



Sun-protective behaviors and sunburn among US adults

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Abstract

Individuals can reduce the risk of developing skin cancer by minimizing ultraviolet sunlight exposure, though recent trends in sun-protective behaviors remain to be investigated. To evaluate sun-protective behaviors and sunburn among US adults. We analyzed data from the 2010, 2015, and 2020 National Health Interview Survey (NHIS), an annual, cross-sectional survey conducted by the US Census Bureau. Multivariable regression models were stratified by demographic variables and constructed to evaluate sun-protective behaviors and sunburn avoidance across time. From 2010 through 2020, US adults had significantly increased prevalence of seeking shade (p value, 0.003), wearing wide-brimmed hats (<0.001), wearing long-sleeved shirts (<0.001), using sunscreen (<0.001), and avoiding sunburns (<0.001) and significantly decreased prevalence of sun avoidance (<0.001). Disparities in sun-protective behaviors also exist among different sexes, ages, education levels, and those reporting higher sun sensitivity. This cross-sectional study found that by 2020, US adults had an increased prevalence of wearing sun-protective clothing and sunscreen use, though decreased prevalence of sun avoidance. Although certain sun-protective behaviors have become more prevalent, the incidence of skin cancer continues to rise. Efforts to understand drivers of sun-protective behaviors and targeted intervention efforts are needed.

Keywords Sun protection · Sunburn · Behaviors · Skin cancer · Sunscreen · Epidemiology

Abbreviations

CI	Confidence interval
CPSTF	Community preventive services task force
HS	High school
KC	Keratinocyte carcinoma
NHIS	National health interview survey
OR	Odds ratio
UPF	Ultraviolet protection factor
USPSTF	United States preventive services task force
US	United States

Introduction

Both keratinocyte carcinomas (KCs) and melanomas may be ascribed to ultraviolet (UV) sunlight exposure [1, 2]. The overall incidence of skin cancer in the USA is rising, with the estimated number of new cases nearly doubling between 2000 and 2019 [3].

The pervasiveness of skin cancer represents an important public health concern, given the potential benefits of early skin cancer detection and prevention. The US Preventive Services Task Force (USPSTF) does not currently recommend whole body cutaneous exams by primary care physicians or patient self-examination in asymptomatic patients as there is currently insufficient data for these recommendations [4, 5]. Nevertheless, the USPSTF does recommend interventions aimed at education and prevention. Messaging and preventative efforts for skin cancer have been devised and implemented on a local, national, and international level with direct patient intervention and policy changes to decrease the skin cancer burden [6–15].

Patient-directed efforts have included education about minimizing UV exposure and using sun protection [2]. Policies and environmental interventions, including provisions for shades at schools and free sunscreen dispensers, have

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been implemented on a local level [6, 7]. Globally, regulations to restrict indoor tanning have been adopted, and several studies have shown that technological messaging (i.e., via SMS texts, social media, YouTube) has been successful in improving sun-protective behaviors [2, 16–19].

These educational efforts represent a concerted effort to decrease the burden of skin cancers on patients and the healthcare system. Understanding changes in behavior as it pertains to sun exposure and protection may provide insight into the impact of these interventions over time. Herein, we use the National Health Interview Survey (NHIS) database to evaluate sun-protective behaviors and sunburn exposure in the US adult population.

Patients and methods

Study sample

We used data from the National Health Interview Survey (NHIS), an annual, cross-sectional survey conducted by the US Census Bureau. Sample weights provided by the NHIS are used to yield estimates representative of the non-military, non-institutionalized US population. The NHIS is conducted using face-to-face interviews in respondents' homes, though follow-ups may be conducted via telephone. Of note, due to the COVID-19 pandemic, the NHIS shifted from in-person interviewing to all-telephone interviewing starting in late March 2020 and continuing through June 2020. Data regarding sun-protective behaviors and sunburn are collected by the NHIS in 5-year interval. We collected data from 2010, 2015, and 2020, the most recent databases which contain our data of interest. This study was exempt from New York University Institutional Review Board.

Measures

We evaluated engagement in five unique sun-protective behaviors (staying in the shade, wearing a sun hat, wearing long-sleeved shirts, sunscreen use, and sun avoidance). A positive response to sun-protective behaviors was defined as most of the time or always engaging in a behavior when outside on a sunny day for more than one hour. Some respondents reported they “don't go outside on a sunny day for more than one hour,” which was defined as a positive response to sun avoidance. Sunburn frequency was recoded as a dichotomous variable (0 vs. ≥ 1) and was determined by the response to “During the past 12 months, how many times have you had a sunburn?”. Indoor tanning was not assessed in the 2020 NHIS survey and, therefore, was not included in our analysis.

Statistical analysis

Multivariable logistic regression models were constructed with sun-protective behaviors and sunburn avoidance as the dependent variables. All multivariable models included the adult's sex (male/ female), age (18–39/40–65/ ≥ 66), race (White/Black or African American/Other), education level (high school or less/some college or undergraduate degree/graduate degree), region (west, south, midwest, northeast), and report of sun sensitivity (after 1 h of sun exposure does, one gets severe, moderate, or mild sunburn/ no sunburn). Adjusted odds ratios (aOR) were estimated with 95% confidence intervals (CI). Statistical analysis was performed in SAS (SAS Institute Inc. 2012. SAS OnlineDoc® 9.4. Cary, NC).

Results

Demographic data regarding sex, age, race, education level, region, and sun sensitivity is shown in Table 1. We observed positive trends in the prevalence of shade seeking, wide-brimmed hat-wearing, long-sleeved shirt wearing, sunscreen use, and sunburn avoidance. Adults in 2020 had increased odds of seeking shade (aOR [95% CI], 1.07 [1.02–1.11]), wearing wide-brimmed hats (3.12 [2.95–3.30]), wearing long-sleeved shirt (1.32 [1.24–1.41]), using sunscreen (1.31 [1.25–1.37]), and sunburn avoidance (1.44 [1.37–1.52]) when compared to adults in 2010 (Table 2). We noticed fewer overall changes in these trends from 2010 to 2015 than from 2015 to 2020. Despite these positive trends, there was an initial increase in sun avoidance from 2010 to 2015, with a subsequent decrease from 2015 to 2020 (Table 2).

When stratified by sex, males and females in 2020 exhibited significantly increased odds of wearing wide-brimmed hats, wearing long-sleeved shirts, using sunscreen, and avoiding sunburn as compared to 2010 (Table 3). Notably, in 2020, adult women have increased odds of seeking shade, using sunscreen, avoiding sun, and avoiding sunburn than men, though decreased odds of wearing wide-brimmed and long-sleeved shirts (Table 4).

Adults of all ages in 2020 had significantly increased odds of wearing wide-brimmed hats, wearing long-sleeved shirts, using sunscreen, and avoiding sunburn compared to 2010. Furthermore, adults aged 18–30 had significantly increased odds of seeking shade (1.08 [1.01–1.16]), whereas adults aged 40–65 had significantly decreased odds of sun avoidance (0.76 [0.61–0.95]) (Table 3). Notably, adults aged 18–65 had decreased odds of seeking shade, wearing wide-brimmed hats, wearing long-sleeved

Table 1 Weighted demographics

Variables	Year					
	2010		2015		2020	
	Study partici- pants, no	Weighted % (95% CI)	Study partici- pants, no	Weighted % (95% CI)	Study partici- pants, no	Weighted % (95% CI)
Sex						
Male	11,897	45.1 (44.5–45.8)	14,948	45.7 (45.1–46.4)	14,399	48.2 (47.5–49.0)
Female	15,089	54.9 (54.2–55.5)	18,493	54.3 (53.6–54.9)	16,936	51.8 (51.0–52.5)
Age						
18–39	10,184	36.9 (36.3–37.5)	11,334	34.9 (34.3–35.5)	8526	37.7 (37.0–38.4)
40–65	11,760	43.7 (43.0–44.3)	14,421	42.6 (42.0–43.3)	13,442	42.1(41.4– 42.8)
≥ 66	5042	19.6 (18.9–20.0)	7686	22.5 (21.9–23.0)	9367	20.1 (19.7–20.7)
Race						
White	19,933	80.6 (80.2–81.1)	25,606	79.6 (79.1–80.1)	23,934	76.8 (76.2–77.5)
Black/AA	4582	12.9 (12.5–13.3)	4672	12.6 (12.2–13.0)	4672	13.0 (12.5–13.6)
Other	2471	6.5 (6.2–6.7)	3163	7.8 (7.5–6.78.1)	3163	10.1 (9.7–10.6)
Education level						
HS or less	11,766	40.8 (40.2–41.4)	12,971	36.2 (35.6–36.8)	9885	40.3 (39.5–41.0)
College	12,583	49.3 (48.6–49.9)	16,546	51.5 (50.8–52.2)	16,388	48.6 (47.9–49.3)
Graduate	2512	9.9 (9.5–10.3)	3776	12.3 (11.8–12.7)	4913	11.2 (10.8–11.5)
Region						
Northeast	4338	17.4 (16.9–17.9)	5545	17.4 (16.9–17.9)	5576	17.6 (17.0–18.1)
Midwest	5954	24.2 (23.7–24.8)	7051	23.6 (23.0–24.1)	7125	20.9 (20.3–21.5)
South	9912	36.1(35.5–36.7)	11,578	37.4 (36.7–38.0)	10,833	37.9 (37.1–38.6)
West	6782	22.2 (21.7–22.7)	9267	21.7 (21.2–22.2)	7801	23.6(23.0–24.2)
Sun sensitivity						
Burns	11,855	56.5 (55.8–57.2)	15,965	57.7 (57.0–58.4)	15,643	52.3 (51.5–53.0)
Does not burn	11,020	43.5 (42.7–44.2)	12,613	42.3 (41.6–43.0)	12,783	47.7 (47.0–48.5)

Table 2 Prevalence and odds of sun-protective behaviors and lack of sunburns in US adults across time

Variables	Year			P _{trend}	aOR (2020 vs 2010)
	2010	2015	2020		
	% (95% CI)	% (95% CI)	% (95% CI)		
Seeks shade	37.7 (37.0–38.4)	39.7 (38.9–40.5)	39.5 (38.8–40.2)	0.003	1.07 (1.02–1.11)
Wide-brimmed hat	13.2 (12.7–13.6)	15.6 (15.1–16.1)	31.6 (30.9–32.2)	<0.001	3.12 (2.95–3.30)
Long-sleeved shirt	11.9 (11.4–12.3)	13.2 (12.8–13.7)	16.4 (15.8–16.9)	<0.001	1.32 (1.24–1.41)
Sunscreen	32.6 (31.9–33.2)	34.8 (34.1–35.5)	36.1 (35.4–36.8)	<0.001	1.31 (1.25–1.37)
Sun avoidance	6.8 (6.5–7.1)	7.1 (6.8–7.5)	3.9 (3.6–4.1)	<0.001	0.82 (0.72–0.94)
Sunburn avoidance	64.2 (63.5–64.8)	67.1 (66.5–67.8)	72.7 (72.1–73.4)	<0.001	1.44 (1.37–1.52)

Bold signifies statistically significant results ($p < 0.05$)

*Adjusted odds ratios controlled for age, sex, race, education levels, region, and reporting higher sun sensitivity

shirts, sun avoidance, and sunburn avoidance compared to adults aged 66 and greater (Table 4).

Adults of all education levels in 2020 significantly increased the odds of wearing wide-brimmed hats, wearing long-sleeved shirts, and avoiding sunburn. Adults with less than high school/high school education also had increased

odds of sunscreen use (1.39 [1.26–1.52]). College graduates had increased odds of sunscreen use (1.34 [1.25–1.43]) and shade seeking (1.12 [1.05–1.19]) (Table 3). Adults with less than high school, high school, or a college education were less likely to wear wide-brimmed hats and

Table 3 Adjusted odds of sun-protective behaviors and lack of sunburns in US adults in 2020 stratified by sex, age, education, and reporting higher sun sensitivity

Variables	aOR (95% CI) 2020 vs 2010					
	Seeks Shade	Wide-Brimmed Hat	Long-Sleeved Shirt	Sunscreen	Sun Avoidance	Sunburn Avoidance
Sex						
Male	1.10 (1.03–1.19)	4.25 (3.93–4.61)	1.30 (1.19–1.42)	1.30 (1.21–1.41)	0.91 (0.71–1.18)	1.50 (1.39–1.61)
Female	1.05 (0.98–1.11)	2.28 (2.11–2.46)	1.35 (1.23–1.48)	1.31 (1.23–1.40)	0.78 (0.67–0.92)	1.39 (1.30–1.50)
Age						
18–39	1.08 (1.01–1.16)	3.97 (3.54–4.45)	1.75 (1.53–2.00)	1.30 (1.20–1.42)	0.75 (0.52–1.09)	1.42 (1.31–1.55)
40–65	1.06 (0.99–1.13)	2.98 (2.75–3.22)	1.24 (1.13–1.36)	1.28 (1.20–1.38)	0.76 (0.61–0.95)	1.46 (1.36–1.56)
≥ 66	1.04 (0.93–1.14)	2.67 (2.40–2.96)	1.11 (1.00–1.23)	1.42 (1.28–1.41)	0.92 (0.76–1.12)	1.54 (1.34–1.77)
Education						
HS or less	1.06 (0.99–1.13)	3.12 (2.86–3.43)	1.27 (1.14–1.42)	1.39 (1.26–1.52)	0.82 (0.68–0.99)	1.54 (1.40–1.69)
College	1.12 (1.05–1.19)	3.19 (2.95–3.44)	1.37 (1.25–1.50)	1.34 (1.25–1.43)	0.82 (0.67–1.02)	1.12 (1.05–1.20)
Graduate	1.00 (0.89–1.13)	2.81 (2.43–3.25)	1.25 (1.06–1.47)	1.06 (0.93–1.20)	0.76 (0.48–1.20)	1.32 (1.16–1.52)
Sun sensitivity						
Sensitive	1.15 (1.06–1.19)	2.92 (2.71–3.13)	1.47 (1.18–1.82)	1.36 (1.28–1.45)	0.84 (0.70–0.99)	1.36 (1.28–1.45)
Not sensitive	0.97 (0.90–1.04)	3.50 (3.21–3.82)	1.31 (1.20–1.42)	1.21 (1.11–1.31)	0.81 (0.66–1.01)	1.63 (1.49–1.79)

Bold signifies statistically significant results ($p < 0.05$)

Table 4 Associations between sun-protective behaviors, lack of sunburns, and demographic variables in 2020

Variables	aOR (95% CI)					
	Seeks shade	Wide-brimmed hat	Long-sleeved shirt	Sunscreen	Sun avoidance	Sunburn avoidance
Sex						
Female	1.61 (1.50–1.72)	0.54 (0.51–0.58)	0.87 (0.80–0.95)	2.80 (2.61–3.00)	1.86 (1.49–2.34)	1.19 (1.09–1.28)
Male	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)
Age						
18–39	0.57 (0.53–0.63)	0.34 (0.31–0.37)	0.36 (0.32–0.41)	1.27 (1.16–1.40)	0.15 (0.11–0.21)	0.10 (0.09–0.12)
40–65	0.72 (0.67–0.77)	0.58 (0.54–0.63)	0.48 (0.44–0.53)	1.33 (1.22–1.44)	0.32 (0.25–0.40)	0.24 (0.22–0.27)
≥ 66	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)
Education						
HS or less	1.13 (1.03–1.25)	0.85 (0.77–0.94)	1.01 (0.89–1.14)	0.34 (0.31–0.38)	2.24 (1.64–3.05)	1.42 (1.27–1.60)
College	1.01 (0.93–1.10)	0.90 (0.82–0.98)	0.82 (0.73–0.91)	0.68 (0.62–0.74)	1.40 (1.04–1.90)	0.99 (0.89–1.09)
Graduate	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)
Sun sensitivity						
Sensitive	1.86 (1.73–2.01)	1.33 (1.24–1.44)	1.27 (1.15–1.40)	2.59 (2.41–2.80)	1.42 (1.13–1.79)	0.24 (0.22–0.26)
Not Sensitive	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)

Bold signifies statistically significant results ($p < 0.05$)

*Adjusted odds ratios controlled for age, race, education levels, region, and reporting higher sun sensitivity

use sunscreen than adults with graduate education, though more likely to practice sun avoidance (Table 4).

Adults who reported having greater sun sensitivity in 2020 had significantly increased odds of wearing wide-brimmed hats, wearing long-sleeved shirts, using sunscreen, and sunburn avoidance. Adults who reported greater sun sensitivity in 2020 also had a significant

increase in seeking shade (1.15 [1.06–1.19]) (Table 3). Notably adults who reported greater sun sensitivity had increased odds of seeking shade, wearing wide-brimmed hats, using sunscreen, and avoiding sun compared to adults who did not report having greater sun sensitivity, though they did have decreased odds of avoiding sunburn (Table 4).

Discussion

Positive trends in sun-protective behaviors and lack of sunburns were seen in the US adult population. We saw the largest increases and consistently positive trends in the prevalence of wide-brimmed hat and long-sleeved shirt-wearing in all cohorts. Despite growing in prevalence since 2010, the overall prevalence of long-sleeve shirt-wearing remains low compared to shade seeking, wide-brimmed hat wearing, and sunscreen use in 2020. Cultural and social norms influence the acceptance of wearing long-sleeve shirts and other sun-protective behaviors [20].

Interestingly, in 2020, adult females had increased odds of seeking shade, using sunscreen, avoiding sun, and avoiding sunburn than males, but had decreased odds of wearing long-sleeved shirts and wide-brimmed hats as compared to males. This contrast may be explained by sun-protective studies demonstrating that image norms differ across genders [21, 22]. In melanoma patients queried on their sun-protective behaviors, the rate of long-sleeve shirt-wearing was the least employed sun-protective behavior [23]. Amongst first-degree relatives of melanoma survivors, inconsistent use of protective clothing such as long-sleeve shirts could be explained by weather, physical activity, being outdoors, going to the beach or water setting, already using sunscreen, and fashion [24]. Visual communication, such as images of long-sleeve shirts worn in an attractive manner, could be an effective tool to increase the use of long-sleeve shirts [25]. Further investigation regarding effective interventions to improve long-sleeve shirt wearing will need to overcome the factors that compete with sun protection when adults choose clothing for outdoor activities.

Despite positive changes in some sun-protective behaviors, there is an overall negative trend in sun avoidance between 2010 and 2020 (Table 2). This is a startling trend as a recent study suggests that only sun avoidance and long sleeves reliably prevent sunburn [26]. This dichotomy may reflect a lack of awareness of the differences in effectiveness between sun-protective behaviors [27]. Increasing use of other sun-protective behaviors, such as sunscreen, may lead to an increased time spent outdoors [28]. Further, outdoor occupations and outdoor leisure activities may negatively impact both the capability and motivation to use sun avoidance relative to other sun-protective behaviors [29–32]. Alternatively, an emphasis on the negative consequences of low serum 25(OH)-vitamin D concentrations has been on the rise [33] and may lead to uncertainty regarding the importance of sun protection [34, 35].

Our analysis is consistent with prior reports that males are less likely to engage in sun-protective behaviors [36]. Across all periods analyzed, males exhibited a

lower prevalence of seeking shade, wearing sunscreen, and avoiding the sun than females (Table 3). Variance in sun-protective behaviors between males and females may reflect gendered differences in messaging. Sun protection messaging often targets females and emphasizes beauty standards regarding aging and sun damage [21, 36, 37]. For example, magazines with majority female audiences contain advertisements for products related to sun protection, whereas magazines with majority male audiences were found to have almost no such advertisements [38]. Further, many males exhibit positive perceptions of tanning and the belief that peers view tanning favorably [39]. Sunscreen formulation may also negatively impact use among males. In a recent survey study, males identified oily sunscreen consistency and skin irritation as primary deterrents to sunscreen usage [40]. While there remains a disparity in sun-protective behaviors between males and females, there was a trending statistical improvement among males over the last decade. This may be attributed to increased health promoting messages, which have been suggested to increase adherence to sunscreen use, though additional research is warranted [41].

Cross-sectional studies also estimate that the most incident cancer in the USA in males in 2040 will be melanoma [42], which is consistent with steadily increasing incidence of melanoma over several decades in the general population [43, 44]. This increase may be related to early exposure to UV light with spikes in incidence related to early detection [45]. Increases across all melanoma tumor stages however, suggest that early detection is not a major factor for these changes [46]. The progressing shift in increasing incidence of melanoma in males implies that behavioral changes in sun protection in males must be made a priority.

When stratified by age group, younger age was generally associated with lower odds of wearing a wide-brimmed hat and long sleeves compared to older adults. Protective clothing choices made by younger adults may be subject to different considerations and needs than those made by older adults, such as style and comfort while engaging in outdoor activities. Further investigation into attitudes regarding sun-protective clothing among different age groups could help identify targets for intervention. Despite recent trends in sun-protective behaviors and sunburn avoidance, younger adults remain an important demographic to target with public health initiatives regarding sun safety, as cumulative sun exposure and sunburns at an early age are associated with increased risks of KCs and melanomas [47–49]. As such, early messaging interventions may have the greatest long-term benefit in preventing skin cancers. While our data show that the prevalence of sun-protective behaviors and lack of sunburn increased with age, sunscreen usage is a notable exception with prevalence declining after the age group 40–65. Older adults are at greater risk for skin cancer

but are more likely to believe their risk is low [50–53]. This may reflect historical beliefs about sun exposure, with older adults also tending to believe there is not much one can do about the prevention of skin cancer at their age [54, 55].

On the other hand, adults 66 and older had increased odds of seeking shade, wearing wide-brimmed hats, wearing long-sleeved shirts, sun avoidance, and sunburn avoidance compared to adults aged 18–65 (Table 4). It has been shown that adults greater than 65 are less likely to get sunburns than younger cohorts [53]. Moreover, skin cancer incidences and risk are the greatest after age 65 [51, 56, 57], and older age groups demonstrate considerably more photodamage [58]. In individuals with a previous history of skin cancers, studies dependably reveal that attitudes about sun protection do appreciably change after a skin cancer diagnosis, especially with a melanoma diagnosis [59–69]. The presence of marked photoaging seen by older individuals themselves can be a motivation for behavioral change. It has been shown that appearance-based interventions, like demonstrating wrinkles and UV photographs, have a positive effect on sun protection behaviors [70–73].

We also found that lower levels of education were associated with decreased odds of sun-protective clothing and sunscreen use, though increased odds of sun avoidance and sunburn avoidance when compared to adults with graduate education. While educational attainment is one of many indicators of socioeconomic status (SES), prior studies have suggested that SES is related to physical leisure activity, a known risk factor for frequent sunburn [74]. Disparities in leisure activity and frequent sun exposure related to SES may have been exacerbated during the height of the COVID-19 pandemic. Further, the decreased odds of sunscreen use among individuals with lower levels of education, which may indicate lower SES, could stem from the cost required to achieve the amount of product and frequency of application required for proper use [75]. Discrepancies in price and availability of sunscreen products may exist between high- and low-income zip codes [76].

Our findings continue to highlight the role of reporting greater sun sensitivity in driving sun-protective behaviors and sunburn. Despite increased odds of seeking shade, wearing wide-brimmed hats, using sunscreen, and practicing sun avoidance, US adults who report having greater sun sensitivity are significantly less likely to avoid sunburn. These adults remain an important target population for future targeted sun protection interventions.

The World Health Organization declared COVID-19 an official pandemic during NHIS 2020 data collection [77]. We suspect that the data trends derived from the latest NHIS may contrast with future surveys. During the COVID-19 pandemic, there was dramatically less public sunscreen distribution [78], an increase in active in outdoor activities [79–81], and an increase in direct and indirect sunlight

exposure for the populace [82]. Reports that open spaces would decreased viral transmission may have also changed attitudes about obtaining sun exposure [83, 84]. Studies suggesting sunlight exposure may aid in the recovery of SARS-CoV2 patients and [85, 86] could also contribute to changes in sun-protective behaviors.

The limitations of this study include using cross-sectional, self-reported data, though prior studies have found validity of self-reported measures to assess sun-protective behaviors [87]. Aberrant changes between survey years may have gone unnoticed in our analyses. Other confounding factors could affect survey outcomes, like lack of data for indoor tanning across all time points and concerns about adverse issues or cancers associated with sunscreens [88–97]. In the future, survey data may be affected by the concerns with sunscreen recalls due to benzene contamination [98, 99]. In addition, in March 2020, the NHIS transitioned from in-person to total telephone interviewing due to the COVID-19 pandemic. The NHIS was able to resume in-person interviews in July 2020 but continued to mostly perform surveys by telephone [100]. These changes in survey mode may impact results and increase the risk of mode effect [101, 102]. Previous studies suggest that telephone and in-person studies provide comparable results [103–106], but rates of non-responsiveness were found to be considerably higher in surveys using the telephone [105].

Although educational programs and interventions for sun protection are currently in place and there are positively trending changes in attitudes toward sun protection, decreases in skin cancer, in particular KCs, have not been seen. The incidence of skin cancer in the USA continues to rise, with the number of new cases almost doubling between 2000 and 2019 [107]. While seemingly at odds with the reported improvements in sun-protective behaviors, it is established that the incidence of skin cancers is primarily driven by older adults [108], who had accumulated years of sun exposure during a time when sunscreen was unavailable or not widely utilized [109–111]. As such, we may have yet to observe the improvements in skin cancer rates. Alternatively, the increasing incidence of skin cancer may be a reflection of other factors such as human papillomavirus infection (HPV), which is on the rise and has been linked to squamous cell carcinoma [112–114].

Despite increased awareness of the unhealthy nature of UV radiation, there remains a disconnect between knowledge, attitudes, and functional behaviors regarding sun protection [115, 116]. Continued efforts to understand drivers of sun-protective behaviors may enable targeted approaches to reducing sunburn incidence and overall skin cancer risk. The true manifestations of these behavioral changes, such as reduced skin cancer incidence and associated direct/indirect costs, may not be apparent for many years. However, current positive trends in sun protection and a negative trend in

sunburn prevalence imply that future significant reductions in the incidence of skin cancers and their associated economic and health costs may be on the horizon for the USA.

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Data availability The datasets generated during and/or analyzed during the current study are available in the National Health Interview survey repository, <https://www.cdc.gov/nchs/nhis/2020nhis.htm>, https://www.cdc.gov/nchs/nhis/nhis_2015_data_release.htm, https://www.cdc.gov/nchs/nhis/nhis_2010_data_release.htm.

Declarations

Conflict of interest The authors have no conflicts of interest to declare.

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