam Med.* 2009;7(1):24–31. <https://doi.org/10.1370/afm.919>.
  38. Glanz K, Yaroch AL, Dancel M, Saraiya M, Crane LA, Buller DB, et al. Measures of sun exposure and sun protection practices for behavioral and epidemiologic research. *Arch Dermatol.* 2008;144(2):217–22. <https://doi.org/10.1001/archdermatol.2007.46>.
  39. Ingledew DK, Ferguson E, Markland D. Motives and sun-related behaviour. *J Health Psychol.* 2010;15(1):8–20. <https://doi.org/10.1177/1359105309342292>.
  40. Lazovich D, Stryker JE, Mayer JA, Hillhouse J, Dennis LK, Pichon L, et al. Measuring nonsolar tanning behavior: indoor and sunless tanning. *Arch Dermatol.* 2008;144(2):225–30. <https://doi.org/10.1001/archdermatol.2007.45>.
  41. Glanz K, Mayer JA. Reducing ultraviolet radiation exposure to prevent skin cancer methodology and measurement. *Am J Prev Med.* 2005;29(2):131–42. <https://doi.org/10.1016/j.amepre.2005.04.007>.
  42. Glanz K, McCarty F, Nehl EJ, O'Riordan DL, Gies P, Bundy L, et al. Validity of self-reported sunscreen use by parents, children, and lifeguards. *Am J Prev Med.* 2009;36(1):63–9. <https://doi.org/10.1016/j.amepre.2008.09.012>.
  43. O'Riordan DL, Steffen AD, Lunde KB, Gies P. A day at the beach while on tropical vacation: sun protection practices in a high-risk setting for UV radiation exposure. *Arch Dermatol.* 2008;144(11):1449–55. <https://doi.org/10.1001/archderm.144.11.1449>.
  44. Hoerster KD, Mayer JA, Woodruff SI, Malceme V, Roesch SC, Clapp E. The influence of parents and peers on adolescent indoor tanning behavior: findings from a multi-city sample. *J Am Acad Dermatol.* 2007;57(6):990–7. <https://doi.org/10.1016/j.jaad.2007.06.007>.
  45. Berinsky AJ, Huber GA, Lenz GS. Evaluating online labor markets for experimental research: Amazon.com's mechanical Turk. *Polit Anal.* 2012;20(3):351–68. <https://doi.org/10.1093/pan/mpr057>.
  46. Chang L, Krosnick JA. National surveys via Rdd telephone interviewing versus the Internet: comparing sample representativeness and response quality. *Public Opin Q.* 2009;73(4):641–78. <https://doi.org/10.1093/poq/nfp075>.
  47. Liu H, Cella D, Gershon R, Shen J, Morales LS, Riley W, et al. Representativeness of the Patient-Reported Outcomes Measurement Information System Internet panel. *J Clin Epidemiol.* 2010;63(11):1169–78. <https://doi.org/10.1016/j.jclinepi.2009.11.021>.
  48. Heckman CJ, Darlow SD, Ritterband LM, Handorf EA, Manne SL. Efficacy of an intervention to alter skin cancer risk behaviors in young adults. *Am J Prev Med.* 2016;51(1):1–11. <https://doi.org/10.1016/j.amepre.2015.11.008>.
  49. Heckman CJ, Handorf EA, Darlow SD, Ritterband LM, Manne SL. An online skin cancer risk-reduction intervention for young adults: mechanisms of effects. *Health Psychol.* 2017;36(3):215–25. <https://doi.org/10.1037/hea0000420>.
  50. Schneider S, Zimmermann S, Diehl K, Breitbart EW, Greinert R. Sunbed use in German adults: risk awareness does not correlate with behaviour. *Acta Derm Venereol.* 2009;89(5):470–5. <https://doi.org/10.2340/00015555-0689>.
  51. NCI N, DHHS. Cancer Trends Progress Report. Bethesda, MD; 2018 February.
  52. Wolf MS, Gazmararian JA, Baker DW. Health literacy and health risk behaviors among older adults. *Am J Prev Med.* 2007;32(1):19–24. <https://doi.org/10.1016/j.amepre.2006.08.024>.
  53. Ziefreund S, Schuster B, Zink A. Primary prevention of keratinocyte carcinoma among outdoor workers, the general population and medical professionals: a systematic review updated for 2019. *J Eur Acad Dermatol Venereol.* 2019. <https://doi.org/10.1111/jdv.15525>.
  54. Ashinoff R, Levine VJ, Steuer AB, Sedwick C. Teens and tanning knowledge and attitudes. *J Clin Aesthet Dermatol.* 2009;2(2):48–50.
  55. Glanz K, Maddock JE, Lew RA, Murakami-Akatsuka L. A randomized trial of the Hawaii sunsmart program's impact on outdoor recreation staff. *J Am Acad Dermatol.* 2001;44(6):973–8. <https://doi.org/10.1067/mjd.2001.113466>.
  56. Buller DB, Walkosz BJ, Buller MK, Wallis A, Andersen PA, Scott MD, et al. Results of a randomized trial on an intervention promoting adoption of occupational sun protection policies. *Am J Health Promot.* 2018;32(4):1042–53. <https://doi.org/10.1177/0890117117704531>.
  57. Sheridan SL, Halpern DJ, Viera AJ, Berkman ND, Donahue KE, Crotty K. Interventions for individuals with low health literacy: a systematic review. *J Health Commun.* 2011;16(Suppl 3):30–54.
  58. Seidenberg AB, Mahalingam-Dhingra A, Weinstock MA, Sinclair C, Geller AC. Youth indoor tanning and skin cancer prevention: lessons from tobacco control. *Am J Prev Med.* 2015;48(2):188–94. <https://doi.org/10.1016/j.amepre.2014.08.034>.

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