BMJ Open

BMJ Open is committed to open peer review. As part of this commitment we make the peer review history of every article we publish publicly available.

When an article is published we post the peer reviewers' comments and the authors' responses online. We also post the versions of the paper that were used during peer review. These are the versions that the peer review comments apply to.

The versions of the paper that follow are the versions that were submitted during the peer review process. They are not the versions of record or the final published versions. They should not be cited or distributed as the published version of this manuscript.

BMJ Open is an open access journal and the full, final, typeset and author-corrected version of record of the manuscript is available on our site with no access controls, subscription charges or pay-per-view fees (http://bmjopen.bmj.com).

If you have any questions on BMJ Open's open peer review process please email info.bmjopen@bmj.com

BMJ Open

Association between sun-protective behaviors and psoriasis in US adults in the 2009-2014 NAHNES: a cross-sectional study

SCHOLARONE™
Manuscripts

I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd ("BMJ") its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our licence.

The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge ("APC") for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which Creative Commons licence will apply to this Work are set out in our licence referred to above.

Other than as permitted in any relevant BMJ Author's Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.

Association between sun-protective behaviors and psoriasis in US adults in the 2009-2014 NAHNES: a cross-sectional study

Yawen Xuan[1], Yibin Feng[2], Fen Rong[3], Xufeng He[1], Wuqing Wang[1#], Wen Li[1#]

[1]Department of Dermatology, Shuguang Hospital Affiliated to Shanghai University of TCM, Shanghai, China.

[2] School of Chinese Medicine, Li Ka Shing Faculty of Medicine, The University of Hong Kong, 6 Sassoon Road, Pokfulam, Hong Kong.

[3]School of Public Health, Shanghai University of Traditional Chinese Medicine, Shanghai, China.

 # Wuqing Wang and Wen Li are both corresponding author of this paper.

1. Yawen Xuan

·Title: Bachelor

·Affiliation: School of Public Health, Shanghai University of Traditional Chinese Medicine, Shanghai, China.

·E-mail: yawenx0928@163.com

2. Yibin Feng,

·Title: PhD

·Affiliation: School of Chinese Medicine, Li Ka Shing Faculty of Medicine, The University of Hong Kong, 6 Sassoon Road, Pokfulam, Hong Kong.

·E-mail: yfeng@hku.hk

3. Fen Rong

·Title: PhD

1

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

·Affiliation: School of Public Health, Shanghai University of Traditional Chinese Medicine, Shanghai

201203, China.

·E-mail: rf97328@163.com

4. Xufeng He

·Title: MD

·Affiliation: Department of Dermatology, Shuguang Hospital Affiliated to Shanghai University of

TCM, Shanghai, China.

·E-mail: yake2004@163.com

Corresponding authors:

Postal address: Wuqing Wang and Wen Li, Department of Dermatology, Shuguang Hospital Affiliated

to Shanghai University of Traditional Chinese Medicine, Shanghai 201203, China.

Wuqing Wang: E-mail: wuqingw2006@sina.com

Wen Li: E-mail: liwen@shutcm.edu.cn

2

Abstract

Objective: To evaluate the association between sun-protective behaviors and psoriasis in a nationally

representative sample of US adults.

Design: Cross-sectional study.

Setting: The National Health and Nutrition Examination Survey 2009-2014.

Participants: A total of 9735 participants aged 20-59 years with available data on psoriasis, sun-

protective behaviors, and covariates were included in this study.

Primary and secondary outcome measures: The information on sun-protective behaviors

(staying in the shade, wearing long sleeves, and using sunscreen) and psoriasis was obtained from

questionnaires in the NHANES database. Logistic regression models and subgroup analysis were

employed to investigate the association between sun-protective behaviors and psoriasis.

Results: After adjusting for covariates in multivariate model 4, moderate wearing of long sleeves was

associated with psoriasis (odds ratio [OR], 0.55; 95% CI, 0.33-0.90), but there was no significant

relationship between overall sun protection and psoriasis. In subgroup analyses, moderate wearing of

long sleeves was associated with a lower prevalence of psoriasis among those aged 20 to 39 years (OR,

0.42; 95% CI, 0.18-0.98), among non-Hispanic Whites (OR, 0.52; 95% CI, 0.28-0.97), and among

nonsmokers (OR, 0.49; 95% CI, 0.25-0.95), as it was among women in overall sun protection (OR,

0.58; 95%CI, 0.35-0.97). However, among non-Hispanic whites (shade: OR, 1.69; 95%CI, 1.00-2.84)

and former/current smokers (overall: OR, 3.28; 95%CI, 1.41-7.63), frequent sun protection was

positively associated with psoriasis.

Conclusions: Moderate sun-protective behaviors among US adults may be associated with a

decreased risk of psoriasis. But among non-Hispanic whites and former/current smokers, frequent sun

3

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

protection was associated with an increased risk of psoriasis. For individuals with different

characteristics, the findings may be taken into consideration to guide daily sun protection practice.

4

Article Summary

Strengths and limitations of this study

- This is the first attempt to explore the relationship between sun-protective behaviors and psoriasis.

- The data in the NHNAES database is nationally representative and collected under strict control.

- This study adjusted for a variety of confounding variables and performed subgroup analysis.

- As with the feature of any cross-sectional study, only association but no causal link could be

  determined.

- Self-reported psoriasis and sun-protective behaviors may induce recall bias and reporting bias.

5

1.Introduction:

Psoriasis is a common chronic inflammatory skin disease that will cause a reduction in quality of life, sleep impairment,

psychological problems and so on[1]. The prevalence of it is expected to increase[2], with the current prevalence of about 3%

in US adults, affecting over 7.5 million US adult population[3].

Various treatment options are available for psoriasis, including pharmacotherapy, psychotherapy and rapidly

developing biologic therapies. Phototherapy (broadband UV-B, narrowband UV-B and heliotherapy) is an effective and

safe treatment recommended by The Joint American Academy of Dermatology and National Psoriasis Foundation

guidelines[4]. It is commonly used for widespread psoriasis due to its efficacy and safety. Many researches have shown

that Ultraviolet B(UVB) contributes to faster lesion clearance, fewer excessive erythema episodes and longer remission

periods in psoriasis[5] by inducing apoptosis in keratinocytes[6], CD4+ T cells and CD8+ T cells[7], inhibiting mast cell

degranulation and histamine release[8], immunosuppression and changing the level of cytokines such as interleukin [IL]-

10, IL-17A[9,10].Moreover, there are several evidence to support the claim that UV-B therapy or heliotherapy also can

improve vitamin D level and lessen the severity of the psoriasis.[11,12]And association between low levels of serum 25-

hydroxyvitamin D(25(OH)D) and increased risk of developing psoriasis has been observed[13]. In addition, as we all know,

there is a strong tendency for psoriasis to be more frequent in winter but it is the opposite in summer[14,15], which suggests

that ultraviolet radiation may be the reason for this phenomenon.

In US, some health organizations and clinicians advise using sunscreen and other sun protection measures to lower

the chance of developing melanoma and other types of skin cancer as well as to prevent premature aging of the skin.

Given that ultraviolet radiation has the function of treating psoriasis, possible issue with sun-protective behaviors may

cause or aggravate psoriasis. Despite having found that using sunscreen for both daily and recreational photo-protection

has no impact on the synthesis of vitamin D[16], there is scarce data on whether sunscreen use and other sun-protective

behaviors affect the prevalence of psoriasis.

6

To address this research gap, in this cross-sectional study, we included and analyzed data from the 2009 to 2014

cycles of the National Health and Nutrition Examination Survey (NHANES) to explore the association between

multimodal sun-protective behaviors and prevalence of psoriasis among US adults.

2. Methods:

2.1 Data Sources

We used National Health and Nutrition Examination Survey (NHANES) data in 2009-2014 to investigate the association

between multimodal sun-protective behaviors and prevalence of psoriasis among US adults.[17] The NHANES is a

nationally representative survey that captures statistics of the US noninstitutionalized civilian population on a biennial

basis based on complex survey design and population-specific sample weights in order to assess their health or

nutritional status.

2.2 Study Design and Population

This was a population-based cross-sectional study. Our analyses were based on data collected from participants during

three 2-year NHANES cycles (2009-2010, 2011-2012 and 2013-2014).

Of 11842 participants aged 20-59 years, 6 participants were excluded due to unavailable self-reported psoriasis data

and 168 participants were excluded with unavailable information on three kind of sun-protective behaviors. Additionally,

1933 participants with missing date on covariates, including age, gender, race and ethnicity, education level, marital

status, country of birth, body measure index(BMI), alcohol drinking status, smoking status, sun sensitivity and time spent

outdoors were excluded, making 9735 individuals included in the final analysis (**figure 1**).

To our knowledge, all participants provided informed consent for data collection and for the data to be publicly

disseminated in a de-identified format.

7

2.3 Psoriasis

The information was obtained from medical conditions section of questionnaire data in NHANES. The participants aged

20 years and older were asked if they have ever been told by a doctor or other health care professional that they had

psoriasis. If the answer is "yes", he or she was considered to have psoriasis.

2.4 Sun-Protective Behaviors, Sun Sensitivity and Time Spent Outdoors

We assessed three different sun-protective behaviors from the NHANES dermatology questionnaire section (DEQ), for

which the target group was participants aged 20-59 years. The question asked for sun protective behavior was: "When

you go outside on a very sunny day, for more than one hour, how often do you (1) Stay in the shade, (2) Wear a long

sleeved shirt, (3) Use sunscreen?" The valid answer can be "always," "most of the time," "sometimes," "rarely," "never"

and "don't go out in the sun." We reclassified these different answers into 3 categories: frequent (always or most of the

time), moderate (sometimes), or rare (never, rarely or don't go out in the sun). Furthermore, overall sun protection was

classified into three levels according to a total score for three sun protective behaviors. The total score for sun protection

ranged from 3 to 9 was further divided down into rare (3-4), moderate (5-7), and frequent (8-9) categories[18] after every

behavior was scored 1, 2 or 3 depending on their frequency of use(rare, moderate and frequent).

Sun sensitivity was defined based on the question about skin reaction to sun without sunscreen or protective

clothing for half an hour after several months of not exposed to the sun. According to their responses, survey participants

were then divided into three groups: no sun sensitivity ("nothing would happen"), mild sun sensitivity ("mildly burn with

some tanning" or "turn darker without a sunburn") and severe sun sensitivity ("severe sunburn with blisters" or "severe

sunburn for a few days with peeling").

In NHANES 2009-2014 cycles, participants were questioned how many minutes (min) they spent outdoors over the

course of the previous 30 days between 9 am and 5 pm on workdays and non-workdays. Considering a week with five

working days and two off, we calculated average time(minutes/day) spent outdoors using the following formula:

8

(minutes outdoors 9 am-5 pm on working day×5+minutes outdoors 9 am-5 pm on nonworking day×2)/7. If the response

is "Does not work or go to school" for working day or "At work or at school 9 to 5 seven days a week" for nonworking

day, the counterpart will be regarded as the final average time.

2.5 Other covariates

In addition to sun sensitivity and time spent outdoors, the other covariates were included age, gender, race and ethnicity,

education level, marital status, country of birth, BMI, alcohol drinking status, smoking status. Race and ethnicity was

derived from responses to the survey questions on race and Hispanic origin in the demographics file. Respondents were

reclassified into four groups: non-Hispanic White, non-Hispanic Black, Hispanic and other [Mexican American or other

race (including multi-racial)]. Marital status was categorized into the following 3 groups: never married, married or

living with partner and widowed, divorced or separated. Country of birth was encoded as a binary variable (0, born in

another country,1, born in the USA). The survey question "In any 1 year, have you had at least 12 drinks of any type of

alcoholic beverage?" was used to establish participants' alcohol drinking status. Participants who responded "yes" were

considered to be alcohol drinkers. Smoking status was divided into 3 categories: nonsmoker (smoked <100 cigarettes in

lifetime), former smoker (smoked ≥100 cigarettes in lifetime but has quit), and current smoker (smoked ≥100 cigarettes

in lifetime and still on smoking), according to data on cigarette use in questionnaire.

2.6 Statistical Analysis

All analyses were conducted in accordance with the NHANES analytic guidelines[19,20], taking into consideration the

complex sample design and appropriate sampling weights. In this study, we extracted three cycles of NHANES, thus the

sampling weight was calculated using the following equation: full sample 6-year mobile examination center (MEC) exam

weight=full sample 2-year MEC exam weight/3. Quantitative data were reported as means, standard deviations and 95%

CIs, whilst qualitative data were expressed as numbers, weighted percentage frequencies and 95% CIs. The t-test for

comparing quantitative data, and χ^2 test for comparing qualitative data were used for comparing baseline characteristics

9

by the presence of psoriasis. Logistic regression analysis was performed to calculate weighted ORs and 95%Cis to

explore the association of sun protection and psoriasis after adjustment for covariates. There were four models created in

multivariate analysis to reduce the impact of bothersome factors. Model 1 was the crude model with no covariates

adjusted. Model 2 was adjusted for sociodemographic variables, including age, gender, race or ethnicity, education level,

marital status and country of birth. Based on model 2, model 3 were adjusted for three more variables, including BMI,

alcohol drinking status and smoking status. And based on model 3, model 4 were adjusted for two more variables closely

related with sun-protective behaviors, which were sun sensitivity and time spent outdoors. Subgroup analysis was

conducted to determine the association in specific subgroups. In all tests, p-values of less than 0.05(2-sided) were

considered to be statistically significant. And all statistical analyses were conducted in Stata (Stata Corp), version 17.

3. RESULTS

3.1 Characteristics of the Population

Baseline characteristics and comparisons of included and excluded participants were shown in **Supplementary Table 1**.

Of 9735 participants who were finally included in our study, 255 (2.8%) had psoriasis, while 9480(97.2%) did not. As

shown in **table 1**, 50.3% of participants were male and the weighted mean age of the participants was 39.6 years (95%

CI: 39.3-39.9). Not surprisingly, compared with participants without psoriasis, patients with psoriasis were more likely to

be older, non-Hispanic white, US born, former smoker, but they did not differ significantly in gender, education level,

marital status, BMI and alcohol drinking status. Additionally, participants with psoriasis had lower prevalence of severe

sun sensitivity, but no difference existed in the time spent outdoors. In terms of frequently staying in the shade, wearing

long sleeves, using sunscreen and the overall sun protection, the percentages were 31.0% (95% CI: 29.8%-32.1%), 9.0%

(95% CI: 8.3%-9.7%), and 29.8% (95% CI: 28.6%-31.0%), 6.8%(95% CI: 6.2%-7.5%), respectively. And there were

significantly different distributions in long sleeves (*P*=0.002), sunscreen use (*P*=0.04) and overall sun protection

10

(*P*<0.001) between psoriasis group and non-psoriasis group.

Table 1 Characteristics of participants by psoriasis in 2009-2014 NHNAES

Characteristic	Participants			
	Total	Without psoriasis	With psoriasis	
	(N = 9735)	(n = 9480)	(n = 255)	*P* value
Age, mean ± SD(95%CI), y	39.6 ± 11.7(39.3-39.9)	39.5 ± 11.7(39.2-39.8)	42.7 ± 11.3(40.9-44.5)	**<0.001**
Gender				
Female	4882(49.7)[48.4-50.9]	4750(49.7)[48.4-50.9]	132(50.0)[42.2-57.8]	0.91
Male	4853(50.3)[49.1-51.6]	4730(50.3)[49.1-51.6]	123(50.0)[42.2-57.8]	
Race and ethnicity				
Non-Hispanic White	4030(64.5)[63.5-65.6]	3883(64.2)[63.1-65.2]	147(77.4)[72.0-82.0]	
Non-Hispanic Black	2048(11.9)[11.3-12.4]	2021(12.0)[11.5-12.6]	27(5.4)[3.6-8.0]	**<0.001**
Hispanic	938(6.2)[5.8-6.6]	915(6.2)[5.8-6.7]	23(5.3)[3.4-8.2]	
Other[a]	2719(17.4)[16.7-18.2]	2661(17.6)[16.8-18.4]	58(11.9)[8.7-16.1]	
Education level				
Less than 9th grade	645(4.0)[3.6-4.4]	631(4.0)[3.7-4.4]	14(2.3)[1.3-4.1]	
9-11th grade	1363(10.9)[10.2-11.6]	1336(11.0)[10.3-11.7]	27(6.7)[4.3-10.5]	
High school grad/GED or equivalent	2137(21.1)[20.1-22.1]	2080(21.1)[20.1-22.1]	57(21.5)[15.8-28.6]	0.06
Some college or AA degree	3115(33.1)[31.9-34.3]	3035(33.1)[31.9-34.3]	80(33.0)[26.0-40.9]	
College graduate or above	2475(31.0)[29.8-32.2]	2398(30.8)[29.6-32.1]	77(36.4)[29.1-44.4]	
Country of birth				
Not US born	2793(18.5)[17.7-19.3]	2745(18.7)[17.9-19.5]	48(9.9)[7.1-13.6]	**<0.001**
US born	6942(81.5)[80.7-82.3]	6735(81.3)[80.5-82.1]	207(90.1)[86.4-92.9]	
Marital status				
Never married	2563(24.1)[23.1-25.2]	2507(24.2)[23.1-25.2]	56(22.9)[17.0-30.1]	
Married or living with partner	5719(62.1)[60.8-63.3]	5571(62.1)[60.9-63.3]	148(61.4)[53.6-68.7]	0.64
Widowed or divorced or separated	1453(13.8)[13.0-14.7]	1402(13.8)[12.9-14.7]	51(15.7)[10.9-22]	
BMI (kg/m²)				
<25	3043(31.4)[30.2-32.6]	2977(31.5)[30.4-32.7]	66(26.2)[20.0-33.5]	
25-30	3071(32.8)[31.6-34.0]	2991(32.7)[31.5-34.0]	80(35.4)[28.1-43.4]	0.17
≥30	3621(35.8)[34.6-37.0]	3512(35.7)[34.5-37.0]	109(38.5)[31.3-46.2]	
Alcohol drinkers				
No	2279(18.6)[17.7-19.5]	2226(18.6)[17.7-19.5]	53(17.7)[12.8-23.9]	0.70
Yes	7456(81.4)[80.5-82.3]	7254(81.4)[80.5-82.3]	202(82.3)[76.1-87.2]	
Smoking status				
Nonsmokers	5670(57.8)[56.6-59.1]	5547(58.1)[56.8-59.3]	123(49.2)[41.4-57.0]	
Former smokers	1647(19.2)[18.2-20.3]	1587(18.9)[17.9-20.0]	60(30.1)[23.0-38.2]	**<0.001**
Current smokers	2418(22.9)[21.9-24.0]	2346(23.0)[22.0-24.1]	72(20.8)[15.7-27.0]	
Sun sensitivity[b]				
None	956(12.7)[11.9-13.7]	923(12.7)[11.8-13.6]	33(15.4)[10.3-22.4]	**0.006**

11

Mild	4667(52.1)[50.8-53.3]	4524(51.9)[50.6-53.2]	143(58.4)[50.6-65.9]	
Severe	4112(35.2)[34.0-36.3]	4033(35.4)[34.3-36.6]	79(26.2)[20.1-33.3]	
Time spent outdoors[c] (min/d)				
<60	3891(38.8)[37.6-40.1]	3790(38.9)[37.7-40.2]	101(35.2)[28.1-42.9]	0.21
≥60	5844(61.2)[59.9-62.4]	5690(61.1)[59.8-62.3]	154(64.8)[57.1-71.9]	
Staying in the shade				
Rare	2546(27.2)[26.0-28.3]	2489(27.2)[26.1-28.4]	57(24.8)[18.6-32.2]	
Moderate	3776(41.9)[40.6-43.1]	3677(42.0)[40.7-43.3]	99(37.9)[30.7-45.7]	0.07
Frequent	3413(31.0)[29.8-32.1]	3314(30.8)[29.6-31.9]	99(37.3)[30.0-45.2]	
Wearing long sleeves				
Rare	6742(70.9)[69.8-72.1]	6557(70.8)[69.6-71.9]	185(76.0)[68.8-81.9]	
Moderate	1941(20.1)[19.1-21.1]	1907(20.3)[19.3-21.4]	34(12.0)[7.9-17.9]	**0.002**
Frequent	1052(9.0)[8.3-9.7]	1016(8.9)[8.2-9.6]	36(12.0)[7.9-17.9]	
Using sunscreen				
Rare	5579(48.5)[47.2-49.7]	5449(48.7)[47.4-50.0]	130(41.8)[34.5-49.5]	
Moderate	1819(21.8)[20.7-22.9]	1763(21.6)[20.5-22.7]	56(27.2)[20.5-35.2]	**0.04**
Frequent	2337(29.8)[28.6-31.0]	2268(29.7)[28.5-31.0]	69(31.0)[24.2-38.8]	
Overall sun protection[d]				
Rare	3249(31.9)[30.8-33.1]	3174(31.9)[30.8-33.1]	75(31.4)[24.5-39.1]	
Moderate	5850(61.3)[60.0-62.5]	5698(61.4)[60.2-62.6]	152(56.1)[48.2-63.7]	**<0.001**
Frequent	636(6.8)[6.2-7.5]	608(6.7)[6.0-7.4]	28(12.5)[7.9-19.3]	

Data are presented as unweighted number (weighted percentage) [95% CI] unless otherwise indicated.

Abbreviations: NHANES, National Health and Nutrition Examination Survey; BMI, body mass index (calculated as weight in kilograms divided by height in meters squared). Boldface indicates statistical significance.

[a] Included Mexican American and multiracial participants.

[b] Sun sensitivity was determined by the answer to the skin reaction to sun without sunscreen or protective clothing for half an hour: none ("nothing would happen"), mild ("mildly burn with some tanning" or "turn darker without a sunburn"), and severe ("severe sunburn with blisters" or "severe sunburn for a few days with peeling").

[c] Time spent outdoors refers to the average minutes spent outdoors from 9: 00 am to 5: 00 pm on each day of the week considering that there are 5 working days and 2 non-working days in a week.

[d] Overall sun protection reflects the general condition of sun protection, including staying in the shade, wearing long sleeves and sunscreen.

3.2 Multivariable Regression Analyses

In **table 2,** the results of one crude regression model (model 1) and three sample-weighted multivariable regression models (model 2-4) to evaluate the association between sun-protective behaviors and psoriasis are presented. In model 1, moderate wearing of long sleeves was associated with a decreased prevalence of psoriasis (OR, 0.55; 95% CI, 0.34-0.89). After adjustment for covariates, the association remained statistically significant (all *P*<0.05). However, overall sun

12

protection had positive association with psoriasis in crude model (OR, 1.91; 95%CI, 1.08-3.39), but the relationship

disappeared after adjustment. Meanwhile, other two behaviors were not significantly associated with psoriasis in the

unadjusted or adjusted models.

Table 2 Association between sun-protective behaviors and psoriasis in NHANES, 2009-2014

	Presence of psoriasis by sun-protective behaviors			
	Staying in the shade	Wearing long sleeves	Using sunscreen	Overall sun protection
Model	OR(95%CI)	OR(95%CI)	OR(95%CI)	OR(95%CI)
Model 1[a]				
Rare	1[reference]	1[reference]	1[reference]	1[reference]
Moderate	0.99(0.66-1.50)	**0.55(0.34-0.89)**	1.47(0.98-2.20)	0.93(0.65-1.32)
Frequent	1.33(0.88-2.02)	1.26(0.77-2.03)	1.22(0.84-1.76)	**1.91(1.08-3.39)**
Model 2[b]				
Rare	1[reference]	1[reference]	1[reference]	1[reference]
Moderate	0.96(0.63-1.46)	**0.54(0.33-0.88)**	1.22(0.79-1.88)	0.89(0.61-1.29)
Frequent	1.42(0.93-2.18)	1.36(0.82-2.26)	0.96(0.61-1.50)	1.68(0.91-3.10)
Model 3[c]				
Rare	1[reference]	1[reference]	1[reference]	1[reference]
Moderate	0.96(0.63-1.45)	**0.54(0.33-0.88)**	1.27(0.83-1.95)	0.90(0.62-1.31)
Frequent	1.40(0.92-2.15)	1.36(0.82-2.25)	0.98(0.63-1.52)	1.67(0.90-3.09)
Model 4[d]				
Rare	1[reference]	1[reference]	1[reference]	1[reference]
Moderate	0.95(0.62-1.45)	**0.55(0.33-0.90)**	1.25(0.82-1.91)	0.90(0.62-1.31)
Frequent	1.42(0.92-2.18)	1.36(0.82-2.26)	0.96(0.62-1.50)	1.67(0.90-3.12)

Abbreviations: NHANES, National Health and Nutrition Examination Survey; OR, odds ratio. Boldface indicates statistical

significance.

[a] Crude model.

[b] Adjusted for sociodemographic variables (age, gender, race and ethnicity, educational level, country of birth and marital

status).

[c] Adjusted for sociodemographic variables, body mass index(BMI), smoking and alcohol drinking status.

[d] Adjusted for sociodemographic variables, body mass index(BMI), smoking and alcohol drinking status, sun sensitivity,

and time spent outdoors.

3.3 Subgroup Analyses

The results of subgroup analysis, stratified by age, gender, race and smoking status, are presented in **table 3**. Among

participants aged 20 to 39 years (OR, 0.42; 95% CI, 0.18-0.98), non-Hispanic whites (OR, 0.52; 95% CI, 0.28-0.97), and

nonsmokers (OR, 0.49; 95% CI, 0.25-0.95), moderate wearing of long sleeves was associated with lower prevalence of

13

psoriasis, as it was among female in terms of overall sun protection (OR, 0.58; 95%CI, 0.35-0.97).

However, among former or current smokers, those with frequent stays in shade (OR, 1.92; 95%CI, 1.03-3.60), long

sleeves (OR, 2.84; 95%CI, 1.46-5.53) or overall sun protection (OR, 3.28; 95%CI, 1.41-7.63) had a higher risk of

psoriasis. And there were also slightly significant and positive relationships between frequent shade-seeking behavior

and psoriasis among non-Hispanic whites (OR,1.69; 95%CI, 1.00-2.84).

Table 3 Association between sun-protective behaviors and psoriasis, stratified by age, gender, race and smoking status

Subgroup	frequency	Staying in the shade OR(95% CI)	P value	Wearing long sleeves OR(95% CI)	P value	Using sunscreen OR(95% CI)	P value	Overall sun protection OR(95% CI)	P value
Overall									
Crude	Rare	1[reference]		1[reference]		1[reference]		1[reference]	
	Moderate	0.99(0.66-1.50)	0.97	0.55(0.34-0.89)	**0.01***	1.47(0.98-2.20)	0.06	0.93(0.65-1.32)	0.69
	Frequent	1.33(0.88-2.02)	0.18	1.26(0.77-2.03)	0.36	1.22(0.84-1.76)	0.30	1.91(1.08-3.39)	**0.03***
Adjusted	Rare	1[reference]		1[reference]		1[reference]		1[reference]	
	Moderate	0.95(0.62-1.45)	0.82	0.55(0.33-0.90)	**0.02***	1.25(0.82-1.91)	0.30	0.90(0.62-1.31)	0.59
	Frequent	1.42(0.92-2.18)	0.11	1.36(0.82-2.26)	0.23	0.96(0.62-1.50)	0.86	1.67(0.90-3.12)	0.11
Age, y									
20-39	Rare	1[reference]		1[reference]		1[reference]		1[reference]	
	Moderate	0.71(0.40-1.25)	0.23	0.42(0.18-0.98)	**0.04***	1.21(0.66-2.19)	0.54	0.91(0.53-1.55)	0.73
	Frequent	1.14(0.61-2.13)	0.68	0.86(0.31-2.42)	0.78	1.23(0.66-2.29)	0.52	1.27(0.41-3.93)	0.68
40-59	Rare	1[reference]		1[reference]		1[reference]		1[reference]	
	Moderate	1.24(0.67-2.27)	0.49	0.64(0.34-1.20)	0.16	1.28(0.73-2.27)	0.39	0.92(0.55-1.53)	0.75
	Frequent	1.77(0.96-3.24)	0.07	1.75(0.97-3.16)	0.06	0.84(0.46-1.53)	0.57	1.97(0.92-4.20)	0.08
Gender									
Female	Rare	1[reference]		1[reference]		1[reference]		1[reference]	
	Moderate	0.63(0.35-1.16)	0.14	0.56(0.28-1.12)	0.10	0.88(0.48-1.59)	0.66	0.58(0.35-0.97)	**0.04***
	Frequent	1.33(0.74-2.39)	0.33	1.37(0.62-3.03)	0.43	0.56(0.31-1.02)	0.06	1.23(0.55-2.76)	0.62
Male	Rare	1[reference]		1[reference]		1[reference]		1[reference]	
	Moderate	1.28(0.72-2.29)	0.40	0.53(0.26-1.07)	0.08	1.71(0.95-3.09)	0.08	1.32(0.78-2.23)	0.30
	Frequent	1.40(0.74-2.64)	0.30	1.30(0.68-2.48)	0.42	1.75(0.97-3.15)	0.06	1.95(0.74-5.11)	0.17
Race									
Non-Hispanic White	Rare	1[reference]		1[reference]		1[reference]		1[reference]	
	Moderate	0.93(0.56-1.55)	0.78	0.52(0.28-0.97)	**0.04***	1.28(0.78-2.11)	0.33	0.80(0.50-1.26)	0.33
	Frequent	1.69(1.00-2.84)	**0.049***	1.43(0.71-2.86)	0.32	0.83(0.48-1.43)	0.50	1.73(0.82-3.66)	0.15
other	Rare	1[reference]		1[reference]		1[reference]		1[reference]	
	Moderate	1.14(0.64-2.03)	0.67	0.68(0.37-1.22)	0.20	1.10(0.59-2.06)	0.76	1.39(0.83-2.32)	0.21
	Frequent	0.92(0.52-1.61)	0.77	1.20(0.68-2.12)	0.53	1.94(1.09-3.44)	**0.02***	1.66(0.72-3.82)	0.24

14

Smoking status									
nonsmokers	Rare	1[reference]		1[reference]		1[reference]		1[reference]	
	Moderate	0.76(0.42-1.35)	0.35	0.49(0.25-0.95)	**0.04***	1.71(0.93-3.14)	0.09	0.74(0.43-1.26)	0.26
	Frequent	1.00(0.55-1.82)	1.00	0.42(0.19-0.93)	**0.03***	1.14(0.58-2.21)	0.71	0.87(0.36-2.09)	0.76
smokers[a]	Rare	1[reference]		1[reference]		1[reference]		1[reference]	
	Moderate	1.20(0.66-2.20)	0.55	0.62(0.31-1.25)	0.17	1.00(0.53-1.89)	0.94	1.12(0.67-1.85)	0.73
	Frequent	2.05(1.11-3.78)	**0.02***	3.02(1.57-5.79)	**<0.001****	0.91(0.49-1.70)	0.62	3.28(1.41-7.63)	**0.009****

Each stratification was adjusted for age, gender, race and ethnicity, country of birth, educational level, marital status, body mass index, smoking and alcohol drinking status, sun sensitivity, and time spent outdoors except the stratification factor itself. All ORs and 95% CIs are based on data weighted to represent the US population.

*P<0.05, **P<0.01

Boldface indicates statistical significance.

[a] smokers refer to current smokers and former smokers.

4. DISCUSSION

To our knowledge, this is the first report to investigate the associations between sun-protective behaviors and psoriasis in a population-based setting, specifically in the US adult population. The findings revealed that moderately wearing long sleeves had a statistically significant association with lower odds of psoriasis even after adjustment for some sociodemographic factors, smoking and alcohol drinking status and so on. But there was no association between another two measures (staying in shade and using sunscreen) and psoriasis, and neither was the overall sun protection. In subsequent subgroup analysis, the significant relationships between moderate sun protective behaviors and lower risk of psoriasis was observed in younger adults aged 20-39, female, non-Hispanic whites, and smokers. Remarkably, it was also shown that frequent sun protection was associated with an elevated risk of psoriasis among smokers, non-Hispanic whites.

Psoriasis is a chronic and immune-mediated skin disorder attributed to various genetic and environmental factors. As reported in previous studies, physical trauma[21], life style and habits[22], infection, such as streptococcus[23], medication[24,25] and so on are risk factors or triggers of psoriasis. This relationship between sun protection and lower risk of psoriasis might be because sun protection avoids the traumatic effect of excessive ultraviolet rays on the skin, or people with moderate sun-protective behaviors tend to have better health awareness and are less likely to have psoriasis

15

triggered by infection and poor lifestyle or medication habits. As we all know, natural sunlight contains a wide variety of

bands, which makes it simple to cause negative skin effects, in contrast to NB-UVB and Targeted UVB with specific

spectrum and limited doses in the clinic.

Additionally, although a sizable portion of psoriasis sufferers respond well to phototherapy (mainly in ultraviolet

radiation), excessive ultraviolet exposure will lead to an increase in side effects such as erythema, blistering and even

deterioration of psoriasis. Actually, it was reported that about 5.5% of all cases of psoriasis will aggravate or develop

new lesions after being exposed to sunshine due to genetics, gender (female), and abnormal UV response, and some even

experience symptoms after prolonged sunbathing[26,27], which are all called photosensitive psoriasis(PP) .Therefore, it's

necessary for PP to take some daily sun-protective measures, and long-term exposure to strong sunlight without any

protection is also not recommended for psoriasis patients who are effective in phototherapy. Meanwhile, the association

still remained after the adjustment of gender, race and ethnicity, and sun sensitivity in our study, which shows us that it's

important to pay more attention to the protective effects of moderate sun protection on general population as well as the

potential predisposing effect of sunlight on psoriasis, the underlying mechanism of which is still waiting to be

discovered.

In past few years, the pathogenesis of psoriasis is unveiled gradually. The persistence of skin inflammation due to

cutaneous immune disorder is a hallmark of psoriasis. Dendritic cells (DCs), macrophages, different T cell sets and other

cell types via various cytokines such as LL-37, TNF-α and interleukins play a major role in the initiation and

maintenance phases[28], causing higher level for IL-17, IL-23 and TNF-α, lower level for IL-4 and IL-10, and other

dysregulation of cytokine secretion[29]. And in many studies, it has been found that sunlight or UV radiation can reduce

DCs[30], CD4+ and CD8+, and modulate immune homeostasis and cytokine levels in psoriasis[7]. In our study, there is no

difference in the prevalence of psoriasis between those with rare sun protection and those with frequent sun protection on

the whole, which probably because excessive sun protection frequency prevents the beneficial effects of ultraviolet rays

16

in sunlight.

The results of subgroup analyses indicated the opposing effects of different sun protection usage frequencies on

psoriasis. Among people aged 20-39, female, non-Hispanic whites, and smokers, moderate sun protection was linked to

lower risk of psoriasis. And the frequent was linked to higher risk among non-Hispanic whites, and among smokers. It is

unclear why the association was stronger in the younger adults and female. We speculate that the variability may be due

to the greater attention and requirements for sun protection factor (SPF) of sun protection products for young women.

Unfortunately, the NHANES database did not record details on sunscreen such as SPF and usage per time. As for race, a

previous research discovered that sun-protective behaviors may significantly reduce the level of 25(OH)D in whites

compared to the black and Hispanics[18]. Currently, notable associations between low vitamin D status and psoriasis have

been systematically found, and oral Vitamin D supplementation is deemed to be an effective treatment of psoriasis[31].So,

the decrease in vitamin D caused by frequent sun protection may exacerbate the adverse skin effects brought on by

insufficient UV exposure, which is speculated to be more obvious among white people.

Regarding smoking status, frequent sun protection actually raises the likelihood of getting psoriasis in smokers,

even if sun protection is beneficial for those who don't smoke. It is widely accepted that smoking can increase the risk of

developing psoriasis[32,33] through several mechanisms[34], including oxidation, inflammation and genes. Therefore, when

combined with absence of UV immunosuppressive and anti-inflammatory properties due to excessive application of sun

proof, the difference in the risk of developing psoriasis may become more noticeable.

We also found that adults in the United States have insufficient awareness of sun protection in 2009-2014, with over

30% of people experiencing low or no sun protection. Especially when it comes to wearing long sleeves, less than 30%

of participants included opt to wear one while being outside to the sun for an hour. Although this phenomenon has been

proved to be improving from 2010 to 2020[35], pent-up demand for travel or holiday is already delivering rapid growth in

US after the lockdown for COVID-19 epidemic was totally removed, which exerts a brand new challenge for American

17

people's consciousness of sun protection. We hope that our findings can call attention to the need for people to take

appropriate sun protection measures, not only to avoid skin cancer, but also to prevent skin lesions that may be caused by

excessive ultraviolet radiation such as psoriasis. Definitely, it is worthwhile to think about the possible adverse effects of

frequent sun protection for whites and smokers.

This study has several strengths that deserve mentioning. The principal strength of this study is that this is the first

attempt to explore the relationship between sun-protective behaviors and psoriasis, which can provide advice on sun-

protective behaviors for American people. Furthermore, NHNAES database has large sample size, and the data from it is

nationally representative and collected under strict control so that the results are generalizable to the adult population in

the US. There were still some limitations that need to be acknowledged. Firstly, as with the feature of any cross-sectional

study, only association but no causal link could be determined and we could not determine the temporal association

between sun-protective behaviors and psoriasis. Therefore, additional results from well-designed cohort studies are

required. Secondly, due to the lack of data on the different geographical locations and the timing of data collection of

participants, sunlight intensity was ultimately not included in this study, making us not determining the association

between the frequency of sun protection and prevalence of psoriasis in people under different UV exposure conditions.

Thirdly, data on psoriasis diagnosis and sun-protective behaviors were all obtained in the form of questionnaire surveys,

which were prone to recall bias and reporting bias.

5.Conclusions

The findings of this cross-sectional study suggested that moderate sun protection was associated with decreased psoriasis

in the adult population of the US, particularly in white females aged 20 to 39 years and in nonsmokers, while frequent

sun protection was linked to increased psoriasis in whites and smokers. On the whole, for US adults from various

backgrounds and lifestyles, the findings may shed light on their awareness of and use of sun protection.

18

Patient consent: None.

Patient and public involvement: Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Ethics approval: All data in this study was abstained from NHANES. All participants in NHANES presented the informed consent for data collection and publication. And NHANES protocols were approved by the National Center for Health Statistics Research Ethics Review Board.

Data availability statement: All data in this study are available in a public and open access repository, NHANES. NHANES website: https://www.cdc.gov/nchs/nhanes/index.htm.

19

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

References

1. Langley RGB, Krueger GG, Griffiths CEM. Psoriasis: epidemiology, clinical features, and

   quality of life. *Ann Rheum Dis.*64 Suppl 2(Suppl 2):ii18-23; discussion ii24-15.

2. Icen M, Crowson CS, McEvoy MT, Dann FJ, Gabriel SE, Maradit Kremers H. Trends in

   incidence of adult-onset psoriasis over three decades: a population-based study. *J*

   *Am Acad Dermatol.*60(3):394-401.

3. Armstrong AW, Mehta MD, Schupp CW, Gondo GC, Bell SJ, Griffiths CEM. Psoriasis

   prevalence in adults in the United States. *JAMA Dermatol.*157(8):940-946.

4. Menter A, Gelfand JM, Connor C, et al. Joint American Academy of Dermatology-National

   Psoriasis Foundation guidelines of care for the management of psoriasis with

   systemic nonbiologic therapies. *J Am Acad Dermatol.*82(6):1445-1486.

5. Morita A. Current developments in phototherapy for psoriasis. *J Dermatol.*45(3):287-292.

6. Weatherhead SC, Farr PM, Jamieson D, et al. Keratinocyte apoptosis in epidermal

   remodeling and clearance of psoriasis induced by UV radiation. *J Invest*

   *Dermatol.*131(9):1916-1926.

7. Søyland E, Heier I, Rodríguez-Gallego C, et al. Sun exposure induces rapid immunological

   changes in skin and peripheral blood in patients with psoriasis. *Br J*

   *Dermatol.*164(2):344-355.

8. Siiskonen H, Smorodchenko A, Krause K, Maurer M. Ultraviolet radiation and skin mast

   cells: Effects, mechanisms and relevance for skin diseases. *Exp Dermatol.*27(1):3-8.

20

9. Vacharanukrauh P, Meephansan J, Tangtanatakul P, et al. High-throughput RNA
sequencing reveals the effect of NB-UVB phototherapy on major inflammatory
molecules of lesional psoriasis. *Psoriasis (Auckl).*11:133-149.

10. Hart PH, Norval M. More than effects in skin: ultraviolet radiation-induced changes in
immune cells in human blood. *Front Immunol.*12:694086.

11. Osmancevic A, Landin-Wilhelmsen K, Larkö O, Krogstad AL. Vitamin D status in psoriasis
patients during different treatments with phototherapy. *J Photochem Photobiol
B.*101(2):117-123.

12. Franken SM, Witte B, Pavel S, Rustemeyer T. Psoriasis and daily low-emission
phototherapy: effects on disease and vitamin D level. *Photodermatol Photoimmunol
Photomed.*31(2):83-89.

13. Charoenngam N, Holick MF. Immunologic effects of vitamin D on human health and
disease. 2020;12(7):2097.

14. Harvell JD, Selig DJ. Seasonal variations in dermatologic and dermatopathologic
diagnoses: a retrospective 15-year analysis of dermatopathologic data. *International
Journal of Dermatology.* 2016;55(10):1115-1118.

15. Ammar-Khodja A, Benkaidali I, Bouadjar B, et al. EPIMAG: international cross-sectional
epidemiological psoriasis study in the Maghreb. *Dermatology.* 2015;231(2):134-144.

16. Passeron T, Bouillon R, Callender V, et al. Sunscreen photoprotection and vitamin D
status. *Br J Dermatol.*181(5):916-931.

21

17. National Center for Health Statistics, Centers for Disease Control and Prevention,

National Health and Nutrition Examination Survey, 2009-2014. Available:

https://www.cdc.gov/nchs/nhanes/index.htm.

18. Linos E, Keiser E, Kanzler M, et al. Sun protective behaviors and vitamin D levels in the

US population: NHANES 2003-2006. *Cancer Causes Control.*23(1):133-140.

19. National Health and Nutrition Examination Survey: Analytic Guidelines, 1999-2010.

National Health and Nutrition Examination Survey. Available:

https://wwwn.cdc.gov/nchs/data/nhanes/analyticguidelines/99-10-analytic-

guidelines.pdf.

20. National Health and Nutrition Examination Survey: Analytic Guidelines, 2011-2016.

National Health and Nutrition Examination Survey. Available:

https://wwwn.cdc.gov/nchs/data/nhanes/analyticguidelines/11-16-analytic-

guidelines.pdf.

21. Shams K, Kurowska-Stolarska M, Schütte F, Burden AD, McKimmie CS, Graham GJ.

MicroRNA-146 and cell trauma down-regulate expression of the psoriasis-associated

atypical chemokine receptor ACKR2. *J Biol Chem.*293(8):3003-3012.

22. Madden SK, Flanagan KL, Jones G. How lifestyle factors and their associated

pathogenetic mechanisms impact psoriasis. *Clin Nutr.*39(4):1026-1040.

23. Garritsen FM, Kraag DE, de Graaf M. Guttate psoriasis triggered by perianal

streptococcal infection. *Clinical and Experimental Dermatology.* 2017;42(5):536-538.

24. Fry L, Baker BS. Triggering psoriasis: the role of infections and medications. *Clinics in

Dermatology.* 2007;25(6):606-615.

22

25. Wu S, Han J, Li W-Q, Qureshi AA. Hypertension, antihypertensive medication use, and risk of psoriasis. *JAMA Dermatol.* 2014;150(9):957-963.

26. Ros A-M, Eklund G, D O. Photosensitive psoriasis: an epidemiologic study. *J Am Acad Dermatol.* 1987;17(5, Part 1):752-758.

27. Rutter KJ, Watson REB, Cotterell LF, Brenn T, Griffiths CEM, Rhodes LE. Severely photosensitive psoriasis: a phenotypically defined patient subset. *J Invest Dermatol.*129(12):2861-2867.

28. Rendon A, Schäkel K. Psoriasis pathogenesis and treatment. *Int J Mol Sci.*20(6):1475.

29. Li X, Xiao Q-q, Li F-l, et al. Immune signatures in patients with psoriasis vulgaris of blood-heat syndrome: a systematic review and meta-analysis. *Evidence-Based Complementary and Alternative Medicine.* 2016;2016:9503652.

30. Heier I, Søyland E, Krogstad AL, Rodríguez-Gallego C, Nenseter MS, Jahnsen FL. Sun exposure rapidly reduces plasmacytoid dendritic cells and inflammatory dermal dendritic cells in psoriatic skin. *Br J Dermatol.*165(4):792-801.

31. Barrea L, Savanelli MC, Di Somma C, et al. Vitamin D and its role in psoriasis: an overview of the dermatologist and nutritionist. *Rev Endocr Metab Disord.*18(2):195-205.

32. Williams HC. Smoking and psoriasis. *BMJ (Clinical research ed).* 1994;308(6926):428.

33. Wei J, Zhu J, Xu H, et al. Alcohol consumption and smoking in relation to psoriasis: a Mendelian randomization study. *British Journal of Dermatology.* 2022;187(5):684-691.

23

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

34. Armstrong AW, Armstrong EJ, Fuller EN, Sockolov ME, Voyles SV. Smoking and

pathogenesis of psoriasis: a review of oxidative, inflammatory and genetic

mechanisms. *British Journal of Dermatology.* 2011;165(6):1162-1168.

35. McKenzie C, Nahm WJ, Kearney CA, Zampella JG. Sun-protective behaviors and

sunburn among US adults. *Archives of Dermatological Research.* 2023.
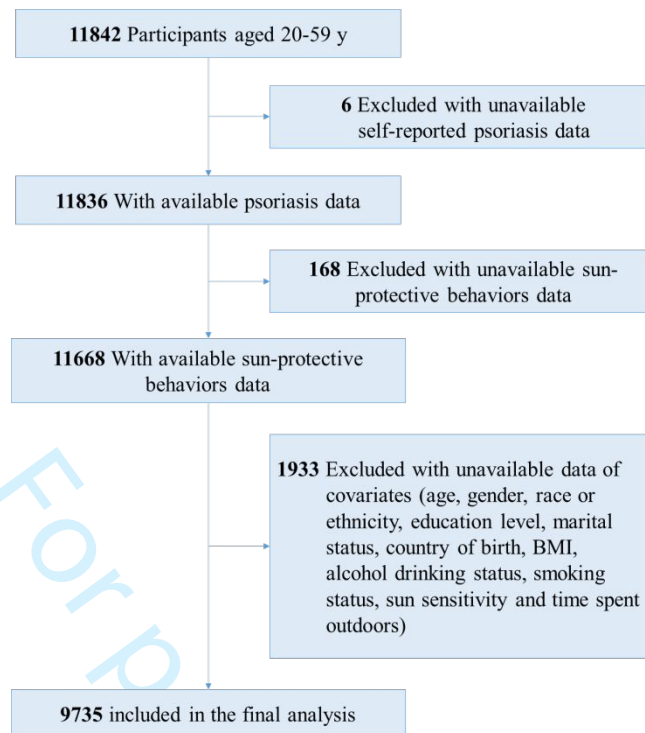
24

Figure 1. Flow diagram of the screening process for the study participants' selection. Sun-protective behaviors include staying in the shade, wearing long sleeves, and using sunscreen. BMI, body mass index.

Table S1. Characteristics of included and excluded participants

	Excluded	Included	*P* value
Number of participants, n(%)	2107 (17.8)	n=9735 (82.2)	
Age, Mean ± SD, y	39.3 ± 11.0	39.1 ± 11.5	0.33
Gender, n(%)			<0.001
Female	1227 (58.2)	4882 (50.1)	
Male	880 (41.8)	4853 (49.9)	
Race and ethnicity, n(%)			<0.001
Non-Hispanic White	676 (32.1)	4030 (41.4)	
Non-Hispanic Black	478 (22.7)	2048 (21.0)	
Hispanic	233 (11.1)	938 (9.6)	
Other[a]	720 (34.2)	2719 (27.9)	
Education level, n(%)			<0.001
Less than 9th grade	230 (10.9)	645 (6.6)	
9-11th grade	343 (16.3)	1363 (14.0)	
High school grad/GED or equivalent	467 (22.2)	2137 (22.0)	
Some college or AA degree	582 (27.6)	3115 (32.0)	
College graduate or above	472 (22.4)	2475 (25.4)	
Missing	13 (0.6)	0 (0)	
Country of birth, n(%)			<0.001
Not US born	844 (40.1)	2793 (28.7)	
US born	1257 (59.7)	6942 (71.3)	
Missing	6 (0.3)	0 (0)	
Marital status, n(%)			<0.001
Never married	533 (25.3)	2563 (26.3)	
Married or living with a partner	1233 (58.5)	5719 (58.7)	
Widowed or divorced or separated	334 (15.9)	1453 (14.9)	
Missing	7 (0.3)	0 (0)	
BMI (kg/m^2), n(%)			<0.001
<25	552 (26.2)	3043 (31.3)	
25-30	500 (23.7)	3071 (31.5)	
≥30	605 (28.7)	3621 (37.2)	
Missing	450 (21.4)	0 (0)	
Alcohol drinking, n(%)			<0.001
No	112 (5.3)	2279 (23.4)	
Yes	227 (10.8)	7456 (76.6)	
Missing	1768 (83.9)	0 (0)	
Smoking status, n(%)			<0.001
Nonsmokers	1280 (60.7)	5670 (58.2)	
Former smokers	298 (14.1)	1647 (16.9)	
Current smokers	523 (24.8)	2418 (24.8)	
Missing	6 (0.3)	0 (0)	
Sun sensitivity[b], n(%)			<0.001
None	146 (6.9)	956 (9.8)	

Mild	858 (40.7)	4667 (47.9)	
Severe	957 (45.4)	4112 (42.2)	
Missing	146 (6.9)	0 (0)	
Time spent outdoors[c], n(%)			<0.001
<60 min/d	950 (45.1)	3891 (40.0)	
≥60 min/d	1114 (52.9)	5844 (60.0)	
Missing	43 (2.0)	0 (0)	

[a] Included Mexican American and multiracial participants.

[b] Sun sensitivity was divided into three levels according to skin reaction to sun without sunscreen or protective clothing for half an hour: none (defined as "nothing would happen"), mild (defined as "mildly burn with some tanning" and "turn darker without a sunburn"), and severe (defined as "severe sunburn with blisters" and "severe sunburn for a few days with peeling").

[c] Time spent outdoors was recalculated based on minutes spent outdoors from 9: 00 am to 5: 00 pm on working days and non-working days, considering that there are 5 working days and 2 non-working days in a week.

BMJ Open

Association between sun-protective behaviors and psoriasis in US adults in the 2009-2014 NAHNES: a cross-sectional study

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2023-078050.R1
Article Type:	Original research
Date Submitted by the Author:	02-Dec-2023
Complete List of Authors:	Xuan, Yawen; Shuguang Hospital Affiliated to Shanghai University of TCM, Department of Dermatology FENG, Yibin ; The University of Hong Kong, School of Chinese Medicine Rong, Fen; Shanghai University of Traditional Chinese Medicine He, Xufeng; Shuguang Hospital Affiliated to Shanghai University of TCM, Department of Dermatology Wang, Wuqing; Shuguang Hospital Affiliated to Shanghai University of TCM, Department of Dermatology Li, Wen; Shuguang Hospital Affiliated to Shanghai University of TCM, Department of Dermatology
Primary Subject Heading:	Dermatology
Secondary Subject Heading:	Epidemiology
Keywords:	Psoriasis < DERMATOLOGY, EPIDEMIOLOGY, Behavior, Adult dermatology < DERMATOLOGY, Photodermatology < DERMATOLOGY

SCHOLARONE™
Manuscripts

BMJ

I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd ("BMJ") its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our licence.

The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge ("APC") for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which Creative Commons licence will apply to this Work are set out in our licence referred to above.

Other than as permitted in any relevant BMJ Author's Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.

Association between sun-protective behaviors and psoriasis in US adults in the 2009-2014 NAHNES: a cross-sectional study

Yawen Xuan[1], Yibin Feng[2], Fen Rong[3], Xufeng He[1], Wuqing Wang[1#], Wen Li[1#]

[1]Department of Dermatology, Shuguang Hospital Affiliated to Shanghai University of TCM, Shanghai, China.

[2]School of Chinese Medicine, Li Ka Shing Faculty of Medicine, The University of Hong Kong, 6 Sassoon Road, Pokfulam, Hong Kong.

[3]School of Public Health, Shanghai University of Traditional Chinese Medicine, Shanghai, China.

 # Wuqing Wang and Wen Li are both corresponding authors of this paper.

1. Yawen Xuan

·Title: Bachelor

·Affiliation: School of Public Health, Shanghai University of Traditional Chinese Medicine, Shanghai, China.

·E-mail: yawenx0928@163.com

2. Yibin Feng,

·Title: PhD

·Affiliation: School of Chinese Medicine, Li Ka Shing Faculty of Medicine, The University of Hong Kong, 6 Sassoon Road, Pokfulam, Hong Kong.

·E-mail: yfeng@hku.hk

3. Fen Rong

·Title: PhD

1

·Affiliation: School of Public Health, Shanghai University of Traditional Chinese Medicine, Shanghai

201203, China.

·E-mail: rf97328@163.com

4. Xufeng He

·Title: MD

·Affiliation: Department of Dermatology, Shuguang Hospital Affiliated to Shanghai University of

TCM, Shanghai, China.

·E-mail: yake2004@163.com

Corresponding authors:

Postal address: Wuqing Wang and Wen Li, Department of Dermatology, Shuguang Hospital Affiliated

to Shanghai University of Traditional Chinese Medicine, Shanghai 201203, China.

Wuqing Wang: E-mail: wuqingw2006@sina.com

Wen Li: E-mail: liwen@shutcm.edu.cn

2

Abstract

Objective: To evaluate the association between sun-protective behaviors and psoriasis in a nationally representative sample of US adults.

Design: Cross-sectional study.

Setting: The National Health and Nutrition Examination Survey 2009-2014.

Participants: A total of 9735 participants aged 20-59 years with available data on psoriasis, sun-protective behaviors, and covariates were included in this study.

Primary and secondary outcome measures: The information on sun-protective behaviors (staying in the shade, wearing long sleeves, and using sunscreen) and psoriasis was obtained from questionnaires in the NHANES database. Logistic regression models and subgroup analysis were employed to investigate the association between sun-protective behaviors and psoriasis.

Results: After adjusting for covariates in multivariate model 4, moderate wearing of long sleeves was associated with psoriasis (odds ratio [OR], 0.55; 95% CI, 0.33-0.90), but there was no significant relationship between overall sun protection and psoriasis. In subgroup analyses, moderate wearing of long sleeves was associated with a lower prevalence of psoriasis among those aged 20 to 39 years (OR, 0.42; 95% CI, 0.18-0.98), among non-Hispanic Whites (OR, 0.52; 95% CI, 0.28-0.97), and among nonsmokers (OR, 0.49; 95% CI, 0.25-0.95), as it was among women in overall sun protection (OR, 0.58; 95%CI, 0.35-0.97). However, among non-Hispanic whites (shade: OR, 1.69; 95%CI, 1.00-2.84) and former/current smokers (overall: OR, 3.28; 95%CI, 1.41-7.63), frequent sun protection was positively associated with psoriasis.

Conclusions: Moderate sun-protective behaviors among US adults may be associated with a decreased risk of psoriasis. However among non-Hispanic whites and former/current smokers, frequent

3

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

sun protection was associated with an increased risk of psoriasis. For individuals with different

characteristics, the findings may be taken into consideration to guide daily sun protection practice.

4

Article Summary

Strengths and limitations of this study

- The data in the NHNAES database is nationally representative and collected under strict control.

- In this study subgroup analysis was employed in addition to logistic regression to explore the

  relationships between sun-protective behaviors and psoriasis in specific subgroups.

- This study adjusted for a variety of confounding variables and performed subgroup analysis.

- As with the feature of any cross-sectional study, only association but no causal link could be

  determined.

- Self-reported psoriasis and sun-protective behaviors may induce recall bias and reporting bias.

5

1.Introduction:

Psoriasis is a common chronic inflammatory skin disease that will cause a reduction in quality of life, sleep impairment, psychological problems and so on[1]. The prevalence of it is expected to increase[2], with the current prevalence of about 3% in US adults, affecting over 7.5 million US adult population[3].

Various treatment options are available for psoriasis, including pharmacotherapy, psychotherapy and rapidly developing biologic therapies. Phototherapy (broadband UV-B, narrowband UV-B and heliotherapy) is an effective and safe treatment recommended by The Joint American Academy of Dermatology and National Psoriasis Foundation guidelines[4]. It is commonly used for widespread psoriasis due to its efficacy and safety. Many researches have shown that Ultraviolet B(UVB) contributes to faster lesion clearance, fewer excessive erythema episodes and longer remission periods in psoriasis[5] by inducing apoptosis in keratinocytes[6], CD4+ T cells and CD8+ T cells[7], inhibiting mast cell degranulation and histamine release[8], immunosuppression and changing the level of cytokines such as interleukin [IL]-10, IL-17A[9 10].Moreover, there are several pieces of evidence to support the claim that UV-B therapy or heliotherapy also can improve vitamin D levels and lessen the severity of psoriasis.[11 12]And association between low levels of serum 25-hydroxyvitamin D(25(OH)D) and increased risk of developing psoriasis has been observed[13]. In addition, as we all know, there is a strong tendency for psoriasis to be more frequent in winter but it is the opposite in summer[14 15], which suggests that ultraviolet radiation may be the reason for this phenomenon.

In the US, some health organizations and clinicians advise using sunscreen and other sun protection measures to lower the chance of developing melanoma and other types of skin cancer as well as to prevent premature aging of the skin, which naturally initiated doubts about whether sun protection will hinder the cutaneous synthesis of vitamin D, reduce the beneficial effects of ultraviolet radiation on the skin, and thus be detrimental to cardiovascular, metabolism, bone and skeletal health, skin health and so on.[16 17] Thyssen et al. have proposed that reduced environmental UV exposure may have a potential role of as a driver of the current epidemic of atopic dermatitis.[18] As for psoriasis, the

6

frequency of psoriasis varies significantly between geographic locations.[19] Many researchers discovered that higher

latitude generally indicates higher prevalence rates.[20 21] Both genetic and environmental factors probably contribute to

the correlation, but variation in UV exposure must also be touched on. Therefore, given that ultraviolet radiation has the

function of treating psoriasis and differences in latitude, it is questionable and worth exploring whether sun-protective

behaviors may cause or aggravate psoriasis. Despite having found that using sunscreen for both daily and recreational

photo-protection has no impact on the synthesis of vitamin D[22], there is scarce data on whether sunscreen use and other

sun-protective behaviors affect the prevalence of psoriasis.

To address this research gap, in this cross-sectional study, we included and analyzed data from the 2009 to 2014

cycles of the National Health and Nutrition Examination Survey (NHANES) to explore the association between

multimodal sun-protective behaviors and the prevalence of psoriasis among US adults.

2. Methods:

2.1 Data Sources

We used National Health and Nutrition Examination Survey (NHANES) data in 2009-2014 to investigate the association

between multimodal sun-protective behaviors and the prevalence of psoriasis among US adults.[23] The NHANES is a

nationally representative survey that captures statistics of the US non-institutionalized civilian population on a biennial

basis based on complex survey design and population-specific sample weights in order to assess their health or

nutritional status.

2.2 Study Design and Population

This was a population-based cross-sectional study. Our analyses were based on data collected from participants during

three 2-year NHANES cycles (2009-2010, 2011-2012 and 2013-2014).

Of 11842 participants aged 20-59 years, 6 participants were excluded due to unavailable self-reported psoriasis data

7

and 168 participants were excluded due to unavailable information on three kinds of sun-protective behaviors.

Additionally, 1933 participants with missing data on covariates, including age, gender, race and ethnicity, education

level, marital status, country of birth, body measure index(BMI), alcohol drinking status, smoking status, sun sensitivity

and time spent outdoors were excluded, making 9735 individuals included in the final analysis (**figure 1**).

To our knowledge, all participants provided informed consent for data collection and for the data to be publicly

disseminated in a de-identified format.

2.3 Psoriasis

The information was obtained from the medical conditions section of the questionnaire data in NHANES. The

participants aged 20 years and older were asked if they had ever been told by a doctor or other health care professional

that they had psoriasis. If the answer is "yes", he or she is considered to have psoriasis.

2.4 Sun-Protective Behaviors, Sun Sensitivity and Time Spent Outdoors

We assessed three different sun-protective behaviors from the NHANES dermatology questionnaire section (DEQ), for

which the target group was participants aged 20-59 years. The question asked for sun protective behavior was: "When

you go outside on a very sunny day, for more than one hour, how often do you (1) Stay in the shade, (2) Wear a long-

sleeved shirt, (3) Use sunscreen?" The valid answer can be "always," "most of the time," "sometimes," "rarely," "never"

and "don't go out in the sun." We reclassified these different answers into 3 categories: frequent (always or most of the

time), moderate (sometimes), or rare (never, rarely or don't go out in the sun). Furthermore, overall sun protection was

classified into three levels according to a total score for three sun-protective behaviors. The total score for sun protection

ranging from 3 to 9 was further divided down into rare (3-4), moderate (5-7), and frequent (8-9) categories[24] after

every behavior was scored 1, 2 or 3 depending on their frequency of use(rare, moderate and frequent).

Sun sensitivity was defined based on the question about skin reaction to the sun without sunscreen or protective

8

clothing for half an hour after several months of not being exposed to the sun. According to their responses, survey

participants were then divided into three groups: no sun sensitivity ("nothing would happen"), mild sun sensitivity

("mildly burn with some tanning" or "turn darker without a sunburn") and severe sun sensitivity ("severe sunburn with

blisters" or "severe sunburn for a few days with peeling").

In NHANES 2009-2014 cycles, participants were questioned how many minutes (min) they spent outdoors over the

previous 30 days between 9 a.m. and 5 p.m. on workdays and non-workdays. Considering a week with five working days

and two off, we calculated the average time(minutes/day) spent outdoors using the following formula: (minutes outdoors

9 a.m.-5 p.m. on working day×5+minutes outdoors 9 a.m.-5 p.m. on nonworking day×2)/7. If the response is "Does not

work or go to school" for the working day or "At work or at school 9 to 5 seven days a week" for the nonworking day,

the counterpart will be regarded as the final average time.

2.5 Other covariates

In addition to sun sensitivity and time spent outdoors, the other covariates included age, gender, race and ethnicity,

education level, marital status, country of birth, BMI, alcohol drinking status, smoking status. Race or ethnicity was

derived from responses to the survey questions on race and Hispanic origin in the demographics file. Respondents were

reclassified into four groups: non-Hispanic White, non-Hispanic Black, Hispanic and other [Mexican American or other

race (including multi-racial)]. Marital status was categorized into the following 3 groups: never married, married or

living with a partner and widowed, divorced or separated. Country of birth was encoded as a binary variable (0, born in

another country,1, born in the USA). The survey question "In any 1 year, have you had at least 12 drinks of any type of

alcoholic beverage?" was used to establish participants' alcohol drinking status. Participants who responded "yes" were

considered to be alcohol drinkers. Smoking status was divided into 3 categories: nonsmoker (smoked <100 cigarettes in a

lifetime), former smoker (smoked ≥100 cigarettes in a lifetime but has quit), and current smoker (smoked ≥100 cigarettes

in a lifetime and still on smoking), according to data on cigarette use in the questionnaire.

9

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

2.6 Statistical Analysis

All analyses were conducted in accordance with the NHANES analytic guidelines[25 26], taking into consideration the

complex sample design and appropriate sampling weights. In this study, we extracted three cycles of NHANES, thus the

sampling weight was calculated using the following equation: full sample 6-year mobile examination center (MEC) exam

weight=full sample 2-year MEC exam weight/3. Quantitative data were reported as means, standard deviations and 95%

CIs, whilst qualitative data were expressed as numbers, weighted percentage frequencies and 95% CIs. The t-test for

comparing quantitative data and χ^2 test for comparing qualitative data were used for comparing baseline characteristics

by the presence of psoriasis. Logistic regression analysis was performed to calculate weighted ORs and 95%CIs to

explore the association of sun protection and psoriasis after adjustment for covariates. There were four models created in

multivariate analysis to reduce the impact of bothersome factors. Model 1 was the crude model with no covariates

adjusted. Model 2 was adjusted for sociodemographic variables, including age, gender, race or ethnicity, education level,

marital status and country of birth. Based on model 2, model 3 was adjusted for three more variables, including BMI,

alcohol drinking status and smoking status. Based on model 3, model 4 was adjusted for two more variables closely

related to sun-protective behaviors, which were sun sensitivity and time spent outdoors. Subgroup analysis was

conducted to determine the association in specific subgroups. In all tests, p-values of less than 0.05(2-sided) were

considered to be statistically significant. And all statistical analyses were conducted in Stata (Stata Corp), version 17.

3. RESULTS

3.1 Characteristics of the Population

Baseline characteristics and comparisons of included and excluded participants were shown in **Supplementary Table 1**.

Of 9735 participants who were finally included in our study, 255 (2.8%) had psoriasis, while 9480(97.2%) did not. As

shown in **table 1**, 50.3% of participants were male and the weighted mean age of the participants was 39.6 years (95%

10

CI: 39.3-39.9). Not surprisingly, compared with participants without psoriasis, patients with psoriasis were more likely to

be older, non-Hispanic white, US-born and former smokers, but they did not differ significantly in gender, education

level, marital status, BMI and alcohol drinking status. Additionally, participants with psoriasis had a lower prevalence of

severe sun sensitivity, but no difference existed in the time spent outdoors. In terms of frequently staying in the shade,

wearing long sleeves, using sunscreen and overall sun protection, the percentages were 31.0% (95% CI: 29.8%-32.1%),

9.0% (95% CI: 8.3%-9.7%), and 29.8% (95% CI: 28.6%-31.0%), 6.8%(95% CI: 6.2%-7.5%), respectively. And there

were significantly different distributions in long sleeves (P=0.002), sunscreen use (P=0.04) and overall sun protection

(P<0.001) between the psoriasis group and the non-psoriasis group.

Table 1 Characteristics of participants by psoriasis in 2009-2014 NHNAES

Characteristic	Participants			
	Total (N = 9735)	Without psoriasis (n = 9480)	With psoriasis (n = 255)	*P* value
Age, mean ± SD(95%CI), y	39.6 ± 11.7(39.3-39.9)	39.5 ± 11.7(39.2-39.8)	42.7 ± 11.3(40.9-44.5)	**<0.001**
Gender				
Female	4882(49.7)[48.4-50.9]	4750(49.7)[48.4-50.9]	132(50.0)[42.2-57.8]	0.91
Male	4853(50.3)[49.1-51.6]	4730(50.3)[49.1-51.6]	123(50.0)[42.2-57.8]	
Race and ethnicity				
Non-Hispanic White	4030(64.5)[63.5-65.6]	3883(64.2)[63.1-65.2]	147(77.4)[72.0-82.0]	**<0.001**
Non-Hispanic Black	2048(11.9)[11.3-12.4]	2021(12.0)[11.5-12.6]	27(5.4)[3.6-8.0]	
Hispanic	938(6.2)[5.8-6.6]	915(6.2)[5.8-6.7]	23(5.3)[3.4-8.2]	
Other[a]	2719(17.4)[16.7-18.2]	2661(17.6)[16.8-18.4]	58(11.9)[8.7-16.1]	
Education level				
Less than 9th grade	645(4.0)[3.6-4.4]	631(4.0)[3.7-4.4]	14(2.3)[1.3-4.1]	0.06
9-11th grade	1363(10.9)[10.2-11.6]	1336(11.0)[10.3-11.7]	27(6.7)[4.3-10.5]	
High school grad/GED or equivalent	2137(21.1)[20.1-22.1]	2080(21.1)[20.1-22.1]	57(21.5)[15.8-28.6]	
Some college or AA degree	3115(33.1)[31.9-34.3]	3035(33.1)[31.9-34.3]	80(33.0)[26.0-40.9]	
College graduate or above	2475(31.0)[29.8-32.2]	2398(30.8)[29.6-32.1]	77(36.4)[29.1-44.4]	
Country of birth				
Not US born	2793(18.5)[17.7-19.3]	2745(18.7)[17.9-19.5]	48(9.9)[7.1-13.6]	**<0.001**
US born	6942(81.5)[80.7-82.3]	6735(81.3)[80.5-82.1]	207(90.1)[86.4-92.9]	
Marital status				
Never married	2563(24.1)[23.1-25.2]	2507(24.2)[23.1-25.2]	56(22.9)[17.0-30.1]	0.64
Married or living with partner	5719(62.1)[60.8-63.3]	5571(62.1)[60.9-63.3]	148(61.4)[53.6-68.7]	

11

Widowed or divorced or separated	1453(13.8)[13.0-14.7]	1402(13.8)[12.9-14.7]	51(15.7)[10.9-22]	
BMI (kg/m²)				
<25	3043(31.4)[30.2-32.6]	2977(31.5)[30.4-32.7]	66(26.2)[20.0-33.5]	
25-30	3071(32.8)[31.6-34.0]	2991(32.7)[31.5-34.0]	80(35.4)[28.1-43.4]	0.17
≥30	3621(35.8)[34.6-37.0]	3512(35.7)[34.5-37.0]	109(38.5)[31.3-46.2]	
Alcohol drinkers				
No	2279(18.6)[17.7-19.5]	2226(18.6)[17.7-19.5]	53(17.7)[12.8-23.9]	0.70
Yes	7456(81.4)[80.5-82.3]	7254(81.4)[80.5-82.3]	202(82.3)[76.1-87.2]	
Smoking status				
Nonsmokers	5670(57.8)[56.6-59.1]	5547(58.1)[56.8-59.3]	123(49.2)[41.4-57.0]	
Former smokers	1647(19.2)[18.2-20.3]	1587(18.9)[17.9-20.0]	60(30.1)[23.0-38.2]	**<0.001**
Current smokers	2418(22.9)[21.9-24.0]	2346(23.0)[22.0-24.1]	72(20.8)[15.7-27.0]	
Sun sensitivity[b]				
None	956(12.7)[11.9-13.7]	923(12.7)[11.8-13.6]	33(15.4)[10.3-22.4]	
Mild	4667(52.1)[50.8-53.3]	4524(51.9)[50.6-53.2]	143(58.4)[50.6-65.9]	**0.006**
Severe	4112(35.2)[34.0-36.3]	4033(35.4)[34.3-36.6]	79(26.2)[20.1-33.3]	
Time spent outdoors[e] (min/d)				
<60	3891(38.8)[37.6-40.1]	3790(38.9)[37.7-40.2]	101(35.2)[28.1-42.9]	0.21
≥60	5844(61.2)[59.9-62.4]	5690(61.1)[59.8-62.3]	154(64.8)[57.1-71.9]	
Staying in the shade				
Rare	2546(27.2)[26.0-28.3]	2489(27.2)[26.1-28.4]	57(24.8)[18.6-32.2]	
Moderate	3776(41.9)[40.6-43.1]	3677(42.0)[40.7-43.3]	99(37.9)[30.7-45.7]	0.07
Frequent	3413(31.0)[29.8-32.1]	3314(30.8)[29.6-31.9]	99(37.3)[30.0-45.2]	
Wearing long sleeves				
Rare	6742(70.9)[69.8-72.1]	6557(70.8)[69.6-71.9]	185(76.0)[68.8-81.9]	
Moderate	1941(20.1)[19.1-21.1]	1907(20.3)[19.3-21.4]	34(12.0)[7.9-17.9]	**0.002**
Frequent	1052(9.0)[8.3-9.7]	1016(8.9)[8.2-9.6]	36(12.0)[7.9-17.9]	
Using sunscreen				
Rare	5579(48.5)[47.2-49.7]	5449(48.7)[47.4-50.0]	130(41.8)[34.5-49.5]	
Moderate	1819(21.8)[20.7-22.9]	1763(21.6)[20.5-22.7]	56(27.2)[20.5-35.2]	**0.04**
Frequent	2337(29.8)[28.6-31.0]	2268(29.7)[28.5-31.0]	69(31.0)[24.2-38.8]	
Overall sun protection[d]				
Rare	3249(31.9)[30.8-33.1]	3174(31.9)[30.8-33.1]	75(31.4)[24.5-39.1]	
Moderate	5850(61.3)[60.0-62.5]	5698(61.4)[60.2-62.6]	152(56.1)[48.2-63.7]	**<0.001**
Frequent	636(6.8)[6.2-7.5]	608(6.7)[6.0-7.4]	28(12.5)[7.9-19.3]	

Data are presented as unweighted number (weighted percentage) [95% CI] unless otherwise indicated.

Abbreviations: NHANES, National Health and Nutrition Examination Survey; BMI, body mass index (calculated as weight in kilograms divided by height in meters squared). Boldface indicates statistical significance.

[a] Included Mexican American and multiracial participants.

[b] Sun sensitivity was determined by the answer to the skin reaction to the sun without sunscreen or protective clothing for half an hour: none ("nothing would happen"), mild ("mildly burn with some tanning" or "turn darker without a sunburn"), and severe ("severe sunburn with blisters" or "severe sunburn for a few days with peeling").

12

[c] Time spent outdoors refers to the average minutes spent outdoors from 9: 00 a.m. to 5: 00 p.m. on each day of the week considering that there are 5 working days and 2 non-working days in a week.

[d] Overall sun protection reflects the general condition of sun protection, including staying in the shade, wearing long sleeves and sunscreen.

3.2 Multivariable Regression Analyses

Based on limited information from NHANES and the understanding of related factors for psoriasis[27] and sun-protective behaviors[28], we included some covariates like some sociodemographic variables, smoking status BMI and sun sensitivity in the regression models to account for confounding effects. In **table 2,** the results of one crude regression model (model 1) and three sample-weighted multivariable regression models (model 2-4) to evaluate the association between sun-protective behaviors and psoriasis are presented. In model 1, moderate wearing of long sleeves was associated with a decreased prevalence of psoriasis (OR, 0.55; 95% CI, 0.34-0.89). After adjustment for covariates, the association remained statistically significant (all *P*<0.05. However, overall sun protection had a positive association with psoriasis in the crude model (OR, 1.91; 95%CI, 1.08-3.39), but the relationship disappeared after adjustment. Meanwhile, the other two behaviors were not significantly associated with psoriasis in the unadjusted or adjusted models.

Table 2 Association between sun-protective behaviors and psoriasis in NHANES, 2009-2014

	Presence of psoriasis by sun-protective behaviors			
	Staying in the shade	Wearing long sleeves	Using sunscreen	Overall sun protection
Model	OR(95%CI)	OR(95%CI)	OR(95%CI)	OR(95%CI)
Model 1[a]				
Rare	1[reference]	1[reference]	1[reference]	1[reference]
Moderate	0.99(0.66-1.50)	**0.55(0.34-0.89)**	1.47(0.98-2.20)	0.93(0.65-1.32)
Frequent	1.33(0.88-2.02)	1.26(0.77-2.03)	1.22(0.84-1.76)	**1.91(1.08-3.39)**
Model 2[b]				
Rare	1[reference]	1[reference]	1[reference]	1[reference]
Moderate	0.96(0.63-1.46)	**0.54(0.33-0.88)**	1.22(0.79-1.88)	0.89(0.61-1.29)
Frequent	1.42(0.93-2.18)	1.36(0.82-2.26)	0.96(0.61-1.50)	1.68(0.91-3.10)
Model 3[c]				
Rare	1[reference]	1[reference]	1[reference]	1[reference]
Moderate	0.96(0.63-1.45)	**0.54(0.33-0.88)**	1.27(0.83-1.95)	0.90(0.62-1.31)
Frequent	1.40(0.92-2.15)	1.36(0.82-2.25)	0.98(0.63-1.52)	1.67(0.90-3.09)
Model 4[d]				
Rare	1[reference]	1[reference]	1[reference]	1[reference]

13

Moderate	0.95(0.62-1.45)	**0.55(0.33-0.90)**	1.25(0.82-1.91)	0.90(0.62-1.31)
Frequent	1.42(0.92-2.18)	1.36(0.82-2.26)	0.96(0.62-1.50)	1.67(0.90-3.12)

Abbreviations: NHANES, National Health and Nutrition Examination Survey; OR, odds ratio. Boldface indicates statistical significance.

[a] Crude model.

[b] Adjusted for sociodemographic variables (age, gender, race and ethnicity, educational level, country of birth and marital status).

[c] Adjusted for sociodemographic variables, body mass index(BMI), smoking and alcohol drinking status.

[d] Adjusted for sociodemographic variables, body mass index(BMI), smoking and alcohol drinking status, sun sensitivity, and time spent outdoors.

3.3 Subgroup Analyses

The results of the subgroup analysis, stratified by age, gender, race and smoking status, are presented in **table 3**. Among participants aged 20 to 39 years (OR, 0.42; 95% CI, 0.18-0.98), non-Hispanic whites (OR, 0.52; 95% CI, 0.28-0.97), and nonsmokers (OR, 0.49; 95% CI, 0.25-0.95), moderate wearing of long sleeves was associated with lower prevalence of psoriasis, as it was among female in terms of overall sun protection (OR, 0.58; 95%CI, 0.35-0.97).

However, among former or current smokers, those with frequent stays in the shade (OR, 1.92; 95%CI, 1.03-3.60), long sleeves (OR, 2.84; 95%CI, 1.46-5.53) or overall sun protection (OR, 3.28; 95%CI, 1.41-7.63) had a higher risk of psoriasis. And there were also slightly significant and positive relationships between frequent shade-seeking behavior and psoriasis among non-Hispanic whites (OR,1.69; 95%CI, 1.00-2.84).

Table 3 Association between sun-protective behaviors and psoriasis, stratified by age, gender, race and smoking status

Subgroup	frequency	Staying in the shade OR(95% CI)	P value	Wearing long sleeves OR(95% CI)	P value	Using sunscreen OR(95% CI)	P value	Overall sun protection OR(95% CI)	P value
Overall									
Crude	Rare	1[reference]		1[reference]		1[reference]		1[reference]	
	Moderate	0.99(0.66-1.50)	0.97	0.55(0.34-0.89)	**0.01***	1.47(0.98-2.20)	0.06	0.93(0.65-1.32)	0.69
	Frequent	1.33(0.88-2.02)	0.18	1.26(0.77-2.03)	0.36	1.22(0.84-1.76)	0.30	1.91(1.08-3.39)	**0.03***
Adjusted	Rare	1[reference]		1[reference]		1[reference]		1[reference]	
	Moderate	0.95(0.62-1.45)	0.82	0.55(0.33-0.90)	**0.02***	1.25(0.82-1.91)	0.30	0.90(0.62-1.31)	0.59
	Frequent	1.42(0.92-2.18)	0.11	1.36(0.82-2.26)	0.23	0.96(0.62-1.50)	0.86	1.67(0.90-3.12)	0.11
Age, y									
20-39	Rare	1[reference]		1[reference]		1[reference]		1[reference]	
	Moderate	0.71(0.40-1.25)	0.23	0.42(0.18-0.98)	**0.04***	1.21(0.66-2.19)	0.54	0.91(0.53-1.55)	0.73

14

	Frequent	1.14(0.61-2.13)	0.68	0.86(0.31-2.42)	0.78	1.23(0.66-2.29)	0.52	1.27(0.41-3.93)	0.68
40-59	Rare	1[reference]		1[reference]		1[reference]		1[reference]	
	Moderate	1.24(0.67-2.27)	0.49	0.64(0.34-1.20)	0.16	1.28(0.73-2.27)	0.39	0.92(0.55-1.53)	0.75
	Frequent	1.77(0.96-3.24)	0.07	1.75(0.97-3.16)	0.06	0.84(0.46-1.53)	0.57	1.97(0.92-4.20)	0.08
Gender									
Female	Rare	1[reference]		1[reference]		1[reference]		1[reference]	
	Moderate	0.63(0.35-1.16)	0.14	0.56(0.28-1.12)	0.10	0.88(0.48-1.59)	0.66	0.58(0.35-0.97)	**0.04***
	Frequent	1.33(0.74-2.39)	0.33	1.37(0.62-3.03)	0.43	0.56(0.31-1.02)	0.06	1.23(0.55-2.76)	0.62
Male	Rare	1[reference]		1[reference]		1[reference]		1[reference]	
	Moderate	1.28(0.72-2.29)	0.40	0.53(0.26-1.07)	0.08	1.71(0.95-3.09)	0.08	1.32(0.78-2.23)	0.30
	Frequent	1.40(0.74-2.64)	0.30	1.30(0.68-2.48)	0.42	1.75(0.97-3.15)	0.06	1.95(0.74-5.11)	0.17
Race									
Non-Hispanic White	Rare	1[reference]		1[reference]		1[reference]		1[reference]	
	Moderate	0.93(0.56-1.55)	0.78	0.52(0.28-0.97)	**0.04***	1.28(0.78-2.11)	0.33	0.80(0.50-1.26)	0.33
	Frequent	1.69(1.00-2.84)	**0.049***	1.43(0.71-2.86)	0.32	0.83(0.48-1.43)	0.50	1.73(0.82-3.66)	0.15
other	Rare	1[reference]		1[reference]		1[reference]		1[reference]	
	Moderate	1.14(0.64-2.03)	0.67	0.68(0.37-1.22)	0.20	1.10(0.59-2.06)	0.76	1.39(0.83-2.32)	0.21
	Frequent	0.92(0.52-1.61)	0.77	1.20(0.68-2.12)	0.53	1.94(1.09-3.44)	**0.02***	1.66(0.72-3.82)	0.24
Smoking status									
nonsmokers	Rare	1[reference]		1[reference]		1[reference]		1[reference]	
	Moderate	0.76(0.42-1.35)	0.35	0.49(0.25-0.95)	**0.04***	1.71(0.93-3.14)	0.09	0.74(0.43-1.26)	0.26
	Frequent	1.00(0.55-1.82)	1.00	0.42(0.19-0.93)	**0.03***	1.14(0.58-2.21)	0.71	0.87(0.36-2.09)	0.76
smokers[a]	Rare	1[reference]		1[reference]		1[reference]		1[reference]	
	Moderate	1.20(0.66-2.20)	0.55	0.62(0.31-1.25)	0.17	1.00(0.53-1.89)	0.94	1.12(0.67-1.85)	0.73
	Frequent	2.05(1.11-3.78)	**0.02***	3.02(1.57-5.79)	**<0.001****	0.91(0.49-1.70)	0.62	3.28(1.41-7.63)	**0.009****

Each stratification was adjusted for age, gender, race and ethnicity, country of birth, educational level, marital status, body mass index, smoking and alcohol drinking status, sun sensitivity, and time spent outdoors except the stratification factor itself. All ORs and 95% CIs are based on data weighted to represent the US population.

*P<0.05, **P<0.01

Boldface indicates statistical significance.

[a] smokers refer to current smokers and former smokers.

4. DISCUSSION

To our knowledge, this is the first report to investigate the associations between sun-protective behaviors and psoriasis in a population-based setting, specifically in the US adult population. The findings revealed that moderately wearing long sleeves had a statistically significant association with lower odds of psoriasis even after adjustment for some sociodemographic factors, smoking and alcohol drinking status and so on. But there was no association between another

15

two measures (staying in the shade and using sunscreen) and psoriasis, and neither was the overall sun protection. In subsequent subgroup analysis, the significant relationships between moderate sun protective behaviors and lower risk of psoriasis were observed in younger adults aged 20-39, females, non-Hispanic whites, and smokers. Remarkably, it was also shown that frequent sun protection was associated with an elevated risk of psoriasis among smokers and non-Hispanic whites.

Psoriasis is a chronic and immune-mediated skin disorder attributed to various genetic and environmental factors. As reported in previous studies, physical trauma[29], lifestyle and habits[30], infection, such as streptococcus[31], medication[32 33] and so on are risk factors or triggers of psoriasis. This relationship between sun protection and lower risk of psoriasis might be because sun protection avoids the traumatic effect of excessive ultraviolet rays on the skin, or people with moderate sun-protective behaviors tend to have better health awareness and are less likely to have psoriasis triggered by infection and poor lifestyle or medication habits. As we all know, natural sunlight contains a wide variety of bands, which makes it simple to cause negative skin effects, in contrast to NB-UVB and Targeted UVB with specific spectrum and limited doses in the clinic.

Additionally, although a sizable portion of psoriasis sufferers respond well to phototherapy (mainly in ultraviolet radiation), excessive ultraviolet exposure will lead to an increase in side effects such as erythema, blistering and even deterioration of psoriasis. Actually, it was reported that about 5.5% of all cases of psoriasis will aggravate or develop new lesions after being exposed to sunshine due to genetics, gender (female), and abnormal UV response, and some even experience symptoms after prolonged sunbathing[34 35], which are all called photosensitive psoriasis(PP). Therefore, it's necessary for PP to take some daily sun-protective measures, and long-term exposure to strong sunlight without any protection is also not recommended for psoriasis patients who are effective in phototherapy. Meanwhile, the association remained after the adjustment of gender, race or ethnicity, and sun sensitivity in our study, which shows us that it's important to pay more attention to the protective effects of moderate sun protection on the general population as well as

16

the potential predisposing effect of sunlight on psoriasis, the underlying mechanism of which is still waiting to be

discovered.

In the past few years, the pathogenesis of psoriasis has been unveiled gradually. The persistence of skin

inflammation due to cutaneous immune disorder is a hallmark of psoriasis. Dendritic cells (DCs), macrophages, different

T cell sets and other cell types via various cytokines such as LL-37, TNF-α and interleukins play a major role in the

initiation and maintenance phases[36], causing higher levels for IL-17, IL-23 and TNF-α, lower level for IL-4 and IL-10,

and other dysregulation of cytokine secretion[37]. And in many studies, it has been found that sunlight or UV radiation

can reduce DCs[38], CD4+ and CD8+, and modulate immune homeostasis and cytokine levels in psoriasis[7]. In our

study, there was no difference in the prevalence of psoriasis between those with rare sun protection and those with

frequent sun protection on the whole, which was probably attributed to the fact that excessive sun protection frequency

prevents the beneficial effects of ultraviolet rays in sunlight. This was in combination with the negative effects of

deficient sun protection on the skin, ultimately linking moderate sun protection to a lower risk of psoriasis.

The results of subgroup analyses indicated the opposing effects of different sun protection usage frequencies on

psoriasis. Among people aged 20-39, females, non-Hispanic whites, and smokers, moderate sun protection was linked to

a lower risk of psoriasis. And the frequent was linked to higher risk among non-Hispanic whites, and among smokers. It

is unclear why the association was stronger in the younger adults and females. We speculate that the variability may be

due to the greater attention and requirements for sun protection factor (SPF) of sun protection products for young

women. Unfortunately, the NHANES database did not record details on sunscreen such as SPF and usage per time. As

for race, a previous research discovered that sun-protective behaviors may significantly reduce the level of 25(OH)D in

whites compared to blacks and Hispanics[24]. Currently, notable associations between low vitamin D status and psoriasis

have been systematically found, and oral Vitamin D supplementation is deemed to be an effective treatment of

psoriasis[39]. So, the decrease in vitamin D caused by frequent sun protection may exacerbate the adverse skin effects

17

brought on by insufficient UV exposure, which is speculated to be more obvious among white people.

Regarding smoking status, frequent sun protection probably raises the likelihood of getting psoriasis in smokers, even if sun protection is beneficial for those who don't smoke. It is widely accepted that smoking can increase the risk of developing psoriasis[40 41] through several mechanisms[42], including oxidation, inflammation and genes. Therefore, when combined with the absence of UV immunosuppressive and anti-inflammatory properties due to excessive application of sun proof, the difference in the risk of developing psoriasis may become more noticeable.

We also found that adults in the United States had insufficient awareness of sun protection in 2009-2014, with over 30% of people experiencing low or no sun protection. Especially when it comes to wearing long sleeves, less than 30% of participants opted to wear one while being outside in the sun for an hour. Although this phenomenon has been proven to be improving from 2010 to 2020[43], pent-up demand for travel or holidays is already delivering rapid growth in the US after the lockdown for the COVID-19 epidemic was totally removed, which exerts a brand new challenge for American people's consciousness of sun protection. We hope that our findings can call attention to the need for people to take appropriate sun protection measures, not only to avoid skin cancer but also to prevent skin lesions that may be caused by excessive ultraviolet radiation such as psoriasis. Definitely, it is worthwhile to think about the possible adverse effects of frequent sun protection for whites and smokers.

This study has several strengths that deserve mentioning. The principal strength of this study is that this is the first attempt to explore the relationship between sun-protective behaviors and psoriasis, which can provide advice on sun-protective behaviors for American people. Furthermore, the NHNAES database has a large sample size, and the data from it is nationally representative and collected under strict control so that the results are generalizable to the adult population in the US. There were still some limitations that need to be acknowledged. First and foremost, as with the feature of any cross-sectional study, only association but no causal link could be determined and we could not determine the temporal association between sun-protective behaviors and psoriasis. Characterized as red plaques covered with

18

silvery white scaly skin, psoriasis may evoke the psychological response of the sufferers such as anxiety and shame. [44

45]Thus, it is undeniable that psoriasis sufferers may choose to conceal visible skin lesions through long sleeves or other

means out of shame on appearance, which could not be for sun protection purposes and make the results subject to

reverse causality bias. But it is worth noting that the collection of information on the frequency of long sleeves has clear

sun protection targeting under specific context, which possibly minimize such bias. Therefore, additional results from

well-designed cohort studies are required. Second, due to the lack of data on the different geographical locations and the

timing of data collection of participants, sunlight intensity was ultimately not included in this study, making us not

determine the association between the frequency of sun protection and the prevalence of psoriasis in people under

different UV exposure conditions. Third, data on psoriasis diagnosis and sun-protective behaviors were all obtained in

the form of questionnaire surveys, which were prone to recall bias and reporting bias. Fourth, due to the limited

information from the NHANES database, some covariates, such as stress from work or life and history of Streptococcal

Laryngitis were not taken into account and adjusted in the regression models. Thus future studies ought to collect and

evaluate information on geographic location and sun protection, as well as other important covariates in more detail so as

to better elucidate the potential relationship.

5.Conclusions

The findings of this cross-sectional study suggested that moderate sun protection was associated with decreased psoriasis

in the adult population of the US, particularly in white females aged 20 to 39 years and in nonsmokers, while frequent

sun protection was linked to increased psoriasis in whites and smokers. On the whole, for US adults from various

backgrounds and lifestyles, the findings may shed light on their awareness of and use of sun protection.

19

Author Contributions: YX had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. YX, WL involved in study concept and design. All authors involved in acquisition, analysis or interpretation of data. YX, WW, YF and FR involved in drafting of the manuscript. WW, WL and XH involved in critical revision of the manuscript for important intellectual content. YX and FR involved in statistical analysis. WL obtained funding. YX, WW and WL contributed in administrative, technical, or material support. WW, WL and YF involved in supervision.

Funding: This study was supported by grants 2023LCRC09 from Training Program for High-caliber Talents of Clinical Research at Affiliated Hospitals of SHUTCM, and 22YF1449500 from Sailing Program of Shanghai Municipal Commission of science and technology.

Competing interests: None.

Patient consent: None.

Patient and public involvement: Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Ethics approval: All data in this study was obtained from NHANES. All participants in NHANES presented the informed consent for data collection and publication. And NHANES protocols were approved by the National Center for Health Statistics Research Ethics Review Board.

Data availability statement: All data in this study are available in a public and open access repository, NHANES. NHANES website: https://www.cdc.gov/nchs/nhanes/index.htm.

20

References

[1] Langley RG, Krueger GG, Griffiths CE. Psoriasis: epidemiology, clinical features, and

quality of life. *Ann Rheum Dis* 2005;64 Suppl 2:ii18-23; discussion ii24-5.

[2] Icen M, Crowson CS, McEvoy MT, et al. Trends in incidence of adult-onset psoriasis over

three decades: a population-based study. *J Am Acad Dermatol* 2009;60:394-401.

[3] Armstrong AW, Mehta MD, Schupp CW, et al. Psoriasis Prevalence in Adults in the United

States. *JAMA Dermatol* 2021;157:940-46.

[4] Menter A, Gelfand JM, Connor C, et al. Joint American Academy of Dermatology-National

Psoriasis Foundation guidelines of care for the management of psoriasis with

systemic nonbiologic therapies. *J Am Acad Dermatol* 2020;82:1445-86.

[5] Morita A. Current developments in phototherapy for psoriasis. *J Dermatol* 2018;45:287-92.

[6] Weatherhead SC, Farr PM, Jamieson D, et al. Keratinocyte apoptosis in epidermal

remodeling and clearance of psoriasis induced by UV radiation. *J Invest Dermatol*

2011;131:1916-26.

[7] Søyland E, Heier I, Rodríguez-Gallego C, et al. Sun exposure induces rapid immunological

changes in skin and peripheral blood in patients with psoriasis. *Br J Dermatol*

2011;164:344-55.

[8] Siiskonen H, Smorodchenko A, Krause K, et al. Ultraviolet radiation and skin mast cells:

Effects, mechanisms and relevance for skin diseases. *Exp Dermatol* 2018;27:3-8.

[9] Hart PH, Norval M. More Than Effects in Skin: Ultraviolet Radiation-Induced Changes in

Immune Cells in Human Blood. *Front Immunol* 2021;12:694086.

21

[10] Vacharanukrauh P, Meephansan J, Tangtanatakul P, et al. High-Throughput RNA Sequencing Reveals the Effect of NB-UVB Phototherapy on Major Inflammatory Molecules of Lesional Psoriasis. *Psoriasis (Auckl)* 2021;11:133-49.

[11] Osmancevic A, Landin-Wilhelmsen K, Larkö O, et al. Vitamin D status in psoriasis patients during different treatments with phototherapy. *J Photochem Photobiol B* 2010;101:117-23.

[12] Franken SM, Witte B, Pavel S, et al. Psoriasis and daily low-emission phototherapy: effects on disease and vitamin D level. *Photodermatol Photoimmunol Photomed* 2015;31:83-9.

[13] Charoenngam N, Holick MF. Immunologic effects of vitamin D on human health and disease. 2020;12:2097.

[14] Harvell JD, Selig DJ. Seasonal variations in dermatologic and dermatopathologic diagnoses: a retrospective 15-year analysis of dermatopathologic data. *International Journal of Dermatology* 2016;55:1115-18.

[15] Ammar-Khodja A, Benkaidali I, Bouadjar B, et al. EPIMAG: international cross-sectional epidemiological psoriasis study in the Maghreb. *Dermatology* 2015;231:134-44.

[16] Yang S, Dai F, Wang Z, et al. Association between sun-protective behaviors and hypertension: a cross-sectional study from National Health and Nutrition Examination Survey 2009 to 2014. *BMC Public Health* 2023;23:1862.

[17] Afarideh M, Sartori-Valinotti JC, Tollefson MM. Association of Sun-Protective Behaviors With Bone Mineral Density and Osteoporotic Bone Fractures in US Adults. *JAMA Dermatol* 2021;157:1437-46.

22

[18] Thyssen JP, Zirwas MJ, Elias PM. Potential role of reduced environmental UV exposure as a driver of the current epidemic of atopic dermatitis. *Journal of Allergy and Clinical Immunology* 2015;136:1163-69.

[19] Rosa P, Ireny YKI, Evangelos K, et al. National, regional, and worldwide epidemiology of psoriasis: systematic analysis and modelling study. *BMJ (Clinical research ed)* 2020;369:m1590.

[20] Valerie A, Sandra W, Matthias A, et al. Regional variations and prevalence of psoriasis in Germany from 2010 to 2017: a cross-sectional, spatio-epidemiological study on ambulatory claims data. *BMJ Open* 2021;11:e047806.

[21] Solberg SM. Psoriasis in Norway: A Prescription-based Registry Study of Incidence and Prevalence. *Acta Dermato-Venereologica* 2023;103:adv4591.

[22] Passeron T, Bouillon R, Callender V, et al. Sunscreen photoprotection and vitamin D status. *Br J Dermatol* 2019;181:916-31.

[23] National Health and Nutrition Examination Survey, 2009-2014. National Center for Health Statistics, Centers for Disease Control and Prevention. Available:

https://www.cdc.gov/nchs/nhanes/index.htm

[24] Linos E, Keiser E, Kanzler M, et al. Sun protective behaviors and vitamin D levels in the US population: NHANES 2003-2006. *Cancer Causes Control* 2012;23:133-40.

[25] National Health and Nutrition Examination Survey: Analytic Guidelines, 1999-2010. National Health and Nutrition Examination Survey. Available:

https://wwwn.cdc.gov/nchs/data/nhanes/analyticguidelines/99-10-analytic-guidelines.pdf

23

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

[26] National Health and Nutrition Examination Survey: Analytic Guidelines, 2011-2016.

National Health and Nutrition Examination Survey. Available:

https://wwwn.cdc.gov/nchs/data/nhanes/analyticguidelines/11-16-analytic-

guidelines.pdf

[27] Griffiths CEM, Armstrong AW, Gudjonsson JE, et al. Psoriasis. *The Lancet*

2021;397:1301-15.

[28] Haluza D, Simic S, Höltge J, et al. Gender aspects of recreational sun-protective

behavior: results of a representative, population-based survey among Austrian

residents. *Photodermatol Photoimmunol Photomed* 2016;32:11-21.

[29] Shams K, Kurowska-Stolarska M, Schütte F, et al. MicroRNA-146 and cell trauma down-

regulate expression of the psoriasis-associated atypical chemokine receptor ACKR2.

J Biol Chem 2018;293:3003-12.

[30] Madden SK, Flanagan KL, Jones G. How lifestyle factors and their associated

pathogenetic mechanisms impact psoriasis. *Clin Nutr* 2020;39:1026-40.

[31] Garritsen FM, Kraag DE, de Graaf M. Guttate psoriasis triggered by perianal

streptococcal infection. *Clinical and Experimental Dermatology* 2017;42:536-38.

[32] Fry L, Baker BS. Triggering psoriasis: the role of infections and medications. *Clinics in

Dermatology* 2007;25:606-15.

[33] Wu S, Han J, Li W-Q, et al. Hypertension, antihypertensive medication use, and risk of

psoriasis. *JAMA Dermatol* 2014;150:957-63.

[34] Ros A-M, Eklund G, D O. Photosensitive psoriasis: an epidemiologic study. *J Am Acad

Dermatol* 1987;17:752-58.

24

[35] Rutter KJ, Watson RE, Cotterell LF, et al. Severely photosensitive psoriasis: a phenotypically defined patient subset. *J Invest Dermatol* 2009;129:2861-7.

[36] Rendon A, Schäkel K. Psoriasis Pathogenesis and Treatment. *Int J Mol Sci* 2019;20:1475.

[37] Li X, Xiao QQ, Li FL, et al. Immune Signatures in Patients with Psoriasis Vulgaris of Blood-Heat Syndrome: A Systematic Review and Meta-Analysis. *Evidence-based complementary and alternative medicine : eCAM* 2016;2016:9503652.

[38] Heier I, Søyland E, Krogstad AL, et al. Sun exposure rapidly reduces plasmacytoid dendritic cells and inflammatory dermal dendritic cells in psoriatic skin. *Br J Dermatol* 2011;165:792-801.

[39] Barrea L, Savanelli MC, Di Somma C, et al. Vitamin D and its role in psoriasis: An overview of the dermatologist and nutritionist. *Rev Endocr Metab Disord* 2017;18:195-205.

[40] Williams HC. Smoking and psoriasis. *BMJ (Clinical research ed)* 1994;308:428.

[41] Wei J, Zhu J, Xu H, et al. Alcohol consumption and smoking in relation to psoriasis: a Mendelian randomization study. *British Journal of Dermatology* 2022;187:684-91.

[42] Armstrong AW, Armstrong EJ, Fuller EN, et al. Smoking and pathogenesis of psoriasis: a review of oxidative, inflammatory and genetic mechanisms. *British Journal of Dermatology* 2011;165:1162-68.

[43] McKenzie C, Nahm WJ, Kearney CA, et al. Sun-protective behaviors and sunburn among US adults. *Archives of Dermatological Research* 2023;315:1665-74.

25

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

[44] Adesanya EI, Matthewman J, Schonmann Y, et al. Factors associated with depression, anxiety and severe mental illness among adults with atopic eczema or psoriasis: a systematic review and meta-analysis. *British Journal of Dermatology* 2023;188:460-70.

[45] Jankowiak B, Kowalewska B, Krajewska-Kułak E, et al. Stigmatization and Quality of Life in Patients with Psoriasis. *Dermatology and Therapy* 2020;10:285-96.

26

Figure legends

Figure 1   Flow diagram of the screening process for the study participants' selection. Sun- protective

behaviors include staying in the shade, wearing long sleeves, and using sunscreen. BMI, body mass index.
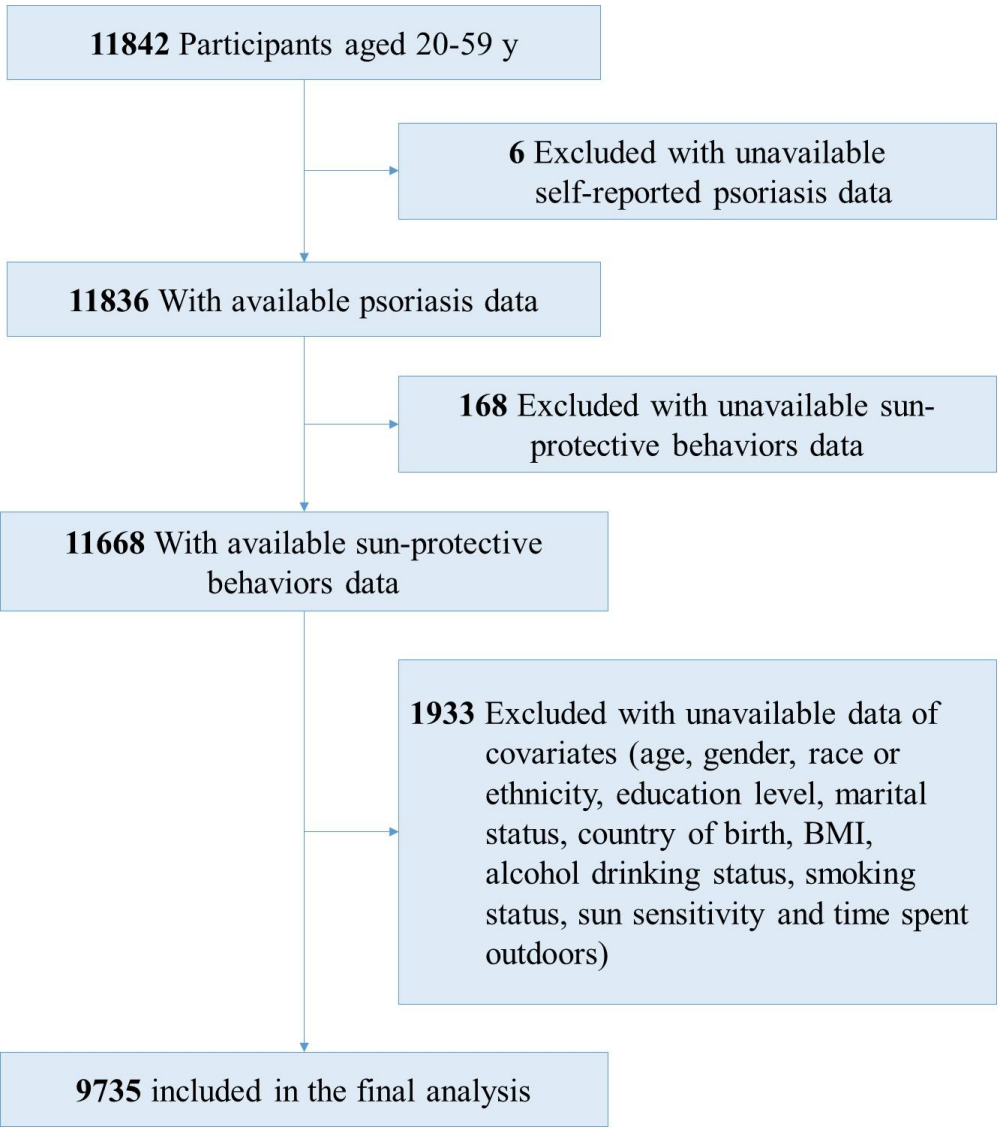
27

Figure 1. Flow diagram of the screening process for the study participants' selection. Sun- protective behaviors include staying in the shade, wearing long sleeves, and using sunscreen. BMI, body mass index.

225x253mm (150 x 150 DPI)

Table S1. Characteristics of included and excluded participants

	Excluded	Included	*P* value
Number of participants, n(%)	2107 (17.8)	n=9735 (82.2)	
Age, Mean ± SD, y	39.3 ± 11.0	39.1 ± 11.5	0.33
Gender, n(%)			<0.001
Female	1227 (58.2)	4882 (50.1)	
Male	880 (41.8)	4853 (49.9)	
Race and ethnicity, n(%)			<0.001
Non-Hispanic White	676 (32.1)	4030 (41.4)	
Non-Hispanic Black	478 (22.7)	2048 (21.0)	
Hispanic	233 (11.1)	938 (9.6)	
Other[a]	720 (34.2)	2719 (27.9)	
Education level, n(%)			<0.001
Less than 9th grade	230 (10.9)	645 (6.6)	
9-11th grade	343 (16.3)	1363 (14.0)	
High school grad/GED or equivalent	467 (22.2)	2137 (22.0)	
Some college or AA degree	582 (27.6)	3115 (32.0)	
College graduate or above	472 (22.4)	2475 (25.4)	
Missing	13 (0.6)	0 (0)	
Country of birth, n(%)			<0.001
Not US born	844 (40.1)	2793 (28.7)	
US born	1257 (59.7)	6942 (71.3)	
Missing	6 (0.3)	0 (0)	
Marital status, n(%)			<0.001
Never married	533 (25.3)	2563 (26.3)	
Married or living with a partner	1233 (58.5)	5719 (58.7)	
Widowed or divorced or separated	334 (15.9)	1453 (14.9)	
Missing	7 (0.3)	0 (0)	
BMI (kg/m^2), n(%)			<0.001
<25	552 (26.2)	3043 (31.3)	
25-30	500 (23.7)	3071 (31.5)	
≥30	605 (28.7)	3621 (37.2)	
Missing	450 (21.4)	0 (0)	
Alcohol drinking, n(%)			<0.001
No	112 (5.3)	2279 (23.4)	
Yes	227 (10.8)	7456 (76.6)	
Missing	1768 (83.9)	0 (0)	
Smoking status, n(%)			<0.001
Nonsmokers	1280 (60.7)	5670 (58.2)	
Former smokers	298 (14.1)	1647 (16.9)	
Current smokers	523 (24.8)	2418 (24.8)	
Missing	6 (0.3)	0 (0)	
Sun sensitivity[b], n(%)			<0.001

None	146 (6.9)	956 (9.8)	
Mild	858 (40.7)	4667 (47.9)	
Severe	957 (45.4)	4112 (42.2)	
Missing	146 (6.9)	0 (0)	
Time spent outdoors[c], n(%)			<0.001
<60 min/d	950 (45.1)	3891 (40.0)	
≥60 min/d	1114 (52.9)	5844 (60.0)	
Missing	43 (2.0)	0 (0)	

[a] Included Mexican American and multiracial participants.

[b] Sun sensitivity was divided into three levels according to skin reaction to sun without sunscreen or protective clothing for half an hour: none (defined as "nothing would happen"), mild (defined as "mildly burn with some tanning" and "turn darker without a sunburn"), and severe (defined as "severe sunburn with blisters" and "severe sunburn for a few days with peeling").

[c] Time spent outdoors was recalculated based on minutes spent outdoors from 9: 00 a.m. to 5: 00 p.m. on working days and non-working days, considering that there are 5 working days and 2 non-working days in a week.

BMJ Open

Association between sun-protective behaviors and psoriasis in US adults in the 2009-2014 NHANES: a cross-sectional study

SCHOLARONE™
Manuscripts

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

BMJ

I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd ("BMJ") its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our licence.

The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge ("APC") for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which Creative Commons licence will apply to this Work are set out in our licence referred to above.

Other than as permitted in any relevant BMJ Author's Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.

Association between sun-protective behaviors and psoriasis in US adults in the 2009-2014 NHANES: a cross-sectional study

Yawen Xuan[1], Yibin Feng[2], Fen Rong[3], Xufeng He[1], Wuqing Wang[1#], Wen Li[1#]

[1]Department of Dermatology, Shuguang Hospital Affiliated to Shanghai University of TCM, Shanghai, China.

[2]School of Chinese Medicine, Li Ka Shing Faculty of Medicine, the University of Hong Kong, 6 Sassoon Road, Pokfulam, Hong Kong.

[3]School of Public Health, Shanghai University of Traditional Chinese Medicine, Shanghai, China.

 # Wuqing Wang and Wen Li are both corresponding authors of this paper.

1. Yawen Xuan

·Title: Bachelor

·Affiliation: School of Public Health, Shanghai University of Traditional Chinese Medicine, Shanghai, China.

·E-mail: yawenx0928@163.com

2. Yibin Feng

·Title: PhD

·Affiliation: School of Chinese Medicine, Li Ka Shing Faculty of Medicine, the University of Hong Kong, 6 Sassoon Road, Pokfulam, Hong Kong.

·E-mail: yfeng@hku.hk

3. Fen Rong

·Title: PhD

1

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

·Affiliation: School of Public Health, Shanghai University of Traditional Chinese Medicine, Shanghai

201203, China.

·E-mail: rf97328@163.com

4. Xufeng He

·Title: MD

·Affiliation: Department of Dermatology, Shuguang Hospital Affiliated to Shanghai University of

TCM, Shanghai, China.

·E-mail: yake2004@163.com

Corresponding authors:

Postal address: Wuqing Wang and Wen Li, Department of Dermatology, Shuguang Hospital Affiliated

to Shanghai University of Traditional Chinese Medicine, Shanghai 201203, China.

Wuqing Wang: E-mail: wuqingw2006@sina.com

Wen Li: E-mail: liwen@shutcm.edu.cn

2

Abstract

Objective: To evaluate the association between sun-protective behaviors and psoriasis in a nationally representative sample of US adults.

Design: Cross-sectional study.

Setting: The National Health and Nutrition Examination Survey (NHANES), 2009-2014.

Participants: A total of 9735 participants aged 20-59 years with available data on psoriasis, sun-protective behaviors, and covariates were included in this study.

Primary and secondary outcome measures: The information on sun-protective behaviors (staying in the shade, wearing long sleeves, and using sunscreen) and psoriasis was obtained from questionnaires in the NHANES database. Logistic regression models and subgroup analyses were employed to investigate the association between sun-protective behaviors and psoriasis.

Results: After adjusting for the sociodemographic, body mass index (BMI), alcohol drinking status, smoking status, sun sensitivity, and time spent outdoors in the multivariable logistic regression model, wearing long sleeves moderately was associated with psoriasis (odds ratio [OR], 0.55; 95% confidence interval [CI], 0.33-0.90), while frequent wearing showed no significant relationship. And there was no significant association between staying in the shade and psoriasis, regardless of frequency. Subgroup analyses stratified by age, gender, race/ethnicity, and smoking status revealed no significant associations in most groups, but moderate wearing of long sleeves was found to be negatively associated with psoriasis among those aged 20 to 39 years, among non-Hispanic White individuals, and among nonsmokers, as it was among females in overall sun protection. However, among non-Hispanic White individuals and former/current smokers, frequent sun protection was positively associated with psoriasis.

3

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

Conclusions: Moderate sun-protective behaviors among US adults were negatively associated with psoriasis. However, among non-Hispanic White individuals and former/current smokers, frequent sun protection was positively associated with psoriasis. For individuals with different characteristics, the findings may be taken into consideration to guide their daily sun protection practices.

4

Article Summary

Strengths and limitations of this study

- The data in the NHANES database are nationally representative and collected under strict control.

- In this study, subgroup analyses were employed in addition to logistic regression to explore the

  relationships between sun-protective behaviors and psoriasis in specific subgroups.

- This study adjusted for a variety of confounding variables to make the results reliable.

- As with the feature of any cross-sectional study, only association but no causal link could be

  determined.

- Self-reported psoriasis and sun-protective behaviors may induce recall bias and reporting bias.

5

1.Introduction

Psoriasis is a common chronic inflammatory skin disease that will cause a reduction in quality of life, sleep impairment,

psychological problems and so on[1]. The prevalence of it is expected to increase[2], with the current prevalence of about

3% in US adults, affecting over 7.5 million US adults[3].

Various treatment options are available for psoriasis, including pharmacotherapy, psychotherapy and rapidly

developing biologic therapies. Phototherapy (broadband ultraviolet B [BB-UVB], narrowband ultraviolet B [NB-UVB]

and heliotherapy) is an effective and safe treatment recommended by the Joint American Academy of Dermatology and

National Psoriasis Foundation guidelines[4]. It is commonly used for widespread psoriasis due to its efficacy and safety.

Many studies have shown that ultraviolet B (UVB) contributes to faster lesion clearance, fewer excessive erythema

episodes and longer remission periods in psoriasis[5] by inducing apoptosis in keratinocytes[6], CD4+ T cells and CD8+

T cells[7], inhibiting mast cell degranulation and histamine release[8], immunosuppression and changing the level of

cytokines such as interleukin [IL]-10, IL-17A[9 10]. Moreover, there are several pieces of evidence to support the claim

that UVB therapy or heliotherapy can also improve vitamin D levels and lessen the severity of psoriasis[11 12]. And

association between low levels of serum 25-hydroxyvitamin D(25(OH)D) and increased risk of developing psoriasis has

been observed[13]. In addition, as we all know, there is a strong tendency for psoriasis to be more frequent in winter, but

it is the opposite in summer[14 15], which suggests that ultraviolet (UV) radiation may be the reason for this

phenomenon.

In the US, some health organizations and clinicians advise using sunscreen and other sun protection measures to

lower the chance of developing melanoma and other types of skin cancer as well as to prevent premature aging of the

skin, which naturally initiated doubts about whether sun protection will hinder the cutaneous synthesis of vitamin D,

reduce the beneficial effects of UV radiation on the skin, and thus be detrimental to cardiovascular, metabolism, bone

and skeletal health, skin health and so on[16 17]. Thyssen et al. have proposed that reduced environmental UV exposure

6

may have a potential role as a driver of the current epidemic of atopic dermatitis[18]. As for psoriasis, the prevalence of

psoriasis exhibits considerable variation across different geographic locations[19]. Many researchers discovered that

higher latitude generally indicates higher prevalence rates[20 21]. Both genetic and environmental factors probably

contribute to the correlation, but variation in UV exposure must also be touched on. Therefore, given that UV radiation

has the function of treating psoriasis and the latitudinal difference in UV exposure, it is pertinent to explore whether

sun-protective behaviors may cause or aggravate psoriasis. Despite having found that using sunscreen for both daily and

recreational photo-protection has no impact on the synthesis of vitamin D[22], there is scarce data on whether sunscreen

use and other sun-protective behaviors affect the prevalence of psoriasis.

To address this research gap, in this cross-sectional study, we included and analyzed data from the 2009 to 2014

cycles of the National Health and Nutrition Examination Survey (NHANES) to explore the association between

multimodal sun-protective behaviors and the prevalence of psoriasis among US adults.

2. Methods

2.1 Data Sources

We used NHANES data in 2009-2014 to investigate the association between multimodal sun-protective behaviors and the

prevalence of psoriasis among US adults[23]. The NHANES is a nationally representative survey that captures statistics of

the US non-institutionalized civilian population on a biennial basis based on complex survey design and population-specific

sample weights in order to assess their health or nutritional status.

2.2 Study Design and Population

This was a population-based cross-sectional study. Our analyses were based on data collected from participants during

three 2-year NHANES cycles (2009-2010, 2011-2012 and 2013-2014).

The total number of initial NHANES participants from 2009-2014 was 30468. Of 11842 participants aged 20-59

7

years, 6 participants were excluded due to unavailable self-reported psoriasis data and 168 participants were excluded due

to unavailable information on three kinds of sun-protective behaviors. Additionally, 1933 participants with missing data

on covariates, including age, gender, race or ethnicity, education level, marital status, country of birth, body measure index

(BMI), alcohol drinking status, smoking status, sun sensitivity and time spent outdoors were excluded, making 9735

individuals included in the final analysis (**figure 1**).

To our knowledge, all participants provided informed consent for data collection and for the data to be publicly

disseminated in a de-identified format.

2.3 Psoriasis

The information was obtained from the medical conditions section of the questionnaire data in NHANES. The

participants aged 20 years and older were asked if they had ever been told by a doctor or other health care professional

that they had psoriasis. If the answer is "yes," he or she is considered to have psoriasis.

2.4 Sun-Protective Behaviors, Sun Sensitivity and Time Spent Outdoors

We assessed three different sun-protective behaviors from the NHANES dermatology questionnaire section (DEQ), for

which the target group was participants aged 20-59 years. The question asked for sun protective behaviors was: "When

you go outside on a very sunny day, for more than one hour, how often do you (1) stay in the shade, (2) wear a long-

sleeved shirt, (3) use sunscreen?" The valid answers can be "always," "most of the time," "sometimes," "rarely," "never"

and "don't go out in the sun." We reclassified these different answers into 3 categories: frequent (always or most of the

time), moderate (sometimes), or rare (never, rarely or don't go out in the sun). Furthermore, overall sun protection was

classified into three levels according to a total score for three sun-protective behaviors. The total score for sun protection

ranging from 3 to 9 was further divided down into rare (3-4), moderate (5-7), and frequent (8-9) categories[24] after

every behavior was scored 1, 2 or 3 depending on their frequency of use (rare, moderate and frequent).

8

Sun sensitivity was defined based on the question about skin reaction to the sun without sunscreen or protective

clothing for half an hour after several months of not being exposed to the sun. According to their responses, survey

participants were then divided into three groups: no sun sensitivity ("nothing would happen"), mild sun sensitivity

("mildly burn with some tanning" or "turn darker without a sunburn") and severe sun sensitivity ("severe sunburn with

blisters" or "severe sunburn for a few days with peeling").

In NHANES 2009-2014 cycles, participants were questioned how many minutes they spent outdoors over the

previous 30 days between 9 a.m. and 5 p.m. on workdays and non-workdays. Considering a week with five working days

and two off, we calculated the average time (minutes/day) spent outdoors using the following formula: (minutes outdoors

9 a.m.-5 p.m. on working days×5+minutes outdoors 9 a.m.-5 p.m. on nonworking days×2)/7. If the response is "does not

work or go to school" for the working day or "at work or at school 9 to 5 seven days a week" for the nonworking day, the

counterpart will be regarded as the final average time.

2.5 Other covariates

In addition to sun sensitivity and time spent outdoors, the other covariates included age, gender, race or ethnicity,

education level, marital status, country of birth, BMI, alcohol drinking status, and smoking status. Race or ethnicity was

derived from responses to the survey questions on race and Hispanic origin in the demographics file. Respondents were

reclassified into four groups: non-Hispanic White, non-Hispanic Black, Hispanic and other (Mexican American or other

race [including multi-racial]). Marital status was categorized into the following 3 groups: never married, married or

living with a partner and widowed, divorced or separated. Country of birth was encoded as a binary variable (0, born in

another country; 1, born in the US). BMI was calculated as weight in kilograms divided by height in meters squared and

then was analyzed as a three-categorical variable (BMI<25, 25≤BMI<30, BMI≤30) in the multivariable models. The

survey question, "In any 1 year, have you had at least 12 drinks of any type of alcoholic beverage?" was used to establish

participants' alcohol drinking status. Participants who responded "yes" were considered to be alcohol drinkers. Smoking

9

status was divided into 3 categories: nonsmoker (smoked<100 cigarettes in a lifetime), former smoker (smoked≥100

cigarettes in a lifetime but has quit), and current smoker (smoked≥100 cigarettes in a lifetime and still on smoking),

according to data on cigarette use in the questionnaire.

2.6 Statistical Analysis

All analyses were conducted in accordance with the NHANES analytic guidelines[25 26], taking into consideration the

complex sample design and appropriate sampling weights. In this study, we extracted three cycles of NHANES; thus the

sampling weight was calculated using the following equation: full sample 6-year mobile examination center (MEC) exam

weight=full sample 2-year MEC exam weight/3. Continuous data were reported as means, standard deviations and 95%

confidence intervals [CIs], whilst categorical data were expressed as numbers, weighted percentage frequencies and 95%

CIs. T-tests for comparing continuous data and χ^2 tests for comparing categorical data were used for comparing baseline

characteristics by the presence of psoriasis. Unadjusted and multivariable adjusted logistic regression analyses were

performed to calculate weighted odd ratios (ORs) and 95% CIs to explore the association of sun protection and psoriasis.

The multivariable model was adjusted for potential confounders (i.e., age, gender, race or ethnicity, education level,

marital status, country of birth, alcohol drinking status, smoking status, sun sensitivity and time spent outdoors).

Subgroup analyses stratified by age, gender, race or ethnicity, and smoking status were conducted to determine the

association in specific subgroups. Notably, in all models, staying in the shade, wearing long sleeves, using sunscreen and

overall sun protection were modelled separately. In all tests, p-values of less than 0.05 (2-sided) were considered to be

statistically significant. And all statistical analyses were conducted in Stata (Stata Corp.), version 17.

3. RESULTS

3.1 Characteristics of the Population

10

Baseline characteristics and comparisons of included and excluded participants were shown in **supplementary table 1**.

Of 9735 participants who were finally included in our study, 255 (2.8%) had psoriasis, while 9480 (97.2%) did not. As

shown in **table 1**, 50.3% of participants were male and the weighted mean age of the participants was 39.6 years (95%

CI: 39.3-39.9). Not surprisingly, compared with participants without psoriasis, patients with psoriasis were more likely to

be older (+3.2 years), non-Hispanic White, US-born and former smokers, but they did not differ significantly in gender,

education level, marital status, BMI and alcohol drinking status. Additionally, participants with psoriasis had a lower

prevalence of severe sun sensitivity, but no difference existed in the time spent outdoors. In terms of frequent staying in

the shade, wearing long sleeves, using sunscreen and overall sun protection, the percentages were 31.0% (95% CI:

29.8%-32.1%), 9.0% (95% CI: 8.3%-9.7%), 29.8% (95% CI: 28.6%-31.0%), and 6.8% (95% CI: 6.2%-7.5%),

respectively. And there were significantly different distributions in long sleeves (*P*=0.002), sunscreen use (*P*=0.04) and

overall sun protection (*P*<0.001) between the psoriasis group and the non-psoriasis group.

Table 1 Characteristics of participants by psoriasis in 2009-2014, NHANES

| Characteristic | Participants | | | *P* value |
	Total (N=9735)	Without psoriasis (n=9480)	With psoriasis (n=255)	
Age, mean±SD (95% CI), y	39.6±11.7 (39.3-39.9)	39.5±11.7 (39.2-39.8)	42.7±11.3 (40.9-44.5)	**<0.001**
Gender				
Female	4882 (49.7) [48.4-50.9]	4750 (49.7) [48.4-50.9]	132 (50.0) [42.2-57.8]	0.91
Male	4853 (50.3) [49.1-51.6]	4730 (50.3) [49.1-51.6]	123 (50.0) [42.2-57.8]	
Race or ethnicity				
Non-Hispanic White	4030 (64.5) [63.5-65.6]	3883 (64.2) [63.1-65.2]	147 (77.4) [72.0-82.0]	
Non-Hispanic Black	2048 (11.9) [11.3-12.4]	2021 (12.0) [11.5-12.6]	27 (5.4) [3.6-8.0]	**<0.001**
Hispanic	938 (6.2) [5.8-6.6]	915 (6.2) [5.8-6.7]	23 (5.3) [3.4-8.2]	
Other[a]	2719 (17.4) [16.7-18.2]	2661 (17.6) [16.8-18.4]	58 (11.9) [8.7-16.1]	
Education level				
Less than 9th grade	645 (4.0) [3.6-4.4]	631 (4.0) [3.7-4.4]	14 (2.3) [1.3-4.1]	
9-11th grade	1363 (10.9) [10.2-11.6]	1336 (11.0) [10.3-11.7]	27 (6.7) [4.3-10.5]	
High school grad/GED or equivalent	2137 (21.1) [20.1-22.1]	2080 (21.1) [20.1-22.1]	57 (21.5) [15.8-28.6]	0.06
Some college or AA degree	3115 (33.1) [31.9-34.3]	3035 (33.1) [31.9-34.3]	80 (33.0) [26.0-40.9]	
College graduate or above	2475 (31.0) [29.8-32.2]	2398 (30.8) [29.6-32.1]	77 (36.4) [29.1-44.4]	
Country of birth				

11

Not US born	2793 (18.5) [17.7-19.3]	2745 (18.7) [17.9-19.5]	48 (9.9) [7.1-13.6]	**<0.001**
US born	6942 (81.5) [80.7-82.3]	6735 (81.3) [80.5-82.1]	207 (90.1) [86.4-92.9]	
Marital status				
Never married	2563 (24.1) [23.1-25.2]	2507 (24.2) [23.1-25.2]	56 (22.9) [17.0-30.1]	
Married or living with partner	5719 (62.1) [60.8-63.3]	5571 (62.1) [60.9-63.3]	148 (61.4) [53.6-68.7]	0.64
Widowed or divorced or separated	1453 (13.8) [13.0-14.7]	1402 (13.8) [12.9-14.7]	51 (15.7) [10.9-22]	
BMI (kg/m^2)				
<25	3043 (31.4) [30.2-32.6]	2977 (31.5) [30.4-32.7]	66 (26.2) [20.0-33.5]	
≥25, <30	3071 (32.8) [31.6-34.0]	2991 (32.7) [31.5-34.0]	80 (35.4) [28.1-43.4]	0.17
≥30	3621 (35.8) [34.6-37.0]	3512 (35.7) [34.5-37.0]	109 (38.5) [31.3-46.2]	
Alcohol drinkers				
No	2279 (18.6) [17.7-19.5]	2226 (18.6) [17.7-19.5]	53 (17.7) [12.8-23.9]	
Yes	7456 (81.4) [80.5-82.3]	7254 (81.4) [80.5-82.3]	202 (82.3) [76.1-87.2]	0.70
Smoking status				
Nonsmokers	5670 (57.8) [56.6-59.1]	5547 (58.1) [56.8-59.3]	123 (49.2) [41.4-57.0]	
Former smokers	1647 (19.2) [18.2-20.3]	1587 (18.9) [17.9-20.0]	60 (30.1) [23.0-38.2]	**<0.001**
Current smokers	2418 (22.9) [21.9-24.0]	2346 (23.0) [22.0-24.1]	72 (20.8) [15.7-27.0]	
Sun sensitivity[b]				
None	956 (12.7) [11.9-13.7]	923 (12.7) [11.8-13.6]	33 (15.4) [10.3-22.4]	
Mild	4667 (52.1) [50.8-53.3]	4524 (51.9) [50.6-53.2]	143 (58.4) [50.6-65.9]	**0.006**
Severe	4112 (35.2) [34.0-36.3]	4033 (35.4) [34.3-36.6]	79 (26.2) [20.1-33.3]	
Time spent outdoors[c] (minute/d)				
<60	3891 (38.8) [37.6-40.1]	3790 (38.9) [37.7-40.2]	101 (35.2) [28.1-42.9]	
≥60	5844 (61.2) [59.9-62.4]	5690 (61.1) [59.8-62.3]	154 (64.8) [57.1-71.9]	0.21
Staying in the shade				
Rare	2546 (27.2) [26.0-28.3]	2489 (27.2) [26.1-28.4]	57 (24.8) [18.6-32.2]	
Moderate	3776 (41.9) [40.6-43.1]	3677 (42.0) [40.7-43.3]	99 (37.9) [30.7-45.7]	0.07
Frequent	3413 (31.0) [29.8-32.1]	3314 (30.8) [29.6-31.9]	99 (37.3) [30.0-45.2]	
Wearing long sleeves				
Rare	6742 (70.9) [69.8-72.1]	6557 (70.8) [69.6-71.9]	185 (76.0) [68.8-81.9]	
Moderate	1941 (20.1) [19.1-21.1]	1907 (20.3) [19.3-21.4]	34 (12.0) [7.9-17.9]	**0.002**
Frequent	1052 (9.0) [8.3-9.7]	1016 (8.9) [8.2-9.6]	36 (12.0) [7.9-17.9]	
Using sunscreen				
Rare	5579 (48.5) [47.2-49.7]	5449 (48.7) [47.4-50.0]	130 (41.8) [34.5-49.5]	
Moderate	1819 (21.8) [20.7-22.9]	1763 (21.6) [20.5-22.7]	56 (27.2) [20.5-35.2]	**0.04**
Frequent	2337 (29.8) [28.6-31.0]	2268 (29.7) [28.5-31.0]	69 (31.0) [24.2-38.8]	
Overall sun protection[d]				
Rare	3249 (31.9) [30.8-33.1]	3174 (31.9) [30.8-33.1]	75 (31.4) [24.5-39.1]	
Moderate	5850 (61.3) [60.0-62.5]	5698 (61.4) [60.2-62.6]	152 (56.1) [48.2-63.7]	**<0.001**
Frequent	636 (6.8) [6.2-7.5]	608 (6.7) [6.0-7.4]	28 (12.5) [7.9-19.3]	

Data are presented as unweighted number (weighted percentage) [95% CI] unless otherwise indicated.

Abbreviations: NHANES, National Health and Nutrition Examination Survey; BMI, body mass index (calculated as weight

12

in kilograms divided by height in meters squared). Boldface indicates statistical significance.

[a] Included Mexican American and multiracial participants.

[b] Sun sensitivity was determined by the answer to the skin reaction to the sun without sunscreen or protective clothing for half an hour: none ("nothing would happen"), mild ("mildly burn with some tanning" or "turn darker without a sunburn"), and severe ("severe sunburn with blisters" or "severe sunburn for a few days with peeling").

[c] Time spent outdoors refers to the average minutes spent outdoors from 9:00 a.m. to 5:00 p.m. on each day of the week considering that there are 5 working days and 2 non-working days in a week.

[d] Overall sun protection reflects the general condition of sun protection, including staying in the shade, wearing long sleeves and sunscreen.

3.2 Multivariable Regression Analyses

Based on the limited information from NHANES and our understanding of related factors for psoriasis[27] and sun-protective behaviors[28], we included some covariates like some sociodemographic variables, smoking status, BMI and sun sensitivity in the regression models to control for confounding effects. In **table 2,** the results of an unadjusted and a sample-weighted adjusted regression model to evaluate the association between sun-protective behaviors and psoriasis are presented. In the unadjusted one, moderate wearing of long sleeves was associated with a decreased prevalence of psoriasis (OR, 0.55; 95% CI, 0.34-0.89). After adjustment for covariates, the association remained statistically significant ($P<0.05$). However, overall sun protection had a positive association with psoriasis in the unadjusted model (OR, 1.91; 95% CI, 1.08-3.39), but the relationship disappeared after adjustment. Meanwhile, the other two behaviors were not significantly associated with psoriasis in the unadjusted or adjusted model.

Table 2 Association between sun-protective behaviors and psoriasis in NHANES, 2009-2014

	Presence of psoriasis by sun-protective behaviors			
	Staying in the shade	Wearing long sleeves	Using sunscreen	Overall sun protection
Model	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Unadjusted				
Rare	1 [reference]	1 [reference]	1 [reference]	1 [reference]
Moderate	0.99 (0.66-1.50)	**0.55 (0.34-0.89)**	1.47 (0.98-2.20)	0.93 (0.65-1.32)
Frequent	1.33 (0.88-2.02)	1.26 (0.77-2.03)	1.22 (0.84-1.76)	**1.91 (1.08-3.39)**
Adjusted[a]				
Rare	1 [reference]	1 [reference]	1 [reference]	1 [reference]
Moderate	0.95 (0.62-1.45)	**0.55 (0.33-0.90)**	1.25 (0.82-1.91)	0.90 (0.62-1.31)
Frequent	1.42 (0.92-2.18)	1.36 (0.82-2.26)	0.96 (0.62-1.50)	1.67 (0.90-3.12)

Abbreviations: NHANES, National Health and Nutrition Examination Survey; OR, odds ratio. Boldface indicates statistical

13

significance.

[a] Adjusted for sociodemographic variables, BMI, alcohol drinking status, smoking status, sun sensitivity, and time spent outdoors.

3.3 Subgroup Analyses

The results of the subgroup analyses, stratified by age, gender, race or ethnicity, and smoking status, are presented in

table 3. Among participants aged 20 to 39 years (OR, 0.42; 95% CI, 0.18-0.98), non-Hispanic White individuals (OR,

0.52; 95% CI, 0.28-0.97), and nonsmokers (OR, 0.49; 95% CI, 0.25-0.95), moderate wearing of long sleeves was

associated with a lower prevalence of psoriasis, as it was among females in terms of overall sun protection (OR, 0.58;

95% CI, 0.35-0.97).

However, among former or current smokers, those with frequent stays in the shade (OR, 1.92; 95% CI, 1.03-3.60),

long sleeves (OR, 2.84; 95% CI, 1.46-5.53) or overall sun protection (OR, 3.28; 95% CI, 1.41-7.63) had a higher

prevalence of psoriasis. And there were also slightly significant and positive relationships between frequent shade-

seeking behavior and psoriasis among non-Hispanic White participants (OR, 1.69; 95% CI, 1.00-2.84).

Table 3 Association between sun-protective behaviors and psoriasis, stratified by age, gender, race or ethnicity, and smoking status

Subgroup	frequency	Staying in the shade OR (95% CI)	Wearing long sleeves OR (95% CI)	Using sunscreen OR (95% CI)	Overall sun protection OR (95% CI)
Overall					
Unadjusted	Rare	1 [reference]	1 [reference]	1 [reference]	1 [reference]
	Moderate	0.99 (0.66-1.50)	**0.55 (0.34-0.89)***	1.47 (0.98-2.20)	0.93 (0.65-1.32)
	Frequent	1.33 (0.88-2.02)	1.26 (0.77-2.03)	1.22 (0.84-1.76)	**1.91 (1.08-3.39)***
Adjusted	Rare	1 [reference]	1 [reference]	1 [reference]	1 [reference]
	Moderate	0.95 (0.62-1.45)	**0.55 (0.33-0.90)***	1.25 (0.82-1.91)	0.90 (0.62-1.31)
	Frequent	1.42 (0.92-2.18)	1.36 (0.82-2.26)	0.96 (0.62-1.50)	1.67 (0.90-3.12)
Age, y					
20-39	Rare	1 [reference]	1 [reference]	1 [reference]	1 [reference]
	Moderate	0.71 (0.40-1.25)	**0.42 (0.18-0.98)***	1.21 (0.66-2.19)	0.91 (0.53-1.55)
	Frequent	1.14 (0.61-2.13)	0.86 (0.31-2.42)	1.23 (0.66-2.29)	1.27 (0.41-3.93)
40-59	Rare	1 [reference]	1 [reference]	1 [reference]	1 [reference]
	Moderate	1.24 (0.67-2.27)	0.64 (0.34-1.20)	1.28 (0.73-2.27)	0.92 (0.55-1.53)
	Frequent	1.77 (0.96-3.24)	1.75 (0.97-3.16)	0.84 (0.46-1.53)	1.97 (0.92-4.20)
Gender					

14

Female	Rare	1 [reference]	1 [reference]	1 [reference]	1 [reference]
	Moderate	0.63 (0.35-1.16)	0.56 (0.28-1.12)	0.88 (0.48-1.59)	**0.58 (0.35-0.97)***
	Frequent	1.33 (0.74-2.39)	1.37 (0.62-3.03)	0.56 (0.31-1.02)	1.23 (0.55-2.76)
Male	Rare	1 [reference]	1 [reference]	1 [reference]	1 [reference]
	Moderate	1.28 (0.72-2.29)	0.53 (0.26-1.07)	1.71 (0.95-3.09)	1.32 (0.78-2.23)
	Frequent	1.40 (0.74-2.64)	1.30 (0.68-2.48)	1.75 (0.97-3.15)	1.95 (0.74-5.11)
Race or ethnicity					
Non-Hispanic White	Rare	1 [reference]	1 [reference]	1 [reference]	1 [reference]
	Moderate	0.93 (0.56-1.55)	**0.52 (0.28-0.97)***	1.28 (0.78-2.11)	0.80 (0.50-1.26)
	Frequent	**1.69 (1.00-2.84)***	1.43 (0.71-2.86)	0.83 (0.48-1.43)	1.73 (0.82-3.66)
other	Rare	1 [reference]	1 [reference]	1 [reference]	1 [reference]
	Moderate	1.14 (0.64-2.03)	0.68 (0.37-1.22)	1.10 (0.59-2.06)	1.39 (0.83-2.32)
	Frequent	0.92 (0.52-1.61)	1.20 (0.68-2.12)	**1.94 (1.09-3.44)***	1.66 (0.72-3.82)
Smoking status					
nonsmokers	Rare	1 [reference]	1 [reference]	1 [reference]	1 [reference]
	Moderate	0.76 (0.42-1.35)	**0.49 (0.25-0.95)***	1.71 (0.93-3.14)	0.74 (0.43-1.26)
	Frequent	1.00 (0.55-1.82)	**0.42 (0.19-0.93)***	1.14 (0.58-2.21)	0.87 (0.36-2.09)
smokers[a]	Rare	1 [reference]	1 [reference]	1 [reference]	1 [reference]
	Moderate	1.20 (0.66-2.20)	0.62 (0.31-1.25)	1.00 (0.53-1.89)	1.12 (0.67-1.85)
	Frequent	**2.05 (1.11-3.78)***	**3.02 (1.57-5.79)****	0.91 (0.49-1.70)	**3.28 (1.41-7.63)****

Each stratification was adjusted for age, gender, race or ethnicity, country of birth, educational level, marital status, BMI, smoking and alcohol drinking status, sun sensitivity, and time spent outdoors except the stratification factor itself. All ORs and 95% CIs are based on data weighted to represent the US population.

*P<0.05, **P<0.01

Boldface indicates statistical significance.

[a] smokers refer to current smokers and former smokers.

4. DISCUSSION

To our knowledge, this is the first report to investigate the associations between sun-protective behaviors and psoriasis in a population-based setting, specifically in the US adult population. The findings revealed that moderately wearing long sleeves had a statistically significant association with a lower prevalence of psoriasis even after adjustment for some potential confounders. But there was no association between another two measures (staying in the shade and using sunscreen) and psoriasis, and neither was the overall sun protection. In subsequent subgroup analysis, the significant relationships between moderate sun protective behaviors and lower prevalence of psoriasis were observed in younger adults aged 20-39, females, non-Hispanic White individuals, and smokers. Remarkably, in smokers, frequent staying in

15

the shade, wearing of long sleeves, and overall sun protection were associated with increased risk but not moderate use.

And, in non-Hispanic White participants, frequent use of sunscreen was associated with increased risk of psoriasis but

not moderate use.

Psoriasis is a chronic and immune-mediated skin disorder attributed to various genetic and environmental factors.

As reported in previous studies, physical trauma[29], lifestyle and habits[30], infection, such as streptococcus[31],

medication[32 33] and so on are risk factors or triggers of psoriasis. This relationship between sun protection and lower

prevalence of psoriasis might be because sun protection avoids the traumatic effect of excessive UV rays on the skin, or

people with moderate sun-protective behaviors tend to have better health awareness and are less likely to have psoriasis

triggered by infection and poor lifestyle or medication habits. As we all know, natural sunlight, with a wide variety of

bands, is more likely to cause negative skin effects in contrast to NB-UVB and targeted UVB with specific spectrum and

limited doses in the clinic.

Additionally, although a sizable portion of psoriasis sufferers respond well to phototherapy (mainly in UV radiation

with a wavelength of 311 nm), excessive UV exposure will lead to an increase in side effects such as erythema, blistering

and even deterioration of psoriasis. Actually, it was reported that about 5.5% of all cases of psoriasis will aggravate or

develop new lesions after being exposed to sunshine due to genetics, gender (female), and abnormal UV response, and

some even experience symptoms after prolonged sunbathing[34 35], which are all called photosensitive psoriasis (PP).

Therefore, it's necessary for PP patients to take some daily sun-protective measures, and long-term exposure to strong

sunlight without any protection is also not recommended for psoriasis patients who are effective in phototherapy.

Meanwhile, the association remained after the adjustment of gender, race or ethnicity, and sun sensitivity in our study,

which shows us that it's important to pay more attention to the protective effects of moderate sun protection on the

general population as well as the potential predisposing effect of sunlight on psoriasis, the underlying mechanism of

which is still waiting to be discovered.

16

In the past few years, the pathogenesis of psoriasis has been unveiled gradually. The persistence of skin

inflammation due to cutaneous immune disorder is a hallmark of psoriasis. Dendritic cells (DCs), macrophages, different

T cell sets and other cell types via various cytokines such as LL-37, tumor necrosis factor α (TNF-α) and interleukins

play a major role in the initiation and maintenance phases[36], causing higher levels for IL-17, IL-23 and TNF-α, lower

levels for IL-4 and IL-10, and other dysregulation of cytokine secretion[37]. And in many studies, it has been found that

sunlight or UV radiation can reduce the number of DCs[38], CD4+ T cells and CD8+ T cells, and modulate immune

homeostasis and cytokine levels in psoriasis[7]. In our study, there was no difference in the prevalence of psoriasis

between those with rare sun protection and those with frequent sun protection on the whole, which was probably

attributed to the fact that excessive sun protection frequency prevents the beneficial effects of UV rays in sunlight. This

was in combination with the negative effects of deficient sun protection on the skin, ultimately linking moderate sun

protection to a lower prevalence of psoriasis.

The results of subgroup analyses indicated an opposing association between different sun protection usage frequencies

and psoriasis. Among people aged 20-39, females, non-Hispanic White individuals, and smokers, moderate sun protection

was linked to a lower prevalence of psoriasis. And the frequent was linked to a higher prevalence among non-Hispanic

White individuals and among smokers. It is unclear why the association was stronger in the younger adults and females.

We speculate that the variability may be due to young women's greater attention to and requirements for sun protection

factor (SPF) in sun protection products. Unfortunately, the NHANES database did not record details on sunscreen such as

SPF and usage per time. As for race or ethnicity, previous research discovered that sun-protective behaviors may

significantly reduce the level of 25(OH)D in White individuals compared to Black and Hispanic individuals[24]. Currently,

notable associations between low vitamin D status and psoriasis have been systematically found, and oral vitamin D

supplementation is deemed to be an effective treatment of psoriasis[39]. So, the decrease in vitamin D caused by frequent

sun protection may exacerbate the adverse skin effects brought on by insufficient UV exposure, which is speculated to be

17

more obvious among White people.

Regarding smoking status, frequent sun protection was positively associated with psoriasis in smokers, whereas wearing long sleeves was negatively associated with psoriasis in nonsmokers. It is widely accepted that smoking can increase the risk of developing psoriasis[40 41] through several mechanisms[42], including oxidation, inflammation and genes. Therefore, when combined with the absence of UV immunosuppressive and anti-inflammatory properties due to excessive use of sun proof, the difference in the risk of developing psoriasis may become more noticeable.

We also found that adults in the United States had insufficient awareness of sun protection between 2009 and 2014, with over 30% of people experiencing low or no sun protection. Especially when it comes to wearing long sleeves, less than 30% of participants opted to wear them while being outside in the sun for an hour. Although this phenomenon has been proven to be improving from 2010 to 2020[43], pent-up demand for travel or holidays is already delivering rapid growth in the US after the lockdown measures for the COVID-19 epidemic were fully lifted, which exerts a brand-new challenge for American people's consciousness of sun protection. We hope that our findings can call attention to the need for people to take appropriate sun protection measures, not only to avoid skin cancer but also to prevent skin lesions that may be caused by excessive UV radiation. Certainly, it is worthwhile to think about the possible adverse effects of frequent sun protection for White individuals and smokers.

This study has several strengths that deserve mentioning. The principal strength of this study is that this is the first attempt to explore the relationship between sun-protective behaviors and psoriasis, which can provide advice on sun-protective behaviors for American people. Furthermore, the NHANES database has a large sample size, and the data from it is nationally representative and collected under strict control so that the results are generalizable to the adult population in the US. There are still some limitations that need to be acknowledged. First and foremost, this is a cross-sectional study that can only suggest association but not causality. Psoriasis may have been diagnosed years ago, and some sufferers may choose to conceal visible skin lesions through long sleeves or other means due to shame over their appearance[44 45]. But

18

the collection of information on the frequency of long sleeves has clear sun protection targeting under specific contexts, which possibly minimizes such reverse causality bias. Therefore, additional results from well-designed cohort studies are required. Second, our data are from the 2009-2014 cycles of NHANES and, thus, might not provide a precise representation of present-day circumstances. To ensure that our analyses and conclusions are aligned with the most recent trends and conditions, further studies that incorporate more recent data are recommended. Third, data on psoriasis diagnosis and sun-protective behaviors were all obtained in the form of questionnaire surveys, which were prone to recall bias and reporting bias. And the NHANES does not record data on the different geographical locations, the timing of data collection, sun-exposure time intervals, the type of sunscreen used, etc. These reasons may limit our ability to accurately evaluate the association between the frequency of sun protection and the prevalence of psoriasis in people under different UV exposure conditions. Fourth, UV radiation has two distinct effects at two different wavelength ranges: ~305 nm for sunburn and 311 nm for psoriasis therapy. Sun-protective behaviors can simultaneously block the penetration of both UV wavelengths into the skin; however, our study cannot clearly measure or distinguish their effects. Fifth, due to the limited information from the NHANES database, there may be some covariates that were not taken into account. Thus, future studies ought to collect and evaluate information on geographic location and sun protection, as well as other important covariates in more detail so as to better elucidate the potential relationship. Lastly, multiple tests may raise the probability of obtaining a significant result by chance.

5.Conclusions

The findings of this cross-sectional study suggested that moderate sun protection was negatively associated with psoriasis in the adult population of the US, particularly in White females aged 20 to 39 years and in nonsmokers, while frequent sun protection was linked to a higher prevalence of psoriasis in White individuals and smokers. On the whole, for US adults from various backgrounds and lifestyles, the findings may shed light on their awareness of and use of sun

1
2
3
4   protection.
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

20

Author Contributions: YX had full access to all the data in the study and took responsibility for the integrity of the data and the accuracy of the data analysis. YX and WL were involved in study concept and design. All authors were involved in the acquisition, analysis or interpretation of data. YX, WW, YF and FR were involved in drafting the manuscript. WW, WL and XH were involved in critical revision of the manuscript for important intellectual content. YX and FR were involved in statistical analysis. WL acted as guarantor. YX, WW and WL contributed to administrative, technical, or material support. WW, WL and YF were involved in supervision.

Funding: This study was supported by grants 2023LCRC09 from the Training Program for High-caliber Talents of Clinical Research at Affiliated Hospitals of SHUTCM, and 22YF1449500 from the Sailing Program of Shanghai Municipal Commission of science and technology.

Competing interests: None.

Patient consent: None.

Patient and public involvement: Patients and/or the public were not involved in the design, conduct, reporting, or dissemination plans of this research.

Ethics approval: This study involves human participants. And all NHANES protocols have been approved by the National Center for Health Statistics Research Ethics Review Board. The specific protocol numbers involved in the study are: #2005-06, #2011-17. All participants in NHANES presented informed consent for data collection and publication. Since the study utilizes publicly accessible and anonymized NHANES data, it is exempt from additional ethical review by the Ethics Committee of Shuguang Hospital Affiliated to Shanghai University of TCM.

Data availability statement: The datasets used in this study are available in a public and open access repository, NHANES. NHANES website: https://www.cdc.gov/nchs/nhanes/index.htm.

21

References

[1] Langley RG, Krueger GG, Griffiths CE. Psoriasis: epidemiology, clinical features, and

quality of life. *Ann Rheum Dis* 2005;64 Suppl 2:ii18-23; discussion ii24-5.

[2] Icen M, Crowson CS, McEvoy MT, et al. Trends in incidence of adult-onset psoriasis over

three decades: a population-based study. *J Am Acad Dermatol* 2009;60:394-401.

[3] Armstrong AW, Mehta MD, Schupp CW, et al. Psoriasis Prevalence in Adults in the United

States. *JAMA Dermatol* 2021;157:940-46.

[4] Menter A, Gelfand JM, Connor C, et al. Joint American Academy of Dermatology-National

Psoriasis Foundation guidelines of care for the management of psoriasis with

systemic nonbiologic therapies. *J Am Acad Dermatol* 2020;82:1445-86.

[5] Morita A. Current developments in phototherapy for psoriasis. *J Dermatol* 2018;45:287-92.

[6] Weatherhead SC, Farr PM, Jamieson D, et al. Keratinocyte apoptosis in epidermal

remodeling and clearance of psoriasis induced by UV radiation. *J Invest Dermatol*

2011;131:1916-26.

[7] Søyland E, Heier I, Rodríguez-Gallego C, et al. Sun exposure induces rapid immunological

changes in skin and peripheral blood in patients with psoriasis. *Br J Dermatol*

2011;164:344-55.

[8] Siiskonen H, Smorodchenko A, Krause K, et al. Ultraviolet radiation and skin mast cells:

Effects, mechanisms and relevance for skin diseases. *Exp Dermatol* 2018;27:3-8.

[9] Hart PH, Norval M. More Than Effects in Skin: Ultraviolet Radiation-Induced Changes in

Immune Cells in Human Blood. *Front Immunol* 2021;12:694086.

22

[10] Vacharanukrauh P, Meephansan J, Tangtanatakul P, et al. High-Throughput RNA

Sequencing Reveals the Effect of NB-UVB Phototherapy on Major Inflammatory

Molecules of Lesional Psoriasis. *Psoriasis (Auckl)* 2021;11:133-49.

[11] Osmancevic A, Landin-Wilhelmsen K, Larkö O, et al. Vitamin D status in psoriasis

patients during different treatments with phototherapy. *J Photochem Photobiol B*

2010;101:117-23.

[12] Franken SM, Witte B, Pavel S, et al. Psoriasis and daily low-emission phototherapy:

effects on disease and vitamin D level. *Photodermatol Photoimmunol Photomed*

2015;31:83-9.

[13] Charoenngam N, Holick MF. Immunologic effects of vitamin D on human health and

disease. 2020;12:2097.

[14] Harvell JD, Selig DJ. Seasonal variations in dermatologic and dermatopathologic

diagnoses: a retrospective 15-year analysis of dermatopathologic data. *International

Journal of Dermatology* 2016;55:1115-18.

[15] Ammar-Khodja A, Benkaidali I, Bouadjar B, et al. EPIMAG: international cross-sectional

epidemiological psoriasis study in the Maghreb. *Dermatology* 2015;231:134-44.

[16] Yang S, Dai F, Wang Z, et al. Association between sun-protective behaviors and

hypertension: a cross-sectional study from National Health and Nutrition Examination

Survey 2009 to 2014. *BMC Public Health* 2023;23:1862.

[17] Afarideh M, Sartori-Valinotti JC, Tollefson MM. Association of Sun-Protective Behaviors

With Bone Mineral Density and Osteoporotic Bone Fractures in US Adults. *JAMA

Dermatol* 2021;157:1437-46.

23

[18] Thyssen JP, Zirwas MJ, Elias PM. Potential role of reduced environmental UV exposure

as a driver of the current epidemic of atopic dermatitis. *Journal of Allergy and Clinical

Immunology* 2015;136:1163-69.

[19] Rosa P, Ireny YKI, Evangelos K, et al. National, regional, and worldwide epidemiology of

psoriasis: systematic analysis and modelling study. *BMJ (Clinical research ed)*

2020;369:m1590.

[20] Valerie A, Sandra W, Matthias A, et al. Regional variations and prevalence of psoriasis in

Germany from 2010 to 2017: a cross-sectional, spatio-epidemiological study on

ambulatory claims data. *BMJ Open* 2021;11:e047806.

[21] Solberg SM. Psoriasis in Norway: A Prescription-based Registry Study of Incidence and

Prevalence. *Acta Dermato-Venereologica* 2023;103:adv4591.

[22] Passeron T, Bouillon R, Callender V, et al. Sunscreen photoprotection and vitamin D

status. *Br J Dermatol* 2019;181:916-31.

[dataset] [23] National Health and Nutrition Examination Survey, 2009-2014. National Center

for Health Statistics, Centers for Disease Control and Prevention. Available:

https://www.cdc.gov/nchs/nhanes/index.htm

[24] Linos E, Keiser E, Kanzler M, et al. Sun protective behaviors and vitamin D levels in the

US population: NHANES 2003-2006. *Cancer Causes Control* 2012;23:133-40.

[25] National Health and Nutrition Examination Survey: Analytic Guidelines, 1999-2010.

National Health and Nutrition Examination Survey. Available:

https://wwwn.cdc.gov/nchs/data/nhanes/analyticguidelines/99-10-analytic-

guidelines.pdf

24

[26] National Health and Nutrition Examination Survey: Analytic Guidelines, 2011-2016.

National Health and Nutrition Examination Survey. Available:

https://wwwn.cdc.gov/nchs/data/nhanes/analyticguidelines/11-16-analytic-

guidelines.pdf

[27] Griffiths CEM, Armstrong AW, Gudjonsson JE, et al. Psoriasis. *The Lancet*

2021;397:1301-15.

[28] Haluza D, Simic S, Höltge J, et al. Gender aspects of recreational sun-protective

behavior: results of a representative, population-based survey among Austrian

residents. *Photodermatol Photoimmunol Photomed* 2016;32:11-21.

[29] Shams K, Kurowska-Stolarska M, Schütte F, et al. MicroRNA-146 and cell trauma down-

regulate expression of the psoriasis-associated atypical chemokine receptor ACKR2.

J Biol Chem 2018;293:3003-12.

[30] Madden SK, Flanagan KL, Jones G. How lifestyle factors and their associated

pathogenetic mechanisms impact psoriasis. *Clin Nutr* 2020;39:1026-40.

[31] Garritsen FM, Kraag DE, de Graaf M. Guttate psoriasis triggered by perianal

streptococcal infection. *Clinical and Experimental Dermatology* 2017;42:536-38.

[32] Fry L, Baker BS. Triggering psoriasis: the role of infections and medications. *Clinics in*

Dermatology 2007;25:606-15.

[33] Wu S, Han J, Li W-Q, et al. Hypertension, antihypertensive medication use, and risk of

psoriasis. *JAMA Dermatol* 2014;150:957-63.

[34] Ros A-M, Eklund G, D O. Photosensitive psoriasis: an epidemiologic study. *J Am Acad*

Dermatol 1987;17:752-58.

25

[35] Rutter KJ, Watson RE, Cotterell LF, et al. Severely photosensitive psoriasis: a

phenotypically defined patient subset. *J Invest Dermatol* 2009;129:2861-7.

[36] Rendon A, Schäkel K. Psoriasis Pathogenesis and Treatment. *Int J Mol Sci*

2019;20:1475.

[37] Li X, Xiao QQ, Li FL, et al. Immune Signatures in Patients with Psoriasis Vulgaris of

Blood-Heat Syndrome: A Systematic Review and Meta-Analysis. *Evidence-based*

complementary and alternative medicine : eCAM 2016;2016:9503652.

[38] Heier I, Søyland E, Krogstad AL, et al. Sun exposure rapidly reduces plasmacytoid

dendritic cells and inflammatory dermal dendritic cells in psoriatic skin. *Br J Dermatol*

2011;165:792-801.

[39] Barrea L, Savanelli MC, Di Somma C, et al. Vitamin D and its role in psoriasis: An

overview of the dermatologist and nutritionist. *Rev Endocr Metab Disord*

2017;18:195-205.

[40] Williams HC. Smoking and psoriasis. *BMJ (Clinical research ed)* 1994;308:428.

[41] Wei J, Zhu J, Xu H, et al. Alcohol consumption and smoking in relation to psoriasis: a

Mendelian randomization study. *British Journal of Dermatology* 2022;187:684-91.

[42] Armstrong AW, Armstrong EJ, Fuller EN, et al. Smoking and pathogenesis of psoriasis: a

review of oxidative, inflammatory and genetic mechanisms. *British Journal of*

Dermatology 2011;165:1162-68.

[43] McKenzie C, Nahm WJ, Kearney CA, et al. Sun-protective behaviors and sunburn among

US adults. *Archives of Dermatological Research* 2023;315:1665-74.

26

[44] Adesanya EI, Matthewman J, Schonmann Y, et al. Factors associated with depression, anxiety and severe mental illness among adults with atopic eczema or psoriasis: a systematic review and meta-analysis. *British Journal of Dermatology* 2023;188:460-70.

[45] Jankowiak B, Kowalewska B, Krajewska-Kułak E, et al. Stigmatization and Quality of Life in Patients with Psoriasis. *Dermatology and Therapy* 2020;10:285-96.

27

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

Figure legends

Figure 1 Flow diagram of the screening process for the study participants' selection. Sun- protective

behaviors include staying in the shade, wearing long sleeves, and using sunscreen. BMI, body mass index.
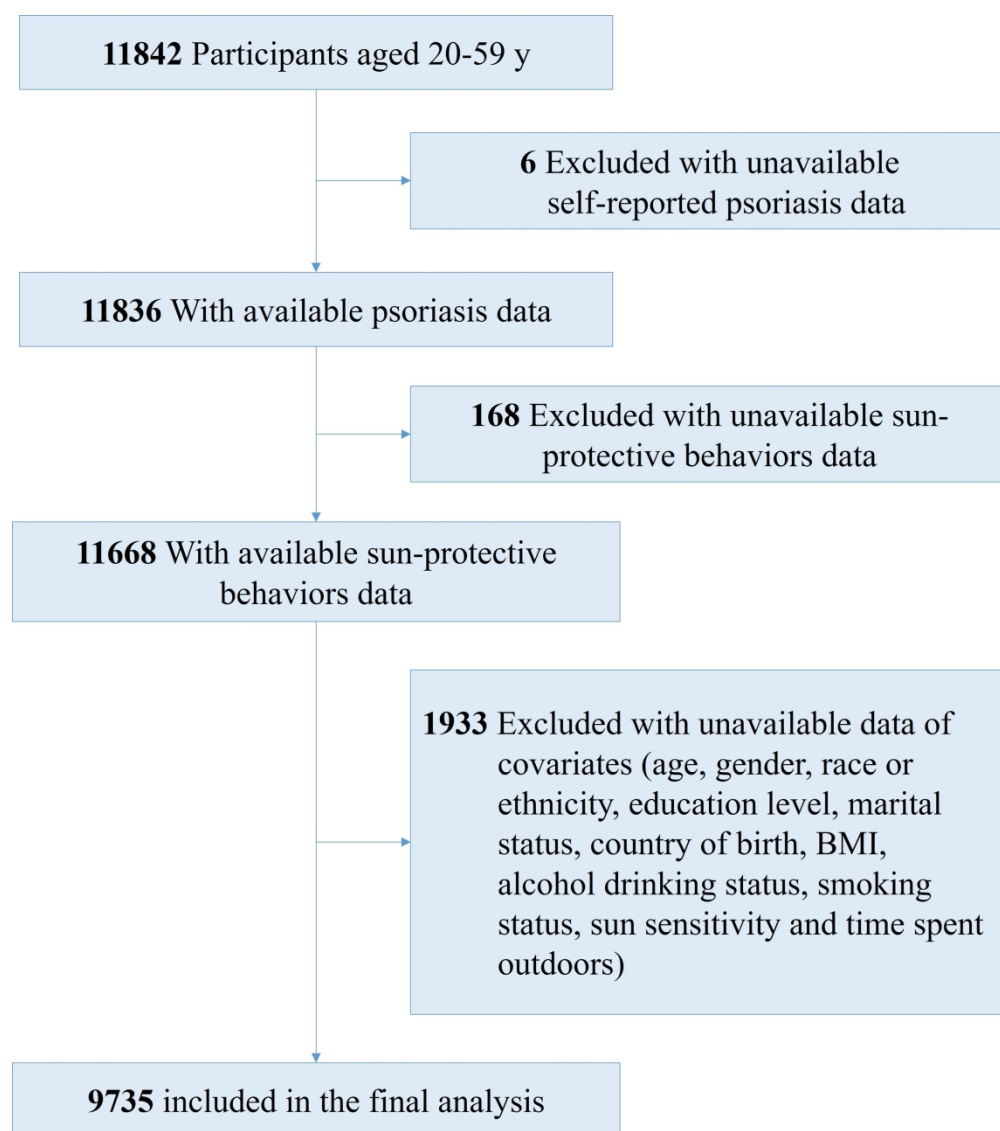
28

Figure 1. Flow diagram of the screening process for the study participants' selection. Sun-protective behaviors include staying in the shade, wearing long sleeves, and using sunscreen. BMI, body mass index.

225x253mm (300 x 300 DPI)

Table S1 Characteristics of included and excluded participants

	Excluded	Included	*P* value
Number of participants, n (%)	2107 (17.8)	9735 (82.2)	
Age, Mean±SD, y	39.3±11.0	39.1 ± 11.5	0.33
Gender, n (%)			<0.001
Female	1227 (58.2)	4882 (50.1)	
Male	880 (41.8)	4853 (49.9)	
Race and ethnicity, n (%)			<0.001
Non-Hispanic White	676 (32.1)	4030 (41.4)	
Non-Hispanic Black	478 (22.7)	2048 (21.0)	
Hispanic	233 (11.1)	938 (9.6)	
Other[a]	720 (34.2)	2719 (27.9)	
Education level, n (%)			<0.001
Less than 9th grade	230 (10.9)	645 (6.6)	
9-11th grade	343 (16.3)	1363 (14.0)	
High school grad/GED or equivalent	467 (22.2)	2137 (22.0)	
Some college or AA degree	582 (27.6)	3115 (32.0)	
College graduate or above	472 (22.4)	2475 (25.4)	
Missing	13 (0.6)	0 (0)	
Country of birth, n (%)			<0.001
Not US born	844 (40.1)	2793 (28.7)	
US born	1257 (59.7)	6942 (71.3)	
Missing	6 (0.3)	0 (0)	
Marital status, n (%)			<0.001
Never married	533 (25.3)	2563 (26.3)	
Married or living with a partner	1233 (58.5)	5719 (58.7)	
Widowed or divorced or separated	334 (15.9)	1453 (14.9)	
Missing	7 (0.3)	0 (0)	
BMI (kg/m^2), n (%)			<0.001
<25	552 (26.2)	3043 (31.3)	
≥25, <30	500 (23.7)	3071 (31.5)	
≥30	605 (28.7)	3621 (37.2)	
Missing	450 (21.4)	0 (0)	
Alcohol drinkers, n (%)			<0.001
No	112 (5.3)	2279 (23.4)	
Yes	227 (10.8)	7456 (76.6)	
Missing	1768 (83.9)	0 (0)	
Smoking status, n (%)			<0.001
Nonsmokers	1280 (60.7)	5670 (58.2)	
Former smokers	298 (14.1)	1647 (16.9)	
Current smokers	523 (24.8)	2418 (24.8)	
Missing	6 (0.3)	0 (0)	
Sun sensitivity[b], n (%)			<0.001
None	146 (6.9)	956 (9.8)	

Mild	858 (40.7)	4667 (47.9)	
Severe	957 (45.4)	4112 (42.2)	
Missing	146 (6.9)	0 (0)	
Time spent outdoors[c], n (%)			<0.001
<60 min/d	950 (45.1)	3891 (40.0)	
≥60 min/d	1114 (52.9)	5844 (60.0)	
Missing	43 (2.0)	0 (0)	

[a] Included Mexican American and multiracial participants.

[b] Sun sensitivity was divided into three levels according to skin reaction to sun without sunscreen or protective clothing for half an hour: none (defined as "nothing would happen"), mild (defined as "mildly burn with some tanning" and "turn darker without a sunburn"), and severe (defined as "severe sunburn with blisters" and "severe sunburn for a few days with peeling").

[c] Time spent outdoors was recalculated based on minutes spent outdoors from 9:00 am to 5:00 pm on working days and non-working days, considering that there are 5 working days and 2 non-working days in a week.

Table S2 Characteristics of participants by the frequency of staying in the shade

	Total (N=9735)	Staying in the shade			P value
		Rare (N=2546)	Moderate (N=3776)	Frequent (N=3413)	
Age, mean ± SD (95% CI), y	39.6±11.7 (39.3-39.9)	39.1±11.9 (38.5-39.7)	39.2±11.8 (38.7-39.7)	40.5±11.5 (40.0-41.0)	<0.001
Gender					<0.001
Female	4882 (49.7) [48.4-50.9]	1012 (41.0) [38.6-43.5]	1770 (46.8) [44.8-48.8]	2100 (61.1) [59.0-63.2]	
Male	4853 (50.3) [49.1-51.6]	1534 (59.0) [56.5-61.4]	2006 (53.2) [51.2-55.2]	1313 (38.9) [36.8-41.0]	
Race or ethnicity					<0.001
Non-Hispanic White	4030 (64.5) [63.5-65.6]	1199 (68.7) [66.7-70.6]	1793 (70.3) [68.8-71.8]	1038 (53.1) [51.0-55.1]	
Non-Hispanic Black	2048 (11.9) [11.3-12.4]	419 (8.9) [8.1-9.9]	715 (9.9) [9.1-10.7]	914 (17.1) [15.9-18.3]	
Hispanic	938 (6.2) [5.8-6.6]	244 (6.0) [5.2-6.8]	284 (4.6) [4.0-5.2]	410 (8.6) [7.7-9.5]	
Other	2719 (17.4) [16.7-18.2]	684 (16.4) [15.0-17.9]	984 (15.3) [14.2-16.4]	1051 (21.3) [19.9-22.8]	
Education level					<0.001
Less than 9th grade	645 (4.0) [3.6-4.4]	207 (4.9) [4.2-5.8]	177 (2.9) [2.4-3.5]	261 (4.7) [4.1-5.3]	
9-11th grade	1363 (10.9) [10.2-11.6]	435 (12.6) [11.3-14.0]	416 (8.3) [7.4-9.4]	512 (12.8) [11.5-14.2]	
High school grad/GED or equivalent	2137 (21.1) [20.1-22.1]	584 (23.0) [21.0-25.1]	833 (20.9) [19.3-22.5]	720 (19.7) [18.1-21.4]	
Some college or AA degree	3115 (33.1) [31.9-34.3]	796 (33.1) [30.9-35.5]	1253 (33.8) [31.9-35.7]	1066 (32.0) [30.0-34.0]	
College graduate or above	2475 (31) [29.8-32.2]	524 (26.4) [24.1-28.7]	1097 (34.1) [32.2-36.0]	854 (30.9) [28.8-33.0]	
Country of birth					<0.001
Not US born	2793 (18.5) [17.7-19.3]	757 (18.2) [16.7-19.7]	917 (15.0) [13.8-16.2]	1119 (23.4) [21.9-25.0]	
US born	6942 (81.5) [80.7-82.3]	1789 (81.8) [80.3-83.3]	2859 (85.0) [83.8-86.2]	2294 (76.6) [75.0-78.1]	
Marital status					0.10
Never married	2563 (24.1) [23.1-25.2]	671 (25.6) [23.6-27.8]	1017 (24.3) [22.7-26.0]	875 (22.6) [20.9-24.3]	
Married or living with partner	5719 (62.1) [60.8-63.3]	1509 (60.8) [58.4-63.2]	2205 (62.2) [60.3-64.1]	2005 (62.9) [60.9-64.9]	
Widowed or divorced or separated	1453 (13.8) [13-14.7]	366 (13.6) [12.0-15.4]	554 (13.5) [12.2-14.9]	533 (14.5) [13.0-16.1]	
BMI (kg/m²)					<0.001
<25	3043 (31.4) [30.2-32.6]	848 (32.7) [30.5-35.0]	1219 (32.1) [30.3-34.0]	976 (29.2) [27.3-31.2]	
≥25, <30	3071 (32.8) [31.6-34]	861 (34.7) [32.3-37.1]	1195 (33.4) [31.5-35.3]	1015 (30.4) [28.5-32.5]	
≥30	3621 (35.8) [34.6-37]	837 (32.6) [30.4-35.0]	1362 (34.5) [32.7-36.4]	1422 (40.3) [38.3-42.4]	
Alcohol drinkers					<0.001
No	2279 (18.6) [17.7-19.5]	524 (16.3) [14.7-18.0]	764 (16.3) [15.0-17.8]	991 (23.6) [22.0-25.3]	
Yes	7456 (81.4) [80.5-82.3]	2022 (83.7) [82.0-85.3]	3012 (83.7) [82.2-85.0]	2422 (76.4) [74.7-78.0]	
Smoking status					<0.001

	Total				P value
Nonsmokers	5670 (57.8) [56.6-59.1]	1382 (55.1) [52.6-57.5]	2197 (57.3) [55.3-59.2]	2091 (61.0) [58.9-63.1]	
Former smokers	1647 (19.2) [18.2-20.3]	439 (19.5) [17.6-21.6]	659 (19.7) [18.1-21.4]	549 (18.3) [16.6-20.1]	
Current smokers	2418 (22.9) [21.9-24]	725 (25.4) [23.4-27.5]	920 (23.0) [21.4-24.7]	773 (20.7) [19.1-22.4]	
Sun sensitivity					<0.001
None	956 (12.7) [11.9-13.7]	147 (7.6) [6.3-9.1]	327 (10.7) [9.5-12.1]	482 (20.0) [18.1-21.9]	
Mild	4667 (52.1) [50.8-53.3]	1145 (50.0) [47.5-52.4]	1924 (56.3) [54.3-58.2]	1598 (48.3) [46.2-50.4]	
Severe	4112 (35.2) [34-36.3]	1254 (42.4) [40.1-44.9]	1525 (33.0) [31.2-34.8]	1333 (31.7) [29.9-33.6]	
Time spent outdoors (minute/d)					<0.001
<60	3891 (38.8) [37.6-40.1]	856 (31.6) [29.4-33.9]	1399 (36.9) [35.0-38.9]	1636 (47.7) [45.6-49.9]	
≥60	5844 (61.2) [59.9-62.4]	1690 (68.4) [66.1-70.6]	2377 (63.1) [61.1-65.0]	1777 (52.3) [50.1-54.4]	
Psoriasis					0.07
No	9480 (97.2) [96.7-97.6]	2489 (97.4) [96.5-98.1]	3677 (97.4) [96.7-98.0]	3314 (96.6) [95.6-97.4]	
Yes	255 (2.8) [2.4-3.3]	57 (2.6) [1.9-3.5]	99 (2.6) [2.0-3.3]	99 (3.4) [2.6-4.4]	

Table S3 Characteristics of participants by the frequency of wearing of long sleeves

	Total (N=9735)	Wearing long sleeves			P value
		Rare (N=6742)	Moderate (N=1941)	Frequent (N=1052)	
Age, mean±SD (95% CI), y	39.6±11.7 (39.3-39.9)	39.1±11.7 (38.7-39.5)	40.2±11.7 (39.5-40.9)	42.1±11.3 (41.2-43.0)	<0.001
Gender					0.005
Female	4882 (49.7) [48.4-50.9]	3437 (49.9) [48.4-51.4]	982 (51.0) [48.2-53.9]	463 (44.6) [40.7-48.5]	
Male	4853 (50.3) [49.1-51.6]	3305 (50.1) [48.6-51.6]	959 (49.0) [46.1-51.8]	589 (55.4) [51.5-59.3]	
Race or ethnicity					<0.001
Non-Hispanic White	4030 (64.5) [63.5-65.6]	2955 (66.2) [65.0-67.4]	796 (65.9) [63.6-68.2]	279 (48.0) [44.0-52.0]	
Non-Hispanic Black	2048 (11.9) [11.3-12.4]	1453 (11.9) [11.3-12.6]	408 (11.8) [10.6-13.1]	187 (11.6) [10.0-13.5]	
Hispanic	938 (6.2) [5.8-6.6]	688 (6.5) [6.0-7.0]	138 (4.3) [3.6-5.1]	112 (8.2) [6.7-10.0]	
Other	2719 (17.4) [16.7-18.2]	1646 (15.4) [14.6-16.3]	599 (17.9) [16.3-19.7]	474 (32.2) [29.0-35.5]	
Education level					<0.001
Less than 9th grade	645 (4.0) [3.6-4.4]	335 (3.0) [2.7-3.4]	141 (4.3) [3.5-5.3]	169 (10.7) [9.0-12.8]	
9-11th grade	1363 (10.9) [10.2-11.6]	1011 (11.6) [10.8-12.5]	211 (8.1) [6.8-9.5]	141 (11.3) [9.3-13.6]	
High school grad/GED or equivalent	2137 (21.1) [20.1-22.1]	1537 (21.8) [20.6-23.0]	397 (19.7) [17.6-22.0]	203 (18.8) [15.9-21.9]	
Some college or AA degree	3115 (33.1) [31.9-34.3]	2248 (34.4) [33.0-35.8]	589 (30.8) [28.2-33.5]	278 (27.8) [24.4-31.4]	
College graduate or above	2475 (31) [29.8-32.2]	1611 (29.2) [27.8-30.6]	603 (37.1) [34.3-40.0]	261 (31.5) [27.7-35.5]	

Country of birth					<0.001
Not US born	2793 (18.5) [17.7-19.3]	1678 (15.9) [15.0-16.8]	603 (19.2) [17.4-21.1]	512 (37.4) [33.9-41.0]	
US born	6942 (81.5) [80.7-82.3]	5064 (84.1) [83.2-85.0]	1338 (80.8) [78.9-82.6]	540 (62.6) [59.0-66.1]	
Marital status					<0.001
Never married	2563 (24.1) [23.1-25.2]	1858 (25.0) [23.8-26.3]	491 (21.4) [19.3-23.7]	214 (23.2) [20.0-26.8]	
Married or living with partner	5719 (62.1) [60.8-63.3]	3847 (60.7) [59.2-62.1]	1195 (65.7) [63.1-68.3]	677 (64.7) [60.9-68.3]	
Widowed or divorced or separated	1453 (13.8) [13-14.7]	1037 (14.3) [13.3-15.4]	255 (12.8) [11.0-14.9]	161 (12.1) [10.0-14.5]	
BMI (kg/m^2)					0.006
<25	3043 (31.4) [30.2-32.6]	2073 (30.9) [29.5-32.3]	673 (34.3) [31.6-37.0]	297 (28.7) [25.2-32.4]	
≥25, <30	3071 (32.8) [31.6-34]	2105 (32.6) [31.2-34.0]	595 (32.8) [30.1-35.5]	371 (34.6) [31.1-38.4]	
≥30	3621 (35.8) [34.6-37]	2564 (36.5) [35.1-38.0]	673 (33.0) [30.4-35.7]	384 (36.7) [33.0-40.6]	
Alcohol drinkers					<0.001
No	2279 (18.6) [17.7-19.5]	1482 (17.4) [16.4-18.5]	503 (20.4) [18.4-22.5]	294 (23.5) [20.5-26.7]	
Yes	7456 (81.4) [80.5-82.3]	5260 (82.6) [81.5-83.6]	1438 (79.6) [77.5-81.6]	758 (76.5) [73.3-79.5]	
Smoking status					<0.001
Nonsmokers	5670 (57.8) [56.6-59.1]	3791 (55.9) [54.4-57.4]	1205 (62.1) [59.2-64.8]	674 (63.8) [60.0-67.5]	
Former smokers	1647 (19.2) [18.2-20.3]	1146 (19.4) [18.2-20.7]	321 (18.8) [16.6-21.3]	180 (18.6) [15.6-22.0]	
Current smokers	2418 (22.9) [21.9-24]	1805 (24.7) [23.5-26.0]	415 (19.1) [17.0-21.4]	198 (17.6) [14.9-20.7]	
Sun sensitivity					0.003
None	956 (12.7) [11.9-13.7]	649 (12.6) [11.6-13.7]	176 (11.6) [9.8-13.7]	131 (16.2) [13.2-19.7]	
Mild	4667 (52.1) [50.8-53.3]	3297 (52.7) [51.3-54.2]	889 (51.8) [48.9-54.6]	481 (47.7) [43.8-51.6]	
Severe	4112 (35.2) [34-36.3]	2796 (34.6) [33.3-36.0]	876 (36.6) [34.0-39.3]	440 (36.1) [32.6-39.7]	
Time spent outdoors (minute/d)					<0.001
<60	3891 (38.8) [37.6-40.1]	2588 (36.8) [35.4-38.3]	880 (45.4) [42.5-48.2]	423 (40.0) [36.2-43.9]	
≥60	5844 (61.2) [59.9-62.4]	4154 (63.2) [61.7-64.6]	1061 (54.6) [51.8-57.5]	629 (60.0) [56.1-63.8]	
Psoriasis					0.002
No	9480 (97.2) [96.7-97.6]	6557 (97.0) [96.4-97.5]	1907 (98.3) [97.4-98.9]	1016 (96.2) [94.2-97.6]	
Yes	255 (2.8) [2.4-3.3]	185 (3.0) [2.5-3.6]	34 (1.7) [1.1-2.6]	36 (3.8) [2.4-5.8]	

Table S4 Characteristics of participants by the frequency of using sunscreen

Using sunscreen		

	Total (N=9735)	Rare (N=5579)	Moderate (N=1819)	Frequent (N=2337)	*P* value
Age, mean±SD (95% CI), y	39.6±11.7 (39.3-39.9)	39.3 ± 11.9 (38.8-39.7)	39.1 ± 11.7 (38.3-39.8)	40.5 ± 11.3 (39.9-41.1)	<0.001
Gender					<0.001
Female	4882 (49.7) [48.4-50.9]	2282 (39.0) [37.4-40.6]	1001 (50.9) [48.1-53.8]	1599 (66.2) [63.8-68.5]	
Male	4853 (50.3) [49.1-51.6]	3297 (61.0) [59.4-62.6]	818 (49.1) [46.2-51.9]	738 (33.8) [31.5-36.2]	
Race or ethnicity					<0.001
Non-Hispanic White	4030 (64.5) [63.5-65.6]	1771 (51.8) [50.2-53.5]	947 (74.6) [72.6-76.6]	1312 (77.8) [76.1-79.4]	
Non-Hispanic Black	2048 (11.9) [11.3-12.4]	1694 (20.1) [19.1-21.2]	196 (5.4) [4.6-6.2]	158 (3.1) [2.6-3.7]	
Hispanic	938 (6.2) [5.8-6.6]	516 (7.0) [6.4-7.7]	180 (5.5) [4.7-6.4]	242 (5.3) [4.6-6.1]	
Other	2719 (17.4) [16.7-18.2]	1598 (21.0) [19.8-22.2]	496 (14.5) [13.0-16.1]	625 (13.8) [12.6-15.2]	
Education level					<0.001
Less than 9th grade	645 (4.0) [3.6-4.4]	515 (6.5) [5.9-7.2]	57 (1.7) [1.2-2.3]	73 (1.5) [1.2-1.9]	
9-11th grade	1363 (10.9) [10.2-11.6]	1028 (16.2) [15.1-17.4]	155 (6.0) [5.0-7.3]	180 (5.8) [4.9-6.9]	
High school grad/GED or equivalent	2137 (21.1) [20.1-22.1]	1454 (26.9) [25.4-28.4]	344 (17.8) [15.7-20.0]	339 (14.0) [12.4-15.8]	
Some college or AA degree	3115 (33.1) [31.9-34.3]	1710 (32.9) [31.3-34.5]	646 (35.8) [33.1-38.5]	759 (31.3) [29.1-33.7]	
College graduate or above	2475 (31) [29.8-32.2]	872 (17.5) [16.2-18.8]	617 (38.7) [36.0-41.6]	986 (47.4) [44.9-49.8]	
Country of birth					<0.001
Not US born	2793 (18.5) [17.7-19.3]	1649 (21.3) [20.2-22.5]	491 (15.7) [14.1-17.4]	653 (15.8) [14.4-17.3]	
US born	6942 (81.5) [80.7-82.3]	3930 (78.7) [77.5-79.8]	1328 (84.3) [82.6-85.9]	1684 (84.2) [82.7-85.6]	
Marital status					<0.001
Never married	2563 (24.1) [23.1-25.2]	1585 (27.3) [25.8-28.7]	465 (23.8) [21.5-26.2]	513 (19.3) [17.5-21.2]	
Married or living with partner	5719 (62.1) [60.8-63.3]	3096 (57.5) [55.8-59.1]	1109 (62.8) [60.1-65.5]	1514 (69.0) [66.7-71.2]	
Widowed or divorced or separated	1453 (13.8) [13-14.7]	898 (15.3) [14.1-16.5]	245 (13.4) [11.5-15.5]	310 (11.7) [10.3-13.4]	
BMI (kg/m²)					<0.001
<25	3043 (31.4) [30.2-32.6]	1527 (27.0) [25.6-28.5]	615 (32.1) [29.5-34.7]	901 (38.0) [35.6-40.4]	
≥25, <30	3071 (32.8) [31.6-34]	1776 (32.6) [31.0-34.2]	565 (33.4) [30.8-36.2]	730 (32.7) [30.4-35.1]	
≥30	3621 (35.8) [34.6-37]	2276 (40.4) [38.7-42.0]	639 (34.5) [31.9-37.3]	706 (29.3) [27.1-31.6]	
Alcohol drinkers					<0.001
No	2279 (18.6) [17.7-19.5]	1367 (20.3) [19.1-21.6]	377 (16.4) [14.5-18.4]	535 (17.3) [15.6-19.1]	
Yes	7456 (81.4) [80.5-82.3]	4212 (79.7) [78.4-80.9]	1442 (83.6) [81.6-85.5]	1802 (82.7) [80.9-84.4]	

Smoking status				<0.001
Nonsmokers	5670 (57.8) [56.6-59.1]	2946 (50.8) [49.2-52.5]	1188 (64.2) [61.4-66.9]	1536 (64.6) [62.2-67.0]
Former smokers	1647 (19.2) [18.2-20.3]	889 (18.4) [17.0-19.8]	296 (18.0) [15.8-20.3]	462 (21.5) [19.5-23.7]
Current smokers	2418 (22.9) [21.9-24]	1744 (30.8) [29.3-32.4]	335 (17.9) [15.8-20.1]	339 (13.9) [12.2-15.6]
Sun sensitivity				<0.001
None	956 (12.7) [11.9-13.7]	356 (8.2) [7.2-9.3]	198 (13.1) [11.3-15.3]	402 (19.8) [17.9-22.0]
Mild	4667 (52.1) [50.8-53.3]	2385 (47.0) [45.3-48.7]	995 (58.2) [55.4-60.9]	1287 (55.9) [53.5-58.4]
Severe	4112 (35.2) [34-36.3]	2838 (44.8) [43.2-46.4]	626 (28.7) [26.3-31.3]	648 (24.2) [22.2-26.3]
Time spent outdoors (minute/d)				<0.001
<60	3891 (38.8) [37.6-40.1]	2059 (35.0) [33.5-36.6]	753 (39.7) [37.0-42.6]	1079 (44.3) [41.9-46.8]
≥60	5844 (61.2) [59.9-62.4]	3520 (65.0) [63.4-66.5]	1066 (60.3) [57.4-63.0]	1258 (55.7) [53.2-58.1]
Psoriasis				0.04
No	9480 (97.2) [96.7-97.6]	5449 (97.6) [97.0-98.0]	1763 (96.5) [95.1-97.4]	2268 (97.1) [96.1-97.8]
Yes	255 (2.8) [2.4-3.3]	130 (2.4) [2.0-3.0]	56 (3.5) [2.6-4.9]	69 (2.9) [2.2-3.9]

Table S5 Characteristics of participants by the frequency of overall sun protection

	Total (N=9735)	Overall sun protection			
		Rare (N=3249)	Moderate (N=5850)	Frequent (N=636)	P value
Age, mean±SD (95% CI), y	39.6±11.7 (39.3-39.9)	38.7±11.9 (38.2-39.3)	39.7±11.6 (39.3-40.0)	42.8±10.9 (41.7-43.9)	<0.001
Gender					<0.001
Female	4882 (49.7) [48.4-50.9]	1238 (36.5) [34.5-38.6]	3209 (54.7) [53.1-56.3]	435 (65.8) [60.9-70.5]	
Male	4853 (50.3) [49.1-51.6]	2011 (63.5) [61.4-65.5]	2641 (45.3) [43.7-46.9]	201 (34.2) [29.5-39.1]	
Race or ethnicity					<0.001
Non-Hispanic White	4030 (64.5) [63.5-65.6]	1387 (63.7) [61.9-65.6]	2365 (64.4) [63.1-65.8]	278 (69.2) [65.3-72.9]	
Non-Hispanic Black	2048 (11.9) [11.3-12.4]	762 (13.9) [12.9-15.0]	1232 (11.6) [10.9-12.3]	54 (4.9) [3.7-6.4]	
Hispanic	938 (6.2) [5.8-6.6]	295 (6.2) [5.4-7.0]	573 (6.2) [5.7-6.8]	70 (6.3) [4.9-8.1]	
Other	2719 (17.4) [16.7-18.2]	805 (16.2) [15.0-17.6]	1680 (17.8) [16.8-18.8]	234 (19.6) [16.8-22.9]	
Education level					<0.001
Less than 9th grade	645 (4.0) [3.6-4.4]	201 (4.1) [3.5-4.9]	406 (4.1) [3.6-4.6]	38 (2.7) [1.9-3.7]	
9-11th grade	1363 (10.9) [10.2-11.6]	575 (14.6) [13.3-16.1]	733 (9.4) [8.6-10.2]	55 (6.9) [5.1-9.4]	
High school grad/GED or equivalent	2137 (21.1) [20.1-22.1]	838 (26.2) [24.4-28.2]	1217 (19.4) [18.2-20.7]	82 (12.0) [9.2-15.6]	
Some college or AA degree	3115 (33.1) [31.9-34.3]	1056 (34.2) [32.1-36.3]	1871 (33.1) [31.6-34.7]	188 (27.1) [23.0-31.7]	

College graduate or above	2475 (31) [29.8-32.2]	579 (20.8) [19.0-22.7]	1623 (34.0) [32.5-35.6]	273 (51.2) [46.2-56.2]	
Country of birth					<0.001
Not US born	2793 (18.5) [17.7-19.3]	837 (16.5) [15.3-17.9]	1699 (18.6) [17.6-19.7]	257 (26.3) [22.6-30.4]	
US born	6942 (81.5) [80.7-82.3]	2412 (83.5) [82.1-84.7]	4151 (81.4) [80.3-82.4]	379 (73.7) [69.6-77.4]	
Marital status					<0.001
Never married	2563 (24.1) [23.1-25.2]	910 (26.3) [24.5-28.2]	1535 (23.8) [22.5-25.1]	118 (17.1) [13.7-21.0]	
Married or living with partner	5719 (62.1) [60.8-63.3]	1824 (58.8) [56.6-60.9]	3482 (62.9) [61.4-64.5]	413 (69.6) [64.9-73.9]	
Widowed or divorced or separated	1453 (13.8) [13-14.7]	515 (14.9) [13.4-16.5]	833 (13.3) [12.2-14.4]	105 (13.3) [10.4-16.9]	
BMI (kg/m²)					<0.001
<25	3043 (31.4) [30.2-32.6]	973 (28.8) [26.9-30.8]	1845 (32.3) [30.8-33.8]	225 (35.2) [30.5-40.1]	
≥25, <30	3071 (32.8) [31.6-34]	1060 (33.9) [31.9-36.1]	1808 (32.1) [30.6-33.7]	203 (33.6) [29.0-38.5]	
≥30	3621 (35.8) [34.6-37]	1216 (37.2) [35.1-39.4]	2197 (35.6) [34.1-37.1]	208 (31.3) [26.8-36.1]	
Alcohol drinkers					<0.001
No	2279 (18.6) [17.7-19.5]	691 (17.2) [15.7-18.7]	1399 (18.7) [17.6-19.9]	189 (23.3) [19.5-27.6]	
Yes	7456 (81.4) [80.5-82.3]	2558 (82.8) [81.3-84.3]	4451 (81.3) [80.1-82.4]	447 (76.7) [72.4-80.5]	
Smoking status					<0.001
Nonsmokers	5670 (57.8) [56.6-59.1]	1685 (50.9) [48.7-53.1]	3553 (60.3) [58.7-61.9]	432 (67.8) [62.9-72.3]	
Former smokers	1647 (19.2) [18.2-20.3]	545 (19.2) [17.5-21.1]	977 (18.9) [17.6-20.3]	125 (21.6) [17.6-26.3]	
Current smokers	2418 (22.9) [21.9-24]	1019 (29.9) [27.9-31.9]	1320 (20.7) [19.5-22.0]	79 (10.5) [8.1-13.6]	
Sun sensitivity					<0.001
None	956 (12.7) [11.9-13.7]	195 (7.5) [6.4-8.9]	615 (13.7) [12.6-15.0]	146 (28.1) [23.7-33.1]	
Mild	4667 (52.1) [50.8-53.3]	1492 (51.4) [49.2-53.5]	2845 (52.5) [50.9-54.1]	330 (52.1) [47.1-57.1]	
Severe	4112 (35.2) [34-36.3]	1562 (41.1) [39.0-43.2]	2390 (33.8) [32.3-35.3]	160 (19.7) [16.3-23.7]	
Time spent outdoors (minute/d)					<0.001
<60	3891 (38.8) [37.6-40.1]	1068 (31.2) [29.2-33.2]	2486 (41.4) [39.8-43.0]	337 (51.4) [46.4-56.4]	
≥60	5844 (61.2) [59.9-62.4]	2181 (68.8) [66.8-70.8]	3364 (58.6) [57.0-60.2]	299 (48.6) [43.6-53.6]	
Psoriasis					<0.001
No	9480 (97.2) [96.7-97.6]	3174 (97.2) [96.3-97.9]	5698 (97.4) [96.8-97.9]	608 (94.8) [91.8-96.8]	
Yes	255 (2.8) [2.4-3.3]	75 (2.8) [2.1-3.7]	152 (2.6) [2.1-3.2]	28 (5.2) [3.2-8.2]	

BMJ Open

Association between sun-protective behaviors and psoriasis in US adults in the 2009-2014 NHANES: a cross-sectional study

SCHOLARONE™
Manuscripts

BMJ

I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd ("BMJ") its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our licence.

The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge ("APC") for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which Creative Commons licence will apply to this Work are set out in our licence referred to above.

Other than as permitted in any relevant BMJ Author's Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.

Association between sun-protective behaviors and psoriasis in US adults in the

2009-2014 NHANES: a cross-sectional study

Yawen Xuan[1], Yibin Feng[2], Fen Rong[3], Xufeng He[1], Wuqing Wang[1#], Wen Li[1#]

[1]Department of Dermatology, Shuguang Hospital Affiliated to Shanghai University of TCM, Shanghai, China.

[2]School of Chinese Medicine, Li Ka Shing Faculty of Medicine, the University of Hong Kong, 6 Sassoon Road, Pokfulam, Hong Kong.

[3]School of Public Health, Shanghai University of Traditional Chinese Medicine, Shanghai, China.

 # Wuqing Wang and Wen Li are both corresponding authors of this paper.

1. Yawen Xuan

·Title: Bachelor

·Affiliation: School of Public Health, Shanghai University of Traditional Chinese Medicine, Shanghai, China.

·E-mail: yawenx0928@163.com

2. Yibin Feng

·Title: PhD

·Affiliation: School of Chinese Medicine, Li Ka Shing Faculty of Medicine, the University of Hong Kong, 6 Sassoon Road, Pokfulam, Hong Kong.

·E-mail: yfeng@hku.hk

3. Fen Rong

·Title: PhD

1

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

·Affiliation: School of Public Health, Shanghai University of Traditional Chinese Medicine, Shanghai

201203, China.

·E-mail: rf97328@163.com

4. Xufeng He

·Title: MD

·Affiliation: Department of Dermatology, Shuguang Hospital Affiliated to Shanghai University of

TCM, Shanghai, China.

·E-mail: yake2004@163.com

Corresponding authors:

Postal address: Wuqing Wang and Wen Li, Department of Dermatology, Shuguang Hospital Affiliated

to Shanghai University of Traditional Chinese Medicine, Shanghai 201203, China.

Wuqing Wang: E-mail: wuqingw2006@sina.com

Wen Li: E-mail: liwen@shutcm.edu.cn

2

Abstract

Objective: To evaluate the association between sun-protective behaviors and psoriasis in a nationally representative sample of US adults.

Design: Cross-sectional study.

Setting: The National Health and Nutrition Examination Survey (NHANES), 2009-2014.

Participants: A total of 9735 participants aged 20-59 years with available data on psoriasis, sun-protective behaviors, and covariates were included in this study.

Primary and secondary outcome measures: The information on sun-protective behaviors (staying in the shade, wearing long sleeves, and using sunscreen) and psoriasis was obtained from questionnaires in the NHANES database. Logistic regression models and subgroup analyses were employed to investigate the association between sun-protective behaviors and psoriasis.

Results: After adjusting for the sociodemographic, body mass index (BMI), alcohol drinking status, smoking status, sun sensitivity, and time spent outdoors in the multivariable logistic regression model, wearing long sleeves moderately was negatively associated with psoriasis (odds ratio [OR], 0.55; 95% confidence interval [CI], 0.33-0.90, P=0.02), while frequent wearing showed no significant relationship. There was no significant association between staying in the shade and psoriasis, regardless of frequency. Subgroup analyses stratified by age, gender, race/ethnicity, and smoking status revealed no significant associations in most groups, but the moderate wearing of long sleeves was found to be negatively associated with psoriasis among those aged 20 to 39 years (OR, 0.42; 95% CI, 0.18-0.98, P=0.04), among non-Hispanic White individuals (OR, 0.52; 95% CI, 0.28-0.97, P=0.04), and among nonsmokers (OR, 0.49; 95% CI, 0.25-0.95, P=0.04), as it was among females in overall sun protection (OR, 0.58; 95% CI, 0.35-0.97, P=0.04). However, among non-Hispanic White individuals (shade: OR,

3

1.69; 95% CI, 1.00-2.84, *P*=0.049) and former/current smokers (overall: OR, 3.28; 95% CI, 1.41-7.63,

P=0.009), frequent sun protection was positively associated with psoriasis.

Conclusions: Moderate sun-protective behaviors among US adults were found to be negatively

associated with psoriasis. However, among non-Hispanic White individuals and former/current

smokers, frequent sun protection was positively associated with psoriasis. Future studies with rigorous

study design could further explore and validate the potential reasons for these associations to better

inform evidence-based behavioral recommendations that protect human health.

4

Article Summary

Strengths and limitations of this study

- The data in the NHANES database are nationally representative and collected under strict control.

- In this study, subgroup analyses were employed in addition to logistic regression to explore the

  relationships between sun-protective behaviors and psoriasis in specific subgroups.

- This study adjusted for a variety of confounding variables to make the results reliable.

- As with the feature of any cross-sectional study, only association but no causal link could be

  determined.

- Self-reported psoriasis and sun-protective behaviors may induce recall bias and reporting bias.

5

1. Introduction

Psoriasis is a prevalent chronic inflammatory skin disease that will cause a decline in quality of life, sleep impairment, psychological problems and other consequences[1]. The prevalence of it is anticipated to increase[2], with the current prevalence of about 3% in US adults, affecting over 7.5 million US adults[3].

A range of therapeutic interventions exists for psoriasis, including pharmacotherapy, psychotherapy, and rapidly developing biologic therapies. Phototherapy modalities (broadband ultraviolet B [BB-UVB], narrowband ultraviolet B [NB-UVB] and heliotherapy) are endorsed as effective and safe treatment options by the Joint American Academy of Dermatology and National Psoriasis Foundation guidelines[4]. It is commonly used for psoriasis due to its efficacy and safety. Empirical evidence indicates that ultraviolet B (UVB) contributes to faster lesion clearance, fewer excessive erythema episodes, and longer remission periods in psoriasis[5] by inducing apoptosis in keratinocytes[6], CD4+ T cells and CD8+ T cells[7], inhibiting mast cell degranulation and histamine release[8], immunosuppression and changing the level of cytokines such as interleukin [IL]-10, IL-17A[9 10]. Furthermore, there are several pieces of evidence supporting the notion that UVB therapy or heliotherapy enhances vitamin D levels and lessens the severity of psoriasis[11 12]. An association between low levels of serum 25-hydroxyvitamin D(25(OH)D) and increased risk of developing psoriasis has been observed[13]. In addition, psoriasis tends to manifest more frequently in winter than in summer[14 15], which suggests that ultraviolet (UV) radiation might influence this seasonal variation.

In the US, some health organizations and clinicians advocate for using sunscreen and other sun protection measures to reduce the risk of developing melanoma and other skin cancer as well as to prevent premature skin aging. This raises concerns regarding whether sun protection will hinder the cutaneous synthesis of vitamin D, diminish the beneficial effects of UV radiation on the skin, and thus be detrimental to cardiovascular, metabolism, bone and skeletal health, and skin health[16 17]. Thyssen et al. have proposed that reduced environmental UV exposure may be a potential driver of the current epidemic of atopic dermatitis[18]. As for psoriasis, the prevalence of psoriasis exhibits considerable variation

6

across different geographic locations[19]. Research has shown that higher latitudes generally correspond with increased

prevalence rates[20 21]. Both genetic and environmental factors probably contribute to the correlation, but variation in

UV exposure must also be touched on. Therefore, given UV radiation's therapeutic role in psoriasis and the geographical

differences in UV exposure, it is pertinent to explore whether sun-protective behaviors may cause or aggravate psoriasis.

Despite having found that using sunscreen for both daily and recreational photo-protection has no impact on the synthesis

of vitamin D[22], there is scarce data on whether sunscreen use and other sun-protective behaviors affect the prevalence

of psoriasis.

To address this research gap, this cross-sectional study analyzed data from the 2009 to 2014 cycles of the National

Health and Nutrition Examination Survey (NHANES) to explore the association between multimodal sun-protective

behaviors and psoriasis prevalence among US adults.

2. Methods

2.1 Data Sources

We used NHANES data from 2009 to 2014 to investigate the association between multimodal sun-protective behaviors

and the prevalence of psoriasis among US adults[23]. The NHANES is a nationally representative survey that captures

statistics of the US non-institutionalized civilian population on a biennial basis based on complex survey design and

population-specific sample weights in order to assess their health or nutritional status.

2.2 Study Design and Population

This was a population-based cross-sectional study. Our analyses were based on data collected from participants during

three 2-year NHANES cycles (2009-2010, 2011-2012 and 2013-2014).

The total number of initial NHANES participants from 2009-2014 was 30468. Of 11842 participants aged 20-59

years, 6 participants were excluded due to unavailable self-reported psoriasis data, and 168 participants were excluded due

7

to unavailable information on three kinds of sun-protective behaviors. Additionally, 1933 participants with missing data

on covariates, including age, gender, race or ethnicity, education level, marital status, country of birth, body measure index

(BMI), alcohol drinking status, smoking status, sun sensitivity and time spent outdoors were excluded, making 9735

individuals included in the final analysis (**figure 1**).

To our knowledge, all participants provided informed consent for data collection and for the data to be publicly

disseminated in a de-identified format.

2.3 Psoriasis

The information was obtained from the medical conditions section of the questionnaire data in NHANES. The

participants aged 20 years and older were asked if they had ever been told by a doctor or other health care professional

that they had psoriasis. If the answer is "yes," he or she is considered to have psoriasis.

2.4 Sun-Protective Behaviors, Sun Sensitivity and Time Spent Outdoors

We assessed three different sun-protective behaviors from the NHANES dermatology questionnaire section (DEQ), for

which the target group was participants aged 20-59 years. The question asked for sun protective behaviors was: "When

you go outside on a very sunny day, for more than one hour, how often do you (1) stay in the shade, (2) wear a long-

sleeved shirt, (3) use sunscreen?" The valid answers can be "always," "most of the time," "sometimes," "rarely," "never"

and "don't go out in the sun." We reclassified these different answers into 3 categories: frequent (always or most of the

time), moderate (sometimes), or rare (never, rarely or don't go out in the sun). Furthermore, overall sun protection was

classified into three levels according to a total score for three sun-protective behaviors. The total score for sun protection

ranging from 3 to 9 was further divided down into rare (3-4), moderate (5-7), and frequent (8-9) categories[24] after

every behavior was scored 1, 2 or 3 depending on their frequency of use (rare, moderate and frequent).

Sun sensitivity was defined based on the question about skin reaction to the sun without sunscreen or protective

8

clothing for half an hour after several months of not being exposed to the sun. According to their responses, survey

participants were then divided into three groups: no sun sensitivity ("nothing would happen"), mild sun sensitivity

("mildly burn with some tanning" or "turn darker without a sunburn") and severe sun sensitivity ("severe sunburn with

blisters" or "severe sunburn for a few days with peeling").

In NHANES 2009-2014 cycles, participants were questioned how many minutes they spent outdoors over the

previous 30 days between 9 a.m. and 5 p.m. on workdays and non-workdays. Considering a week with five working days

and two off, we calculated the average time (minutes/day) spent outdoors using the following formula: (minutes outdoors

9 a.m.-5 p.m. on working days×5+minutes outdoors 9 a.m.-5 p.m. on nonworking days×2)/7. If the response is "does not

work or go to school" for the working day or "at work or at school 9 to 5 seven days a week" for the nonworking day, the

counterpart will be regarded as the final average time.

2.5 Other covariates

In addition to sun sensitivity and time spent outdoors, the other covariates included age, gender, race or ethnicity,

education level, marital status, country of birth, BMI, alcohol drinking status, and smoking status. Race or ethnicity was

derived from responses to the survey questions on race and Hispanic origin in the demographics file. Respondents were

reclassified into four groups: non-Hispanic White, non-Hispanic Black, Hispanic and other (Mexican American or other

race [including multi-racial]). Marital status was categorized into the following 3 groups: never married, married or

living with a partner and widowed, divorced or separated. Country of birth was encoded as a binary variable (0, born in

another country; 1, born in the US). BMI was calculated as weight in kilograms divided by height in meters squared and

then was analyzed as a three-categorical variable (BMI<25, 25≤BMI<30, BMI≤30) in the multivariable models. The

survey question, "In any 1 year, have you had at least 12 drinks of any type of alcoholic beverage?" was used to establish

participants' alcohol drinking status. Participants who responded "yes" were considered to be alcohol drinkers. Smoking

status was divided into 3 categories: nonsmoker (smoked<100 cigarettes in a lifetime), former smoker (smoked≥100

9

cigarettes in a lifetime but has quit), and current smoker (smoked≥100 cigarettes in a lifetime and still on smoking),

according to data on cigarette use in the questionnaire.

2.6 Statistical Analysis

All analyses were conducted in accordance with the NHANES analytic guidelines[25 26], taking into consideration the

complex sample design and appropriate sampling weights. In this study, we extracted three cycles of NHANES; thus the

sampling weight was calculated using the following equation: full sample 6-year mobile examination center (MEC) exam

weight=full sample 2-year MEC exam weight/3. Continuous data were reported as means, standard deviations and 95%

confidence intervals [CIs], whilst categorical data were expressed as numbers, weighted percentage frequencies and 95%

CIs. T-tests for comparing continuous data and χ^2 tests for comparing categorical data were used for comparing baseline

characteristics by the presence of psoriasis. Unadjusted and multivariable adjusted logistic regression analyses were

performed to calculate weighted odd ratios (ORs) and 95% CIs to explore the association between sun protection and

psoriasis. The multivariable model was adjusted for potential confounders (i.e., age, gender, race or ethnicity, education

level, marital status, country of birth, alcohol drinking status, smoking status, sun sensitivity and time spent outdoors).

Subgroup analyses stratified by age, gender, race or ethnicity, and smoking status were conducted to determine the

association in specific subgroups. Notably, in all models, staying in the shade, wearing long sleeves, using sunscreen and

overall sun protection were modeled separately. In all tests, p-values of less than 0.05 (2-sided) were considered to be

statistically significant. All statistical analyses were conducted in Stata (Stata Corp.), version 17.

3. RESULTS

3.1 Characteristics of the Population

Baseline characteristics and comparisons of included and excluded participants were shown in **supplementary table 1**.

10

Of 9735 participants who were finally included in our study, 255 (2.8%) had psoriasis, while 9480 (97.2%) did not. As

shown in **table 1**, 50.3% of participants were male and the weighted mean age of the participants was 39.6 years (95%

CI: 39.3-39.9). Compared with participants without psoriasis, patients with psoriasis were more likely to be older (+3.2

years), non-Hispanic White, US-born and former smokers, but they did not differ significantly in gender, education level,

marital status, BMI and alcohol drinking status. Additionally, participants with psoriasis had a lower prevalence of severe

sun sensitivity, but no difference existed in the time spent outdoors. In terms of frequent staying in the shade, wearing

long sleeves, using sunscreen and overall sun protection, the percentages were 31.0% (95% CI: 29.8%-32.1%), 9.0%

(95% CI: 8.3%-9.7%), 29.8% (95% CI: 28.6%-31.0%), and 6.8% (95% CI: 6.2%-7.5%), respectively. There were

significantly different distributions in long sleeves (*P*=0.002), sunscreen use (*P*=0.04) and overall sun protection

(*P*<0.001) between the psoriasis group and the non-psoriasis group. Additionally, we presented the characteristics of

participants by the frequency of sun-protective behaviors including staying in the shade, wearing long sleeves, using

sunscreen and overall sun protection, as shown in **supplementary table 2~5**, respectively.

Table 1 Characteristics of participants by psoriasis in 2009-2014, NHANES

| Characteristic | Participants | | | |
	Total (N=9735)	Without psoriasis (n=9480)	With psoriasis (n=255)	*P* value
Age, mean±SD (95% CI), y	39.6±11.7 (39.3-39.9)	39.5±11.7 (39.2-39.8)	42.7±11.3 (40.9-44.5)	**<0.001**
Gender				
Female	4882 (49.7) [48.4-50.9]	4750 (49.7) [48.4-50.9]	132 (50.0) [42.2-57.8]	0.91
Male	4853 (50.3) [49.1-51.6]	4730 (50.3) [49.1-51.6]	123 (50.0) [42.2-57.8]	
Race or ethnicity				
Non-Hispanic White	4030 (64.5) [63.5-65.6]	3883 (64.2) [63.1-65.2]	147 (77.4) [72.0-82.0]	
Non-Hispanic Black	2048 (11.9) [11.3-12.4]	2021 (12.0) [11.5-12.6]	27 (5.4) [3.6-8.0]	**<0.001**
Hispanic	938 (6.2) [5.8-6.6]	915 (6.2) [5.8-6.7]	23 (5.3) [3.4-8.2]	
Other[a]	2719 (17.4) [16.7-18.2]	2661 (17.6) [16.8-18.4]	58 (11.9) [8.7-16.1]	
Education level				
Less than 9th grade	645 (4.0) [3.6-4.4]	631 (4.0) [3.7-4.4]	14 (2.3) [1.3-4.1]	
9-11th grade	1363 (10.9) [10.2-11.6]	1336 (11.0) [10.3-11.7]	27 (6.7) [4.3-10.5]	
High school grad/GED or equivalent	2137 (21.1) [20.1-22.1]	2080 (21.1) [20.1-22.1]	57 (21.5) [15.8-28.6]	0.06
Some college or AA degree	3115 (33.1) [31.9-34.3]	3035 (33.1) [31.9-34.3]	80 (33.0) [26.0-40.9]	

11

College graduate or above	2475 (31.0) [29.8-32.2]	2398 (30.8) [29.6-32.1]	77 (36.4) [29.1-44.4]	
Country of birth				
Not US born	2793 (18.5) [17.7-19.3]	2745 (18.7) [17.9-19.5]	48 (9.9) [7.1-13.6]	**<0.001**
US born	6942 (81.5) [80.7-82.3]	6735 (81.3) [80.5-82.1]	207 (90.1) [86.4-92.9]	
Marital status				
Never married	2563 (24.1) [23.1-25.2]	2507 (24.2) [23.1-25.2]	56 (22.9) [17.0-30.1]	
Married or living with partner	5719 (62.1) [60.8-63.3]	5571 (62.1) [60.9-63.3]	148 (61.4) [53.6-68.7]	0.64
Widowed or divorced or separated	1453 (13.8) [13.0-14.7]	1402 (13.8) [12.9-14.7]	51 (15.7) [10.9-22]	
BMI (kg/m²)				
<25	3043 (31.4) [30.2-32.6]	2977 (31.5) [30.4-32.7]	66 (26.2) [20.0-33.5]	
≥25, <30	3071 (32.8) [31.6-34.0]	2991 (32.7) [31.5-34.0]	80 (35.4) [28.1-43.4]	0.17
≥30	3621 (35.8) [34.6-37.0]	3512 (35.7) [34.5-37.0]	109 (38.5) [31.3-46.2]	
Alcohol drinkers				
No	2279 (18.6) [17.7-19.5]	2226 (18.6) [17.7-19.5]	53 (17.7) [12.8-23.9]	
Yes	7456 (81.4) [80.5-82.3]	7254 (81.4) [80.5-82.3]	202 (82.3) [76.1-87.2]	0.70
Smoking status				
Nonsmokers	5670 (57.8) [56.6-59.1]	5547 (58.1) [56.8-59.3]	123 (49.2) [41.4-57.0]	
Former smokers	1647 (19.2) [18.2-20.3]	1587 (18.9) [17.9-20.0]	60 (30.1) [23.0-38.2]	**<0.001**
Current smokers	2418 (22.9) [21.9-24.0]	2346 (23.0) [22.0-24.1]	72 (20.8) [15.7-27.0]	
Sun sensitivity[b]				
None	956 (12.7) [11.9-13.7]	923 (12.7) [11.8-13.6]	33 (15.4) [10.3-22.4]	
Mild	4667 (52.1) [50.8-53.3]	4524 (51.9) [50.6-53.2]	143 (58.4) [50.6-65.9]	**0.006**
Severe	4112 (35.2) [34.0-36.3]	4033 (35.4) [34.3-36.6]	79 (26.2) [20.1-33.3]	
Time spent outdoors[c] (minute/d)				
<60	3891 (38.8) [37.6-40.1]	3790 (38.9) [37.7-40.2]	101 (35.2) [28.1-42.9]	
≥60	5844 (61.2) [59.9-62.4]	5690 (61.1) [59.8-62.3]	154 (64.8) [57.1-71.9]	0.21
Staying in the shade				
Rare	2546 (27.2) [26.0-28.3]	2489 (27.2) [26.1-28.4]	57 (24.8) [18.6-32.2]	
Moderate	3776 (41.9) [40.6-43.1]	3677 (42.0) [40.7-43.3]	99 (37.9) [30.7-45.7]	0.07
Frequent	3413 (31.0) [29.8-32.1]	3314 (30.8) [29.6-31.9]	99 (37.3) [30.0-45.2]	
Wearing long sleeves				
Rare	6742 (70.9) [69.8-72.1]	6557 (70.8) [69.6-71.9]	185 (76.0) [68.8-81.9]	
Moderate	1941 (20.1) [19.1-21.1]	1907 (20.3) [19.3-21.4]	34 (12.0) [7.9-17.9]	**0.002**
Frequent	1052 (9.0) [8.3-9.7]	1016 (8.9) [8.2-9.6]	36 (12.0) [7.9-17.9]	
Using sunscreen				
Rare	5579 (48.5) [47.2-49.7]	5449 (48.7) [47.4-50.0]	130 (41.8) [34.5-49.5]	
Moderate	1819 (21.8) [20.7-22.9]	1763 (21.6) [20.5-22.7]	56 (27.2) [20.5-35.2]	**0.04**
Frequent	2337 (29.8) [28.6-31.0]	2268 (29.7) [28.5-31.0]	69 (31.0) [24.2-38.8]	
Overall sun protection[d]				
Rare	3249 (31.9) [30.8-33.1]	3174 (31.9) [30.8-33.1]	75 (31.4) [24.5-39.1]	
Moderate	5850 (61.3) [60.0-62.5]	5698 (61.4) [60.2-62.6]	152 (56.1) [48.2-63.7]	**<0.001**
Frequent	636 (6.8) [6.2-7.5]	608 (6.7) [6.0-7.4]	28 (12.5) [7.9-19.3]	

12

Data are presented as unweighted number (weighted percentage) [95% CI] unless otherwise indicated.

Abbreviations: NHANES, National Health and Nutrition Examination Survey; BMI, body mass index (calculated as weight in kilograms divided by height in meters squared). Boldface indicates statistical significance.

[a] Included Mexican American and multiracial participants.

[b] Sun sensitivity was determined by the answer to the skin reaction to the sun without sunscreen or protective clothing for half an hour: none ("nothing would happen"), mild ("mildly burn with some tanning" or "turn darker without a sunburn"), and severe ("severe sunburn with blisters" or "severe sunburn for a few days with peeling").

[c] Time spent outdoors refers to the average minutes spent outdoors from 9:00 a.m. to 5:00 p.m. on each day of the week considering that there are 5 working days and 2 non-working days in a week.

[d] Overall sun protection reflects the general condition of sun protection, including staying in the shade, wearing long sleeves and sunscreen.

3.2 Multivariable Regression Analyses

Based on the limited information from NHANES and our understanding of related factors for psoriasis[27] and sun-protective behaviors[28], we included some covariates like some sociodemographic variables, smoking status, BMI and sun sensitivity in the regression models to control for confounding effects. In **table 2,** the results of an unadjusted and a sample-weighted adjusted regression model to evaluate the association between sun-protective behaviors and psoriasis are presented. In the unadjusted one, moderate wearing of long sleeves was associated with a decreased prevalence of psoriasis (OR, 0.55; 95% CI, 0.34-0.89). After adjustment for covariates, the association remained statistically significant (P<0.05). However, overall sun protection had a positive association with psoriasis in the unadjusted model (OR, 1.91; 95% CI, 1.08-3.39), but the relationship disappeared after adjustment. Meanwhile, the other two behaviors were not significantly associated with psoriasis in the unadjusted or adjusted model.

Table 2 Association between sun-protective behaviors and psoriasis in NHANES, 2009-2014

	Presence of psoriasis by sun-protective behaviors			
	Staying in the shade	Wearing long sleeves	Using sunscreen	Overall sun protection
Model	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Unadjusted				
Rare	1 [reference]	1 [reference]	1 [reference]	1 [reference]
Moderate	0.99 (0.66-1.50)	**0.55 (0.34-0.89)***	1.47 (0.98-2.20)	0.93 (0.65-1.32)
Frequent	1.33 (0.88-2.02)	1.26 (0.77-2.03)	1.22 (0.84-1.76)	**1.91 (1.08-3.39)***
Adjusted[a]				
Rare	1 [reference]	1 [reference]	1 [reference]	1 [reference]
Moderate	0.95 (0.62-1.45)	**0.55 (0.33-0.90)***	1.25 (0.82-1.91)	0.90 (0.62-1.31)

13

Frequent	1.42 (0.92-2.18)	1.36 (0.82-2.26)	0.96 (0.62-1.50)	1.67 (0.90-3.12)

Abbreviations: NHANES, National Health and Nutrition Examination Survey; OR, odds ratio. Boldface indicates statistical significance.

*P<0.05, **P<0.01

[a] Adjusted for sociodemographic variables, BMI, alcohol drinking status, smoking status, sun sensitivity, and time spent outdoors.

3.3 Subgroup Analyses

The results of the subgroup analyses, stratified by age, gender, race or ethnicity, and smoking status, are presented in

table 3. Among participants aged 20 to 39 years (OR, 0.42; 95% CI, 0.18-0.98), non-Hispanic White individuals (OR,

0.52; 95% CI, 0.28-0.97), and nonsmokers (OR, 0.49; 95% CI, 0.25-0.95), moderate wearing of long sleeves was

associated with a lower prevalence of psoriasis, as it was among females in terms of overall sun protection (OR, 0.58;

95% CI, 0.35-0.97).

However, among former or current smokers, those with frequent stays in the shade (OR, 1.92; 95% CI, 1.03-3.60),

long sleeves (OR, 2.84; 95% CI, 1.46-5.53) or overall sun protection (OR, 3.28; 95% CI, 1.41-7.63) had a higher

prevalence of psoriasis. There were also slightly significant and positive relationships between frequent shade-seeking

behavior and psoriasis among non-Hispanic White participants (OR, 1.69; 95% CI, 1.00-2.84).

Table 3 Association between sun-protective behaviors and psoriasis, stratified by age, gender, race or ethnicity, and smoking status

Subgroup	frequency	Staying in the shade OR (95% CI)	Wearing long sleeves OR (95% CI)	Using sunscreen OR (95% CI)	Overall sun protection OR (95% CI)
Overall					
Unadjusted	Rare	1 [reference]	1 [reference]	1 [reference]	1 [reference]
	Moderate	0.99 (0.66-1.50)	**0.55 (0.34-0.89)***	1.47 (0.98-2.20)	0.93 (0.65-1.32)
	Frequent	1.33 (0.88-2.02)	1.26 (0.77-2.03)	1.22 (0.84-1.76)	**1.91 (1.08-3.39)***
Adjusted	Rare	1 [reference]	1 [reference]	1 [reference]	1 [reference]
	Moderate	0.95 (0.62-1.45)	**0.55 (0.33-0.90)***	1.25 (0.82-1.91)	0.90 (0.62-1.31)
	Frequent	1.42 (0.92-2.18)	1.36 (0.82-2.26)	0.96 (0.62-1.50)	1.67 (0.90-3.12)
Age, y					
20-39	Rare	1 [reference]	1 [reference]	1 [reference]	1 [reference]
	Moderate	0.71 (0.40-1.25)	**0.42 (0.18-0.98)***	1.21 (0.66-2.19)	0.91 (0.53-1.55)
	Frequent	1.14 (0.61-2.13)	0.86 (0.31-2.42)	1.23 (0.66-2.29)	1.27 (0.41-3.93)
40-59	Rare	1 [reference]	1 [reference]	1 [reference]	1 [reference]

14

	Moderate	1.24 (0.67-2.27)	0.64 (0.34-1.20)	1.28 (0.73-2.27)	0.92 (0.55-1.53)
	Frequent	1.77 (0.96-3.24)	1.75 (0.97-3.16)	0.84 (0.46-1.53)	1.97 (0.92-4.20)
Gender					
Female	Rare	1 [reference]	1 [reference]	1 [reference]	1 [reference]
	Moderate	0.63 (0.35-1.16)	0.56 (0.28-1.12)	0.88 (0.48-1.59)	**0.58 (0.35-0.97)***
	Frequent	1.33 (0.74-2.39)	1.37 (0.62-3.03)	0.56 (0.31-1.02)	1.23 (0.55-2.76)
Male	Rare	1 [reference]	1 [reference]	1 [reference]	1 [reference]
	Moderate	1.28 (0.72-2.29)	0.53 (0.26-1.07)	1.71 (0.95-3.09)	1.32 (0.78-2.23)
	Frequent	1.40 (0.74-2.64)	1.30 (0.68-2.48)	1.75 (0.97-3.15)	1.95 (0.74-5.11)
Race or ethnicity					
Non-Hispanic White	Rare	1 [reference]	1 [reference]	1 [reference]	1 [reference]
	Moderate	0.93 (0.56-1.55)	**0.52 (0.28-0.97)***	1.28 (0.78-2.11)	0.80 (0.50-1.26)
	Frequent	**1.69 (1.00-2.84)***	1.43 (0.71-2.86)	0.83 (0.48-1.43)	1.73 (0.82-3.66)
other	Rare	1 [reference]	1 [reference]	1 [reference]	1 [reference]
	Moderate	1.14 (0.64-2.03)	0.68 (0.37-1.22)	1.10 (0.59-2.06)	1.39 (0.83-2.32)
	Frequent	0.92 (0.52-1.61)	1.20 (0.68-2.12)	**1.94 (1.09-3.44)***	1.66 (0.72-3.82)
Smoking status					
nonsmokers	Rare	1 [reference]	1 [reference]	1 [reference]	1 [reference]
	Moderate	0.76 (0.42-1.35)	**0.49 (0.25-0.95)***	1.71 (0.93-3.14)	0.74 (0.43-1.26)
	Frequent	1.00 (0.55-1.82)	**0.42 (0.19-0.93)***	1.14 (0.58-2.21)	0.87 (0.36-2.09)
smokers[a]	Rare	1 [reference]	1 [reference]	1 [reference]	1 [reference]
	Moderate	1.20 (0.66-2.20)	0.62 (0.31-1.25)	1.00 (0.53-1.89)	1.12 (0.67-1.85)
	Frequent	**2.05 (1.11-3.78)***	**3.02 (1.57-5.79)****	0.91 (0.49-1.70)	**3.28 (1.41-7.63)****

Each stratification was adjusted for age, gender, race or ethnicity, country of birth, educational level, marital status, BMI, smoking and alcohol drinking status, sun sensitivity, and time spent outdoors except the stratification factor itself. All ORs and 95% CIs are based on data weighted to represent the US population.

*$P<0.05$, **$P<0.01$

Boldface indicates statistical significance.

[a] smokers refer to current smokers and former smokers.

4. DISCUSSION

To our knowledge, this is the first report to investigate the associations between sun-protective behaviors and psoriasis in a population-based setting, specifically in the US adult population. The findings revealed that moderately wearing long sleeves had a statistically significant association with a lower prevalence of psoriasis, even after adjusting for some potential confounders. But no associations were found between psoriasis and either staying in the shade, using sunscreen, or overall sun protection. In subsequent subgroup analysis, significant relationships between moderate sun protective

15

behaviors and a lower prevalence of psoriasis were observed among younger adults aged 20-39, females, non-Hispanic

White individuals, and smokers. Remarkably, among smokers, frequent staying in the shade, wearing of long sleeves,

and overall sun protection were associated with an increased prevalence of psoriasis, whereas moderate use was not.

Among non-Hispanic White participants, frequent sunscreen use was associated with an increased prevalence of

psoriasis, but moderate use was not.

Psoriasis is a chronic and immune-mediated skin disorder attributed to various genetic and environmental factors.

As reported in previous studies, physical trauma[29], lifestyle and habits[30], infection such as streptococcus[31], and

medication[32 33] are risk factors or triggers of psoriasis. The observed relationship between sun protection and a lower

prevalence of psoriasis might be due to sun protection preventing the traumatic effects of excessive UV rays on the skin,

or people practicing moderate sun protection possess higher health awareness, thereby reducing psoriasis triggers related

to infections, unhealthy lifestyles, or medication habits. Natural sunlight, with a wide variety of bands, is more likely to

cause negative skin effects in contrast to NB-UVB and targeted UVB with specific spectrum and controlled doses in the

clinic.

Additionally, although a sizable portion of psoriasis patients respond well to phototherapy (mainly at a UV wavelength of

311 nm), excessive UV exposure can lead to side effects like erythema, blistering and even deterioration of psoriasis. It

was reported that approximately 5.5% of psoriasis cases worsen or develop new lesions post-sun exposure due to

genetics, gender (female), and abnormal UV response, and some even experience symptoms after prolonged

sunbathing[34 35]. They are collectively referred to as photosensitive psoriasis (PP). Consequently, it's necessary for PP

patients to take some daily sun-protective measures. Meanwhile, the association remained after the adjustment of gender,

race or ethnicity, and sun sensitivity in our study, which may suggest the protective effects of moderate sun protection on

the general population as well as the potential predisposing effect of sunlight on psoriasis. However, further research is

warranted to explore the conjecture and the underlying mechanism of these associations.

16

In the past few years, the pathogenesis of psoriasis has been unveiled gradually. The persistence of skin

inflammation due to cutaneous immune disorder is a hallmark of psoriasis. Dendritic cells (DCs), macrophages, different

T cell sets and other cell types via various cytokines such as LL-37, tumor necrosis factor α (TNF-α) and interleukins

play a major role in the initiation and maintenance phases[36], causing higher levels for IL-17, IL-23 and TNF-α, lower

levels for IL-4 and IL-10, and other dysregulation of cytokine secretion[37]. In many studies, it has been found that

sunlight or UV radiation can reduce the number of DCs[38], CD4+ T cells and CD8+ T cells, and modulate immune

homeostasis and cytokine levels in psoriasis[7]. In our study, there was no difference in psoriasis prevalence between

individuals with rare versus frequent sun protection, potentially due to excessive sun protection inhibiting UV's

beneficial effects. The negative impact of insufficient sun protection, combined with excessive protection, links moderate

sun protection to a lower prevalence of psoriasis.

The results of subgroup analyses indicated an opposing association between different frequencies of sun protection

use and psoriasis. Among people aged 20-39, females, non-Hispanic White individuals, and smokers, moderate sun

protection was linked to a lower prevalence of psoriasis. Conversely, frequent sun protection was linked to a higher

prevalence among non-Hispanic White individuals and among smokers. The stronger association observed in younger

adults and females may stem from greater attention to sun protection factor (SPF) in products. Unfortunately, the NHANES

database did not record details on sunscreen such as SPF and usage per time. As for race or ethnicity, previous research

discovered that sun-protective behaviors may significantly reduce the level of 25(OH)D in White individuals compared to

Black and Hispanic individuals[24]. Currently, notable associations between low vitamin D status and psoriasis have been

systematically found, and oral vitamin D supplementation is deemed to be an effective treatment of psoriasis[39]. So, the

decrease in vitamin D caused by frequent sun protection may exacerbate the adverse skin effects brought on by insufficient

UV exposure, which is speculated to be more obvious among White people.

Regarding smoking status, frequent sun protection was positively associated with psoriasis in smokers, whereas

17

wearing long sleeves was negatively associated with psoriasis in nonsmokers. It is widely accepted that smoking can

increase the risk of developing psoriasis[40 41] through several mechanisms[42], including oxidation, inflammation and

genes. Therefore, when combined with the absence of UV immunosuppressive and anti-inflammatory properties due to

excessive use of sun proof, the difference in the risk of developing psoriasis may be amplified.

We also found that over 30% of US adults aged 20-59 rarely engaged in sun protection practices. Especially when it

comes to wearing long sleeves, less than 30% of participants opted to wear them while being outside in the sun for an

hour. Although this phenomenon has been proven to be improving from 2010 to 2020[43], pent-up demand for travel or

holidays is already delivering rapid growth in the US after the lockdown measures for the COVID-19 epidemic were

fully lifted, which exerts a brand-new challenge for American people's consciousness of sun protection. We hope that

our findings can draw public attention to appropriate sun protection measures and encourage further research for

convincing evidence in this area.

This study has several strengths that deserve mentioning. The principal strength of this study is that this is the first

attempt to explore the relationship between sun-protective behaviors and psoriasis. Furthermore, the NHANES database

boasts a large and nationally representative sample size and was collected under strict control, ensuring that the results are

generalizable to the adult population in the US. There are still some limitations that need to be acknowledged. First and

foremost, this is a cross-sectional study that can only suggest association but not causation. Psoriasis may have been

diagnosed years ago, and some sufferers may choose to conceal visible skin lesions through long sleeves or other means

due to shame over their appearance[44 45]. But the collection of information on the frequency of long sleeves has clear

sun protection targeting under specific contexts, which possibly minimizes such reverse causality bias. Therefore,

additional results from well-designed cohort studies are required. Second, our data are from the 2009-2014 cycles of

NHANES and, thus, might not provide a precise representation of present-day circumstances. To ensure that our analyses

and conclusions are aligned with the most recent trends and conditions, further studies that incorporate more recent data

18

are recommended. Third, data on psoriasis diagnosis and sun-protective behaviors were all obtained in the form of

questionnaire surveys, which were prone to recall bias and reporting bias. Fourth, variations in geographical locations, data

collection timing, sun exposure intervals, and sunscreen type were not captured, which may hinder our capacity to

accurately evaluate the association between sun protection frequency and psoriasis prevalence among individuals with

varying UV exposure levels. Similarly, there may be other covariates that were not considered. Thus, future studies ought

to collect and evaluate more detailed information on geographic location and sun protection, as well as other important

covariates so as to better elucidate the potential relationship. Fifth, UV's dual effects at ~305 nm (sunburn) and 311 nm

(psoriasis therapy) further complicate assessments of sun protection effects, which cannot be clearly distinguished in our

study. Lastly, multiple tests may raise the probability of obtaining a significant result by chance.

5.Conclusions

The findings of this cross-sectional study suggested that moderate sun protection was negatively associated with psoriasis

in the adult population of the US, particularly in White females aged 20 to 39 years and in nonsmokers, while frequent

sun protection was linked to a higher prevalence of psoriasis in White individuals and smokers. Additional research is

required to reach more convincing conclusions and propose practical recommendations on sun protection.

19

Competing interests: None.

Patient consent: None.

Patient and public involvement: Patients and/or the public were not involved in the design, conduct, reporting, or dissemination plans of this research.

Ethics approval: This study involves human participants. All NHANES protocols have been approved by the National Center for Health Statistics Research Ethics Review Board. The specific protocol numbers involved in the study are: #2005-06, #2011-17. All participants in NHANES presented informed consent for data collection and publication. Since the study utilizes publicly accessible and anonymized NHANES data, it is exempt from additional ethical review by the Ethics Committee of Shuguang Hospital Affiliated to Shanghai University of TCM.

Data availability statement: The datasets used in this study are available in a public and open access repository, NHANES. NHANES website: https://www.cdc.gov/nchs/nhanes/index.htm.

References

[1] Langley RG, Krueger GG, Griffiths CE. Psoriasis: epidemiology, clinical features, and quality of life. *Ann Rheum Dis* 2005;64 Suppl 2:ii18-23; discussion ii24-5.

[2] Icen M, Crowson CS, McEvoy MT, et al. Trends in incidence of adult-onset psoriasis over three decades: a population-based study. *J Am Acad Dermatol* 2009;60:394-401.

[3] Armstrong AW, Mehta MD, Schupp CW, et al. Psoriasis Prevalence in Adults in the United States. *JAMA Dermatol* 2021;157:940-46.

[4] Menter A, Gelfand JM, Connor C, et al. Joint American Academy of Dermatology-National Psoriasis Foundation guidelines of care for the management of psoriasis with systemic nonbiologic therapies. *J Am Acad Dermatol* 2020;82:1445-86.

[5] Morita A. Current developments in phototherapy for psoriasis. *J Dermatol* 2018;45:287-92.

[6] Weatherhead SC, Farr PM, Jamieson D, et al. Keratinocyte apoptosis in epidermal remodeling and clearance of psoriasis induced by UV radiation. *J Invest Dermatol* 2011;131:1916-26.

[7] Søyland E, Heier I, Rodríguez-Gallego C, et al. Sun exposure induces rapid immunological changes in skin and peripheral blood in patients with psoriasis. *Br J Dermatol* 2011;164:344-55.

[8] Siiskonen H, Smorodchenko A, Krause K, et al. Ultraviolet radiation and skin mast cells: Effects, mechanisms and relevance for skin diseases. *Exp Dermatol* 2018;27:3-8.

[9] Hart PH, Norval M. More Than Effects in Skin: Ultraviolet Radiation-Induced Changes in Immune Cells in Human Blood. *Front Immunol* 2021;12:694086.

[10] Vacharanukrauh P, Meephansan J, Tangtanatakul P, et al. High-Throughput RNA Sequencing Reveals the Effect of NB-UVB Phototherapy on Major Inflammatory Molecules of Lesional Psoriasis. *Psoriasis (Auckl)* 2021;11:133-49.

[11] Osmancevic A, Landin-Wilhelmsen K, Larkö O, et al. Vitamin D status in psoriasis patients during different treatments with phototherapy. *J Photochem Photobiol B* 2010;101:117-23.

[12] Franken SM, Witte B, Pavel S, et al. Psoriasis and daily low-emission phototherapy: effects on disease and vitamin D level. *Photodermatol Photoimmunol Photomed* 2015;31:83-9.

[13] Charoenngam N, Holick MF. Immunologic effects of vitamin D on human health and disease. 2020;12:2097.

[14] Harvell JD, Selig DJ. Seasonal variations in dermatologic and dermatopathologic diagnoses: a retrospective 15-year analysis of dermatopathologic data. *International Journal of Dermatology* 2016;55:1115-18.

[15] Ammar-Khodja A, Benkaidali I, Bouadjar B, et al. EPIMAG: international cross-sectional epidemiological psoriasis study in the Maghreb. *Dermatology* 2015;231:134-44.

[16] Yang S, Dai F, Wang Z, et al. Association between sun-protective behaviors and hypertension: a cross-sectional study from National Health and Nutrition Examination Survey 2009 to 2014. *BMC Public Health* 2023;23:1862.

[17] Afarideh M, Sartori-Valinotti JC, Tollefson MM. Association of Sun-Protective Behaviors With Bone Mineral Density and Osteoporotic Bone Fractures in US Adults. *JAMA Dermatol* 2021;157:1437-46.

[18] Thyssen JP, Zirwas MJ, Elias PM. Potential role of reduced environmental UV exposure as a driver of the current epidemic of atopic dermatitis. *Journal of Allergy and Clinical Immunology* 2015;136:1163-69.

21

[19] Rosa P, Ireny YKI, Evangelos K, et al. National, regional, and worldwide epidemiology of psoriasis: systematic analysis and modelling study. *BMJ (Clinical research ed)* 2020;369:m1590.

[20] Valerie A, Sandra W, Matthias A, et al. Regional variations and prevalence of psoriasis in Germany from 2010 to 2017: a cross-sectional, spatio-epidemiological study on ambulatory claims data. *BMJ Open* 2021;11:e047806.

[21] Solberg SM. Psoriasis in Norway: A Prescription-based Registry Study of Incidence and Prevalence. *Acta Dermato-Venereologica* 2023;103:adv4591.

[22] Passeron T, Bouillon R, Callender V, et al. Sunscreen photoprotection and vitamin D status. *Br J Dermatol* 2019;181:916-31.

[dataset] [23] National Health and Nutrition Examination Survey, 2009-2014. National Center for Health Statistics, Centers for Disease Control and Prevention. Available: https://www.cdc.gov/nchs/nhanes/index.htm

[24] Linos E, Keiser E, Kanzler M, et al. Sun protective behaviors and vitamin D levels in the US population: NHANES 2003-2006. *Cancer Causes Control* 2012;23:133-40.

[25] National Health and Nutrition Examination Survey: Analytic Guidelines, 1999-2010. National Health and Nutrition Examination Survey. Available: https://wwwn.cdc.gov/nchs/data/nhanes/analyticguidelines/99-10-analytic-guidelines.pdf

[26] National Health and Nutrition Examination Survey: Analytic Guidelines, 2011-2016. National Health and Nutrition Examination Survey. Available: https://wwwn.cdc.gov/nchs/data/nhanes/analyticguidelines/11-16-analytic-guidelines.pdf

[27] Griffiths CEM, Armstrong AW, Gudjonsson JE, et al. Psoriasis. *The Lancet* 2021;397:1301-15.

[28] Haluza D, Simic S, Höltge J, et al. Gender aspects of recreational sun-protective behavior: results of a representative, population-based survey among Austrian residents. *Photodermatol Photoimmunol Photomed* 2016;32:11-21.

[29] Shams K, Kurowska-Stolarska M, Schütte F, et al. MicroRNA-146 and cell trauma down-regulate expression of the psoriasis-associated atypical chemokine receptor ACKR2. *J Biol Chem* 2018;293:3003-12.

[30] Madden SK, Flanagan KL, Jones G. How lifestyle factors and their associated pathogenetic mechanisms impact psoriasis. *Clin Nutr* 2020;39:1026-40.

[31] Garritsen FM, Kraag DE, de Graaf M. Guttate psoriasis triggered by perianal streptococcal infection. *Clinical and Experimental Dermatology* 2017;42:536-38.

[32] Fry L, Baker BS. Triggering psoriasis: the role of infections and medications. *Clinics in Dermatology* 2007;25:606-15.

[33] Wu S, Han J, Li W-Q, et al. Hypertension, antihypertensive medication use, and risk of psoriasis. *JAMA Dermatol* 2014;150:957-63.

[34] Ros A-M, Eklund G, D O. Photosensitive psoriasis: an epidemiologic study. *J Am Acad Dermatol* 1987;17:752-58.

[35] Rutter KJ, Watson RE, Cotterell LF, et al. Severely photosensitive psoriasis: a phenotypically defined patient subset. *J Invest Dermatol* 2009;129:2861-7.

[36] Rendon A, Schäkel K. Psoriasis Pathogenesis and Treatment. *Int J Mol Sci* 2019;20:1475.

[37] Li X, Xiao QQ, Li FL, et al. Immune Signatures in Patients with Psoriasis Vulgaris of Blood-Heat Syndrome: A Systematic Review and Meta-Analysis. *Evidence-based complementary and alternative medicine : eCAM* 2016;2016:9503652.

22

[38] Heier I, Søyland E, Krogstad AL, et al. Sun exposure rapidly reduces plasmacytoid dendritic cells and inflammatory dermal dendritic cells in psoriatic skin. *Br J Dermatol* 2011;165:792-801.

[39] Barrea L, Savanelli MC, Di Somma C, et al. Vitamin D and its role in psoriasis: An overview of the dermatologist and nutritionist. *Rev Endocr Metab Disord* 2017;18:195-205.

[40] Williams HC. Smoking and psoriasis. *BMJ (Clinical research ed)* 1994;308:428.

[41] Wei J, Zhu J, Xu H, et al. Alcohol consumption and smoking in relation to psoriasis: a Mendelian randomization study. *British Journal of Dermatology* 2022;187:684-91.

[42] Armstrong AW, Armstrong EJ, Fuller EN, et al. Smoking and pathogenesis of psoriasis: a review of oxidative, inflammatory and genetic mechanisms. *British Journal of Dermatology* 2011;165:1162-68.

[43] McKenzie C, Nahm WJ, Kearney CA, et al. Sun-protective behaviors and sunburn among US adults. *Archives of Dermatological Research* 2023;315:1665-74.

[44] Adesanya EI, Matthewman J, Schonmann Y, et al. Factors associated with depression, anxiety and severe mental illness among adults with atopic eczema or psoriasis: a systematic review and meta-analysis. *British Journal of Dermatology* 2023;188:460-70.

[45] Jankowiak B, Kowalewska B, Krajewska-Kułak E, et al. Stigmatization and Quality of Life in Patients with Psoriasis. *Dermatology and Therapy* 2020;10:285-96.

23

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

Figure legends

Figure 1 Flow diagram of the screening process for the study participants' selection. Sun- protective

behaviors include staying in the shade, wearing long sleeves, and using sunscreen. BMI, body mass index.
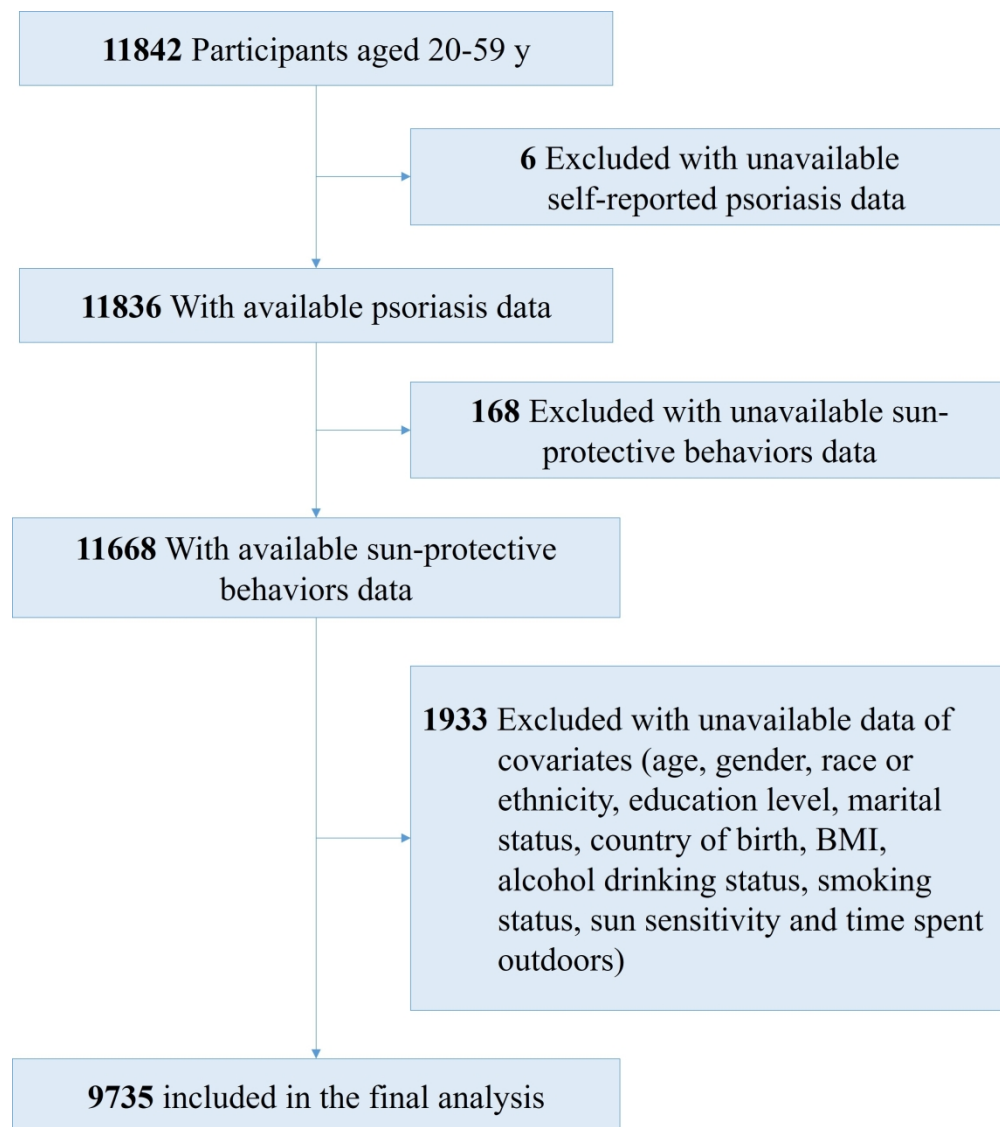
24

Figure 1. Flow diagram of the screening process for the study participants' selection. Sun-protective behaviors include staying in the shade, wearing long sleeves, and using sunscreen. BMI, body mass index.

225x253mm (330 x 330 DPI)

Table S1 Characteristics of included and excluded participants

	Excluded	Included	*P* value
Number of participants, n (%)	2107 (17.8)	9735 (82.2)	
Age, Mean±SD, y	39.3±11.0	39.1 ± 11.5	0.33
Gender, n (%)			<0.001
Female	1227 (58.2)	4882 (50.1)	
Male	880 (41.8)	4853 (49.9)	
Race and ethnicity, n (%)			<0.001
Non-Hispanic White	676 (32.1)	4030 (41.4)	
Non-Hispanic Black	478 (22.7)	2048 (21.0)	
Hispanic	233 (11.1)	938 (9.6)	
Other[a]	720 (34.2)	2719 (27.9)	
Education level, n (%)			<0.001
Less than 9th grade	230 (10.9)	645 (6.6)	
9-11th grade	343 (16.3)	1363 (14.0)	
High school grad/GED or equivalent	467 (22.2)	2137 (22.0)	
Some college or AA degree	582 (27.6)	3115 (32.0)	
College graduate or above	472 (22.4)	2475 (25.4)	
Missing	13 (0.6)	0 (0)	
Country of birth, n (%)			<0.001
Not US born	844 (40.1)	2793 (28.7)	
US born	1257 (59.7)	6942 (71.3)	
Missing	6 (0.3)	0 (0)	
Marital status, n (%)			<0.001
Never married	533 (25.3)	2563 (26.3)	
Married or living with a partner	1233 (58.5)	5719 (58.7)	
Widowed or divorced or separated	334 (15.9)	1453 (14.9)	
Missing	7 (0.3)	0 (0)	
BMI (kg/m^2), n (%)			<0.001
<25	552 (26.2)	3043 (31.3)	
≥25, <30	500 (23.7)	3071 (31.5)	
≥30	605 (28.7)	3621 (37.2)	
Missing	450 (21.4)	0 (0)	
Alcohol drinkers, n (%)			<0.001
No	112 (5.3)	2279 (23.4)	
Yes	227 (10.8)	7456 (76.6)	
Missing	1768 (83.9)	0 (0)	
Smoking status, n (%)			<0.001
Nonsmokers	1280 (60.7)	5670 (58.2)	
Former smokers	298 (14.1)	1647 (16.9)	
Current smokers	523 (24.8)	2418 (24.8)	
Missing	6 (0.3)	0 (0)	
Sun sensitivity[b], n (%)			<0.001
None	146 (6.9)	956 (9.8)	

Mild	858 (40.7)	4667 (47.9)	
Severe	957 (45.4)	4112 (42.2)	
Missing	146 (6.9)	0 (0)	
Time spent outdoors[c], n (%)			<0.001
<60 min/d	950 (45.1)	3891 (40.0)	
≥60 min/d	1114 (52.9)	5844 (60.0)	
Missing	43 (2.0)	0 (0)	

[a] Included Mexican American and multiracial participants.

[b] Sun sensitivity was divided into three levels according to skin reaction to sun without sunscreen or protective clothing for half an hour: none (defined as "nothing would happen"), mild (defined as "mildly burn with some tanning" and "turn darker without a sunburn"), and severe (defined as "severe sunburn with blisters" and "severe sunburn for a few days with peeling").

[c] Time spent outdoors was recalculated based on minutes spent outdoors from 9:00 am to 5:00 pm on working days and non-working days, considering that there are 5 working days and 2 non-working days in a week.

Table S2 Characteristics of participants by the frequency of staying in the shade

| | Total (N=9735) | Staying in the shade | | | P value |
		Rare (N=2546)	Moderate (N=3776)	Frequent (N=3413)	
Age, mean ± SD (95% CI), y	39.6±11.7 (39.3-39.9)	39.1±11.9 (38.5-39.7)	39.2±11.8 (38.7-39.7)	40.5±11.5 (40.0-41.0)	<0.001
Gender					<0.001
Female	4882 (49.7) [48.4-50.9]	1012 (41.0) [38.6-43.5]	1770 (46.8) [44.8-48.8]	2100 (61.1) [59.0-63.2]	
Male	4853 (50.3) [49.1-51.6]	1534 (59.0) [56.5-61.4]	2006 (53.2) [51.2-55.2]	1313 (38.9) [36.8-41.0]	
Race or ethnicity					<0.001
Non-Hispanic White	4030 (64.5) [63.5-65.6]	1199 (68.7) [66.7-70.6]	1793 (70.3) [68.8-71.8]	1038 (53.1) [51.0-55.1]	
Non-Hispanic Black	2048 (11.9) [11.3-12.4]	419 (8.9) [8.1-9.9]	715 (9.9) [9.1-10.7]	914 (17.1) [15.9-18.3]	
Hispanic	938 (6.2) [5.8-6.6]	244 (6.0) [5.2-6.8]	284 (4.6) [4.0-5.2]	410 (8.6) [7.7-9.5]	
Other	2719 (17.4) [16.7-18.2]	684 (16.4) [15.0-17.9]	984 (15.3) [14.2-16.4]	1051 (21.3) [19.9-22.8]	
Education level					<0.001
Less than 9th grade	645 (4.0) [3.6-4.4]	207 (4.9) [4.2-5.8]	177 (2.9) [2.4-3.5]	261 (4.7) [4.1-5.3]	
9-11th grade	1363 (10.9) [10.2-11.6]	435 (12.6) [11.3-14.0]	416 (8.3) [7.4-9.4]	512 (12.8) [11.5-14.2]	
High school grad/GED or equivalent	2137 (21.1) [20.1-22.1]	584 (23.0) [21.0-25.1]	833 (20.9) [19.3-22.5]	720 (19.7) [18.1-21.4]	
Some college or AA degree	3115 (33.1) [31.9-34.3]	796 (33.1) [30.9-35.5]	1253 (33.8) [31.9-35.7]	1066 (32.0) [30.0-34.0]	
College graduate or above	2475 (31) [29.8-32.2]	524 (26.4) [24.1-28.7]	1097 (34.1) [32.2-36.0]	854 (30.9) [28.8-33.0]	
Country of birth					<0.001
Not US born	2793 (18.5) [17.7-19.3]	757 (18.2) [16.7-19.7]	917 (15.0) [13.8-16.2]	1119 (23.4) [21.9-25.0]	
US born	6942 (81.5) [80.7-82.3]	1789 (81.8) [80.3-83.3]	2859 (85.0) [83.8-86.2]	2294 (76.6) [75.0-78.1]	
Marital status					0.10
Never married	2563 (24.1) [23.1-25.2]	671 (25.6) [23.6-27.8]	1017 (24.3) [22.7-26.0]	875 (22.6) [20.9-24.3]	
Married or living with partner	5719 (62.1) [60.8-63.3]	1509 (60.8) [58.4-63.2]	2205 (62.2) [60.3-64.1]	2005 (62.9) [60.9-64.9]	
Widowed or divorced or separated	1453 (13.8) [13-14.7]	366 (13.6) [12.0-15.4]	554 (13.5) [12.2-14.9]	533 (14.5) [13.0-16.1]	
BMI (kg/m²)					<0.001
<25	3043 (31.4) [30.2-32.6]	848 (32.7) [30.5-35.0]	1219 (32.1) [30.3-34.0]	976 (29.2) [27.3-31.2]	
≥25, <30	3071 (32.8) [31.6-34]	861 (34.7) [32.3-37.1]	1195 (33.4) [31.5-35.3]	1015 (30.4) [28.5-32.5]	
≥30	3621 (35.8) [34.6-37]	837 (32.6) [30.4-35.0]	1362 (34.5) [32.7-36.4]	1422 (40.3) [38.3-42.4]	
Alcohol drinkers					<0.001
No	2279 (18.6) [17.7-19.5]	524 (16.3) [14.7-18.0]	764 (16.3) [15.0-17.8]	991 (23.6) [22.0-25.3]	
Yes	7456 (81.4) [80.5-82.3]	2022 (83.7) [82.0-85.3]	3012 (83.7) [82.2-85.0]	2422 (76.4) [74.7-78.0]	
Smoking status					<0.001

	Total	Rare	Moderate	Frequent	P value
Nonsmokers	5670 (57.8) [56.6-59.1]	1382 (55.1) [52.6-57.5]	2197 (57.3) [55.3-59.2]	2091 (61.0) [58.9-63.1]	
Former smokers	1647 (19.2) [18.2-20.3]	439 (19.5) [17.6-21.6]	659 (19.7) [18.1-21.4]	549 (18.3) [16.6-20.1]	
Current smokers	2418 (22.9) [21.9-24]	725 (25.4) [23.4-27.5]	920 (23.0) [21.4-24.7]	773 (20.7) [19.1-22.4]	
Sun sensitivity					<0.001
None	956 (12.7) [11.9-13.7]	147 (7.6) [6.3-9.1]	327 (10.7) [9.5-12.1]	482 (20.0) [18.1-21.9]	
Mild	4667 (52.1) [50.8-53.3]	1145 (50.0) [47.5-52.4]	1924 (56.3) [54.3-58.2]	1598 (48.3) [46.2-50.4]	
Severe	4112 (35.2) [34-36.3]	1254 (42.4) [40.1-44.9]	1525 (33.0) [31.2-34.8]	1333 (31.7) [29.9-33.6]	
Time spent outdoors (minute/d)					<0.001
<60	3891 (38.8) [37.6-40.1]	856 (31.6) [29.4-33.9]	1399 (36.9) [35.0-38.9]	1636 (47.7) [45.6-49.9]	
≥60	5844 (61.2) [59.9-62.4]	1690 (68.4) [66.1-70.6]	2377 (63.1) [61.1-65.0]	1777 (52.3) [50.1-54.4]	
Psoriasis					0.07
No	9480 (97.2) [96.7-97.6]	2489 (97.4) [96.5-98.1]	3677 (97.4) [96.7-98.0]	3314 (96.6) [95.6-97.4]	
Yes	255 (2.8) [2.4-3.3]	57 (2.6) [1.9-3.5]	99 (2.6) [2.0-3.3]	99 (3.4) [2.6-4.4]	

Table S3 Characteristics of participants by the frequency of wearing of long sleeves

	Total (N=9735)	Wearing long sleeves			P value
		Rare (N=6742)	Moderate (N=1941)	Frequent (N=1052)	
Age, mean±SD (95% CI), y	39.6±11.7 (39.3-39.9)	39.1±11.7 (38.7-39.5)	40.2±11.7 (39.5-40.9)	42.1±11.3 (41.2-43.0)	<0.001
Gender					0.005
Female	4882 (49.7) [48.4-50.9]	3437 (49.9) [48.4-51.4]	982 (51.0) [48.2-53.9]	463 (44.6) [40.7-48.5]	
Male	4853 (50.3) [49.1-51.6]	3305 (50.1) [48.6-51.6]	959 (49.0) [46.1-51.8]	589 (55.4) [51.5-59.3]	
Race or ethnicity					<0.001
Non-Hispanic White	4030 (64.5) [63.5-65.6]	2955 (66.2) [65.0-67.4]	796 (65.9) [63.6-68.2]	279 (48.0) [44.0-52.0]	
Non-Hispanic Black	2048 (11.9) [11.3-12.4]	1453 (11.9) [11.3-12.6]	408 (11.8) [10.6-13.1]	187 (11.6) [10.0-13.5]	
Hispanic	938 (6.2) [5.8-6.6]	688 (6.5) [6.0-7.0]	138 (4.3) [3.6-5.1]	112 (8.2) [6.7-10.0]	
Other	2719 (17.4) [16.7-18.2]	1646 (15.4) [14.6-16.3]	599 (17.9) [16.3-19.7]	474 (32.2) [29.0-35.5]	
Education level					<0.001
Less than 9th grade	645 (4.0) [3.6-4.4]	335 (3.0) [2.7-3.4]	141 (4.3) [3.5-5.3]	169 (10.7) [9.0-12.8]	
9-11th grade	1363 (10.9) [10.2-11.6]	1011 (11.6) [10.8-12.5]	211 (8.1) [6.8-9.5]	141 (11.3) [9.3-13.6]	
High school grad/GED or equivalent	2137 (21.1) [20.1-22.1]	1537 (21.8) [20.6-23.0]	397 (19.7) [17.6-22.0]	203 (18.8) [15.9-21.9]	
Some college or AA degree	3115 (33.1) [31.9-34.3]	2248 (34.4) [33.0-35.8]	589 (30.8) [28.2-33.5]	278 (27.8) [24.4-31.4]	
College graduate or above	2475 (31) [29.8-32.2]	1611 (29.2) [27.8-30.6]	603 (37.1) [34.3-40.0]	261 (31.5) [27.7-35.5]	

Country of birth					<0.001
Not US born	2793 (18.5) [17.7-19.3]	1678 (15.9) [15.0-16.8]	603 (19.2) [17.4-21.1]	512 (37.4) [33.9-41.0]	
US born	6942 (81.5) [80.7-82.3]	5064 (84.1) [83.2-85.0]	1338 (80.8) [78.9-82.6]	540 (62.6) [59.0-66.1]	
Marital status					<0.001
Never married	2563 (24.1) [23.1-25.2]	1858 (25.0) [23.8-26.3]	491 (21.4) [19.3-23.7]	214 (23.2) [20.0-26.8]	
Married or living with partner	5719 (62.1) [60.8-63.3]	3847 (60.7) [59.2-62.1]	1195 (65.7) [63.1-68.3]	677 (64.7) [60.9-68.3]	
Widowed or divorced or separated	1453 (13.8) [13-14.7]	1037 (14.3) [13.3-15.4]	255 (12.8) [11.0-14.9]	161 (12.1) [10.0-14.5]	
BMI (kg/m^2)					0.006
<25	3043 (31.4) [30.2-32.6]	2073 (30.9) [29.5-32.3]	673 (34.3) [31.6-37.0]	297 (28.7) [25.2-32.4]	
≥25, <30	3071 (32.8) [31.6-34]	2105 (32.6) [31.2-34.0]	595 (32.8) [30.1-35.5]	371 (34.6) [31.1-38.4]	
≥30	3621 (35.8) [34.6-37]	2564 (36.5) [35.1-38.0]	673 (33.0) [30.4-35.7]	384 (36.7) [33.0-40.6]	
Alcohol drinkers					<0.001
No	2279 (18.6) [17.7-19.5]	1482 (17.4) [16.4-18.5]	503 (20.4) [18.4-22.5]	294 (23.5) [20.5-26.7]	
Yes	7456 (81.4) [80.5-82.3]	5260 (82.6) [81.5-83.6]	1438 (79.6) [77.5-81.6]	758 (76.5) [73.3-79.5]	
Smoking status					<0.001
Nonsmokers	5670 (57.8) [56.6-59.1]	3791 (55.9) [54.4-57.4]	1205 (62.1) [59.2-64.8]	674 (63.8) [60.0-67.5]	
Former smokers	1647 (19.2) [18.2-20.3]	1146 (19.4) [18.2-20.7]	321 (18.8) [16.6-21.3]	180 (18.6) [15.6-22.0]	
Current smokers	2418 (22.9) [21.9-24]	1805 (24.7) [23.5-26.0]	415 (19.1) [17.0-21.4]	198 (17.6) [14.9-20.7]	
Sun sensitivity					0.003
None	956 (12.7) [11.9-13.7]	649 (12.6) [11.6-13.7]	176 (11.6) [9.8-13.7]	131 (16.2) [13.2-19.7]	
Mild	4667 (52.1) [50.8-53.3]	3297 (52.7) [51.3-54.2]	889 (51.8) [48.9-54.6]	481 (47.7) [43.8-51.6]	
Severe	4112 (35.2) [34-36.3]	2796 (34.6) [33.3-36.0]	876 (36.6) [34.0-39.3]	440 (36.1) [32.6-39.7]	
Time spent outdoors (minute/d)					<0.001
<60	3891 (38.8) [37.6-40.1]	2588 (36.8) [35.4-38.3]	880 (45.4) [42.5-48.2]	423 (40.0) [36.2-43.9]	
≥60	5844 (61.2) [59.9-62.4]	4154 (63.2) [61.7-64.6]	1061 (54.6) [51.8-57.5]	629 (60.0) [56.1-63.8]	
Psoriasis					0.002
No	9480 (97.2) [96.7-97.6]	6557 (97.0) [96.4-97.5]	1907 (98.3) [97.4-98.9]	1016 (96.2) [94.2-97.6]	
Yes	255 (2.8) [2.4-3.3]	185 (3.0) [2.5-3.6]	34 (1.7) [1.1-2.6]	36 (3.8) [2.4-5.8]	

Table S4 Characteristics of participants by the frequency of using sunscreen

		Using sunscreen			

	Total (N=9735)	Rare (N=5579)	Moderate (N=1819)	Frequent (N=2337)	*P* value
Age, mean±SD (95% CI), y	39.6±11.7 (39.3-39.9)	39.3 ± 11.9 (38.8-39.7)	39.1 ± 11.7 (38.3-39.8)	40.5 ± 11.3 (39.9-41.1)	<0.001
Gender					<0.001
Female	4882 (49.7) [48.4-50.9]	2282 (39.0) [37.4-40.6]	1001 (50.9) [48.1-53.8]	1599 (66.2) [63.8-68.5]	
Male	4853 (50.3) [49.1-51.6]	3297 (61.0) [59.4-62.6]	818 (49.1) [46.2-51.9]	738 (33.8) [31.5-36.2]	
Race or ethnicity					<0.001
Non-Hispanic White	4030 (64.5) [63.5-65.6]	1771 (51.8) [50.2-53.5]	947 (74.6) [72.6-76.6]	1312 (77.8) [76.1-79.4]	
Non-Hispanic Black	2048 (11.9) [11.3-12.4]	1694 (20.1) [19.1-21.2]	196 (5.4) [4.6-6.2]	158 (3.1) [2.6-3.7]	
Hispanic	938 (6.2) [5.8-6.6]	516 (7.0) [6.4-7.7]	180 (5.5) [4.7-6.4]	242 (5.3) [4.6-6.1]	
Other	2719 (17.4) [16.7-18.2]	1598 (21.0) [19.8-22.2]	496 (14.5) [13.0-16.1]	625 (13.8) [12.6-15.2]	
Education level					<0.001
Less than 9th grade	645 (4.0) [3.6-4.4]	515 (6.5) [5.9-7.2]	57 (1.7) [1.2-2.3]	73 (1.5) [1.2-1.9]	
9-11th grade	1363 (10.9) [10.2-11.6]	1028 (16.2) [15.1-17.4]	155 (6.0) [5.0-7.3]	180 (5.8) [4.9-6.9]	
High school grad/GED or equivalent	2137 (21.1) [20.1-22.1]	1454 (26.9) [25.4-28.4]	344 (17.8) [15.7-20.0]	339 (14.0) [12.4-15.8]	
Some college or AA degree	3115 (33.1) [31.9-34.3]	1710 (32.9) [31.3-34.5]	646 (35.8) [33.1-38.5]	759 (31.3) [29.1-33.7]	
College graduate or above	2475 (31) [29.8-32.2]	872 (17.5) [16.2-18.8]	617 (38.7) [36.0-41.6]	986 (47.4) [44.9-49.8]	
Country of birth					<0.001
Not US born	2793 (18.5) [17.7-19.3]	1649 (21.3) [20.2-22.5]	491 (15.7) [14.1-17.4]	653 (15.8) [14.4-17.3]	
US born	6942 (81.5) [80.7-82.3]	3930 (78.7) [77.5-79.8]	1328 (84.3) [82.6-85.9]	1684 (84.2) [82.7-85.6]	
Marital status					<0.001
Never married	2563 (24.1) [23.1-25.2]	1585 (27.3) [25.8-28.7]	465 (23.8) [21.5-26.2]	513 (19.3) [17.5-21.2]	
Married or living with partner	5719 (62.1) [60.8-63.3]	3096 (57.5) [55.8-59.1]	1109 (62.8) [60.1-65.5]	1514 (69.0) [66.7-71.2]	
Widowed or divorced or separated	1453 (13.8) [13-14.7]	898 (15.3) [14.1-16.5]	245 (13.4) [11.5-15.5]	310 (11.7) [10.3-13.4]	
BMI (kg/m²)					<0.001
<25	3043 (31.4) [30.2-32.6]	1527 (27.0) [25.6-28.5]	615 (32.1) [29.5-34.7]	901 (38.0) [35.6-40.4]	
≥25, <30	3071 (32.8) [31.6-34]	1776 (32.6) [31.0-34.2]	565 (33.4) [30.8-36.2]	730 (32.7) [30.4-35.1]	
≥30	3621 (35.8) [34.6-37]	2276 (40.4) [38.7-42.0]	639 (34.5) [31.9-37.3]	706 (29.3) [27.1-31.6]	
Alcohol drinkers					<0.001
No	2279 (18.6) [17.7-19.5]	1367 (20.3) [19.1-21.6]	377 (16.4) [14.5-18.4]	535 (17.3) [15.6-19.1]	
Yes	7456 (81.4) [80.5-82.3]	4212 (79.7) [78.4-80.9]	1442 (83.6) [81.6-85.5]	1802 (82.7) [80.9-84.4]	

Smoking status				<0.001
Nonsmokers	5670 (57.8) [56.6-59.1]	2946 (50.8) [49.2-52.5]	1188 (64.2) [61.4-66.9]	1536 (64.6) [62.2-67.0]
Former smokers	1647 (19.2) [18.2-20.3]	889 (18.4) [17.0-19.8]	296 (18.0) [15.8-20.3]	462 (21.5) [19.5-23.7]
Current smokers	2418 (22.9) [21.9-24]	1744 (30.8) [29.3-32.4]	335 (17.9) [15.8-20.1]	339 (13.9) [12.2-15.6]
Sun sensitivity				<0.001
None	956 (12.7) [11.9-13.7]	356 (8.2) [7.2-9.3]	198 (13.1) [11.3-15.3]	402 (19.8) [17.9-22.0]
Mild	4667 (52.1) [50.8-53.3]	2385 (47.0) [45.3-48.7]	995 (58.2) [55.4-60.9]	1287 (55.9) [53.5-58.4]
Severe	4112 (35.2) [34-36.3]	2838 (44.8) [43.2-46.4]	626 (28.7) [26.3-31.3]	648 (24.2) [22.2-26.3]
Time spent outdoors (minute/d)				<0.001
<60	3891 (38.8) [37.6-40.1]	2059 (35.0) [33.5-36.6]	753 (39.7) [37.0-42.6]	1079 (44.3) [41.9-46.8]
≥60	5844 (61.2) [59.9-62.4]	3520 (65.0) [63.4-66.5]	1066 (60.3) [57.4-63.0]	1258 (55.7) [53.2-58.1]
Psoriasis				0.04
No	9480 (97.2) [96.7-97.6]	5449 (97.6) [97.0-98.0]	1763 (96.5) [95.1-97.4]	2268 (97.1) [96.1-97.8]
Yes	255 (2.8) [2.4-3.3]	130 (2.4) [2.0-3.0]	56 (3.5) [2.6-4.9]	69 (2.9) [2.2-3.9]

Table S5 Characteristics of participants by the frequency of overall sun protection

	Total (N=9735)	Overall sun protection			
		Rare (N=3249)	Moderate (N=5850)	Frequent (N=636)	P value
Age, mean±SD (95% CI), y	39.6±11.7 (39.3-39.9)	38.7±11.9 (38.2-39.3)	39.7±11.6 (39.3-40.0)	42.8±10.9 (41.7-43.9)	<0.001
Gender					<0.001
Female	4882 (49.7) [48.4-50.9]	1238 (36.5) [34.5-38.6]	3209 (54.7) [53.1-56.3]	435 (65.8) [60.9-70.5]	
Male	4853 (50.3) [49.1-51.6]	2011 (63.5) [61.4-65.5]	2641 (45.3) [43.7-46.9]	201 (34.2) [29.5-39.1]	
Race or ethnicity					<0.001
Non-Hispanic White	4030 (64.5) [63.5-65.6]	1387 (63.7) [61.9-65.6]	2365 (64.4) [63.1-65.8]	278 (69.2) [65.3-72.9]	
Non-Hispanic Black	2048 (11.9) [11.3-12.4]	762 (13.9) [12.9-15.0]	1232 (11.6) [10.9-12.3]	54 (4.9) [3.7-6.4]	
Hispanic	938 (6.2) [5.8-6.6]	295 (6.2) [5.4-7.0]	573 (6.2) [5.7-6.8]	70 (6.3) [4.9-8.1]	
Other	2719 (17.4) [16.7-18.2]	805 (16.2) [15.0-17.6]	1680 (17.8) [16.8-18.8]	234 (19.6) [16.8-22.9]	
Education level					<0.001
Less than 9th grade	645 (4.0) [3.6-4.4]	201 (4.1) [3.5-4.9]	406 (4.1) [3.6-4.6]	38 (2.7) [1.9-3.7]	
9-11th grade	1363 (10.9) [10.2-11.6]	575 (14.6) [13.3-16.1]	733 (9.4) [8.6-10.2]	55 (6.9) [5.1-9.4]	
High school grad/GED or equivalent	2137 (21.1) [20.1-22.1]	838 (26.2) [24.4-28.2]	1217 (19.4) [18.2-20.7]	82 (12.0) [9.2-15.6]	
Some college or AA degree	3115 (33.1) [31.9-34.3]	1056 (34.2) [32.1-36.3]	1871 (33.1) [31.6-34.7]	188 (27.1) [23.0-31.7]	

College graduate or above	2475 (31) [29.8-32.2]	579 (20.8) [19.0-22.7]	1623 (34.0) [32.5-35.6]	273 (51.2) [46.2-56.2]	
Country of birth					<0.001
Not US born	2793 (18.5) [17.7-19.3]	837 (16.5) [15.3-17.9]	1699 (18.6) [17.6-19.7]	257 (26.3) [22.6-30.4]	
US born	6942 (81.5) [80.7-82.3]	2412 (83.5) [82.1-84.7]	4151 (81.4) [80.3-82.4]	379 (73.7) [69.6-77.4]	
Marital status					<0.001
Never married	2563 (24.1) [23.1-25.2]	910 (26.3) [24.5-28.2]	1535 (23.8) [22.5-25.1]	118 (17.1) [13.7-21.0]	
Married or living with partner	5719 (62.1) [60.8-63.3]	1824 (58.8) [56.6-60.9]	3482 (62.9) [61.4-64.5]	413 (69.6) [64.9-73.9]	
Widowed or divorced or separated	1453 (13.8) [13-14.7]	515 (14.9) [13.4-16.5]	833 (13.3) [12.2-14.4]	105 (13.3) [10.4-16.9]	
BMI (kg/m²)					<0.001
<25	3043 (31.4) [30.2-32.6]	973 (28.8) [26.9-30.8]	1845 (32.3) [30.8-33.8]	225 (35.2) [30.5-40.1]	
≥25, <30	3071 (32.8) [31.6-34]	1060 (33.9) [31.9-36.1]	1808 (32.1) [30.6-33.7]	203 (33.6) [29.0-38.5]	
≥30	3621 (35.8) [34.6-37]	1216 (37.2) [35.1-39.4]	2197 (35.6) [34.1-37.1]	208 (31.3) [26.8-36.1]	
Alcohol drinkers					<0.001
No	2279 (18.6) [17.7-19.5]	691 (17.2) [15.7-18.7]	1399 (18.7) [17.6-19.9]	189 (23.3) [19.5-27.6]	
Yes	7456 (81.4) [80.5-82.3]	2558 (82.8) [81.3-84.3]	4451 (81.3) [80.1-82.4]	447 (76.7) [72.4-80.5]	
Smoking status					<0.001
Nonsmokers	5670 (57.8) [56.6-59.1]	1685 (50.9) [48.7-53.1]	3553 (60.3) [58.7-61.9]	432 (67.8) [62.9-72.3]	
Former smokers	1647 (19.2) [18.2-20.3]	545 (19.2) [17.5-21.1]	977 (18.9) [17.6-20.3]	125 (21.6) [17.6-26.3]	
Current smokers	2418 (22.9) [21.9-24]	1019 (29.9) [27.9-31.9]	1320 (20.7) [19.5-22.0]	79 (10.5) [8.1-13.6]	
Sun sensitivity					<0.001
None	956 (12.7) [11.9-13.7]	195 (7.5) [6.4-8.9]	615 (13.7) [12.6-15.0]	146 (28.1) [23.7-33.1]	
Mild	4667 (52.1) [50.8-53.3]	1492 (51.4) [49.2-53.5]	2845 (52.5) [50.9-54.1]	330 (52.1) [47.1-57.1]	
Severe	4112 (35.2) [34-36.3]	1562 (41.1) [39.0-43.2]	2390 (33.8) [32.3-35.3]	160 (19.7) [16.3-23.7]	
Time spent outdoors (minute/d)					<0.001
<60	3891 (38.8) [37.6-40.1]	1068 (31.2) [29.2-33.2]	2486 (41.4) [39.8-43.0]	337 (51.4) [46.4-56.4]	
≥60	5844 (61.2) [59.9-62.4]	2181 (68.8) [66.8-70.8]	3364 (58.6) [57.0-60.2]	299 (48.6) [43.6-53.6]	
Psoriasis					<0.001
No	9480 (97.2) [96.7-97.6]	3174 (97.2) [96.3-97.9]	5698 (97.4) [96.8-97.9]	608 (94.8) [91.8-96.8]	
Yes	255 (2.8) [2.4-3.3]	75 (2.8) [2.1-3.7]	152 (2.6) [2.1-3.2]	28 (5.2) [3.2-8.2]	

BMJ Open

Association between sun-protective behaviors and psoriasis in US adults in the National Health and Nutrition Examination Survey, 2009-2014: a cross-sectional study

SCHOLARONE™
Manuscripts

BMJ

Association between sun-protective behaviors and psoriasis in US adults in the National Health and Nutrition Examination Survey, 2009-2014: a cross-sectional study

Yawen Xuan[1], Yibin Feng[2], Fen Rong[3], Xufeng He[1], Wuqing Wang[1#], Wen Li[1#]

[1]Department of Dermatology, Shuguang Hospital Affiliated to Shanghai University of TCM, Shanghai, China.

[2]School of Chinese Medicine, Li Ka Shing Faculty of Medicine, the University of Hong Kong, 6 Sassoon Road, Pokfulam, Hong Kong.

[3]School of Public Health, Shanghai University of Traditional Chinese Medicine, Shanghai, China.

Wuqing Wang and Wen Li are both corresponding authors of this paper.

1. Yawen Xuan

·Title: Bachelor

·Affiliation: School of Public Health, Shanghai University of Traditional Chinese Medicine, Shanghai, China.

·E-mail: yawenx0928@163.com

2. Yibin Feng

·Title: PhD

·Affiliation: School of Chinese Medicine, Li Ka Shing Faculty of Medicine, the University of Hong Kong, 6 Sassoon Road, Pokfulam, Hong Kong.

·E-mail: yfeng@hku.hk

3. Fen Rong

1

·Title: PhD

·Affiliation: School of Public Health, Shanghai University of Traditional Chinese Medicine, Shanghai

201203, China.

·E-mail: rf97328@163.com

4. Xufeng He

·Title: MD

·Affiliation: Department of Dermatology, Shuguang Hospital Affiliated to Shanghai University of

TCM, Shanghai, China.

·E-mail: yake2004@163.com

Corresponding authors:

Postal address: Wuqing Wang and Wen Li, Department of Dermatology, Shuguang Hospital Affiliated

to Shanghai University of Traditional Chinese Medicine, Shanghai 201203, China.

Wuqing Wang: E-mail: wuqingw2006@sina.com

Wen Li: E-mail: liwen@shutcm.edu.cn

2

Abstract

Objective: To evaluate the association between sun-protective behaviors and psoriasis in a nationally

representative sample of US adults.

Design: Analysis of cross-sectional data.

Setting: The National Health and Nutrition Examination Survey (NHANES), 2009-2014.

Participants: A total of 9735 participants aged 20-59 years with available data on psoriasis, sun-

protective behaviors, and covariates were included in the analysis.

Outcome measures: The information on sun-protective behaviors (staying in the shade, wearing

long sleeves, and using sunscreen) and psoriasis was obtained from questionnaires in the NHANES

database. Logistic regression models and subgroup analyses were employed to investigate the

association between sun-protective behaviors and psoriasis.

Results: After adjusting for the sociodemographic, body mass index (BMI), alcohol drinking status,

smoking status, sun sensitivity, and time spent outdoors in the multivariable logistic regression model,

wearing long sleeves moderately was negatively associated with psoriasis (odds ratio [OR], 0.55; 95%

confidence interval [CI], 0.33-0.90, P=0.02), while frequent wearing showed no significant

relationship. There was no significant association between staying in the shade and psoriasis, regardless

of frequency. Subgroup analyses stratified by age, gender, race/ethnicity, and smoking status revealed

no significant associations in most groups, but the moderate wearing of long sleeves was found to be

negatively associated with psoriasis among those aged 20 to 39 years (OR, 0.42; 95% CI, 0.18-0.98,

P=0.04), among non-Hispanic White individuals (OR, 0.52; 95% CI, 0.28-0.97, P=0.04), and among

nonsmokers (OR, 0.49; 95% CI, 0.25-0.95, P=0.04), as it was among females in overall sun protection

(OR, 0.58; 95% CI, 0.35-0.97, P=0.04). However, among non-Hispanic White individuals (shade: OR,

3

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1.69; 95% CI, 1.00-2.84, *P*=0.049) and former/current smokers (overall: OR, 3.28; 95% CI, 1.41-7.63,

P=0.009), frequent sun protection was positively associated with psoriasis.

Conclusions: Moderate sun-protective behaviors among US adults were found to be negatively

associated with psoriasis. However, among non-Hispanic White individuals and former/current

smokers, frequent sun protection was positively associated with psoriasis. Future studies with rigorous

study design could further explore and validate the potential reasons for these associations to better

inform evidence-based behavioral recommendations that protect human health.

4

Strengths and limitations of this study

- The data from the National Health and Nutrition Examination Survey database are nationally

  representative and collected under strict control.

- This study adjusted for a variety of confounding variables.

- In this study, subgroup analyses were employed in addition to logistic regression to explore the

  relationships between sun-protective behaviors and psoriasis in specific subgroups.

- Due to the cross-sectional study design, only associations but no causal links could be determined.

- Self-reported psoriasis and sun-protective behaviors may be subject to recall bias and reporting

  bias.

5

INTRODUCTION

Psoriasis is a prevalent chronic inflammatory skin disease that will cause a decline in quality of life, sleep impairment, psychological problems and other consequences[1]. The prevalence of it is anticipated to increase[2], with the current prevalence of about 3% in US adults, affecting over 7.5 million US adults[3].

A range of therapeutic interventions exists for psoriasis, including pharmacotherapy, psychotherapy, and rapidly developing biologic therapies. Phototherapy modalities (broadband ultraviolet B [BB-UVB], narrowband ultraviolet B [NB-UVB] and heliotherapy) are endorsed as effective and safe treatment options by the Joint American Academy of Dermatology and National Psoriasis Foundation guidelines[4]. It is commonly used for psoriasis due to its efficacy and safety. Empirical evidence indicates that ultraviolet B (UVB) contributes to faster lesion clearance, fewer excessive erythema episodes, and longer remission periods in psoriasis[5] by inducing apoptosis in keratinocytes[6], CD4+ T cells and CD8+ T cells[7], inhibiting mast cell degranulation and histamine release[8], immunosuppression and changing the level of cytokines such as interleukin [IL]-10, IL-17A[9 10]. Furthermore, there are several pieces of evidence supporting the notion that UVB therapy or heliotherapy enhances vitamin D levels and lessens the severity of psoriasis[11 12]. An association between low levels of serum 25-hydroxyvitamin D(25(OH)D) and increased risk of developing psoriasis has been observed[13]. In addition, psoriasis tends to manifest more frequently in winter than in summer[14 15], which suggests that ultraviolet (UV) radiation might influence this seasonal variation.

In the US, some health organizations and clinicians advocate for using sunscreen and other sun protection measures to reduce the risk of developing melanoma and other skin cancer as well as to prevent premature skin aging. This raises concerns regarding whether sun protection will hinder the cutaneous synthesis of vitamin D, diminish the beneficial effects of UV radiation on the skin, and thus be detrimental to cardiovascular, metabolism, bone and skeletal health, and skin health[16 17]. Thyssen et al. have proposed that reduced environmental UV exposure may be a potential driver of the current epidemic of atopic dermatitis[18]. As for psoriasis, the prevalence of psoriasis exhibits considerable variation

across different geographic locations[19]. Research has shown that higher latitudes generally correspond with increased

prevalence rates[20 21]. Both genetic and environmental factors probably contribute to the correlation, but variation in

UV exposure must also be touched on. Therefore, given UV radiation's therapeutic role in psoriasis and the geographical

differences in UV exposure, it is pertinent to explore whether sun-protective behaviors may cause or aggravate psoriasis.

Despite having found that using sunscreen for both daily and recreational photo-protection has no impact on the synthesis

of vitamin D[22], there is scarce data on whether sunscreen use and other sun-protective behaviors affect the prevalence

of psoriasis.

To address this research gap, this cross-sectional study analyzed data from the 2009 to 2014 cycles of the National

Health and Nutrition Examination Survey (NHANES) to explore the association between multimodal sun-protective

behaviors and psoriasis prevalence among US adults.

METHODS

Data source

We used NHANES data from 2009 to 2014 to investigate the association between multimodal sun-protective behaviors

and the prevalence of psoriasis among US adults[23]. The NHANES is a nationally representative survey that captures

statistics of the US non-institutionalized civilian population on a biennial basis based on complex survey design and

population-specific sample weights in order to assess their health or nutritional status.

Study design and population

This was a population-based cross-sectional study. Our analyses were based on data collected from participants during

three 2-year NHANES cycles (2009-2010, 2011-2012 and 2013-2014).

The total number of initial NHANES participants from 2009-2014 was 30468. Of 11842 participants aged 20-59

years, 6 participants were excluded due to unavailable self-reported psoriasis data, and 168 participants were excluded due

7

to unavailable information on three kinds of sun-protective behaviors. Additionally, 1933 participants with missing data

on covariates, including age, gender, race or ethnicity, education level, marital status, country of birth, body measure index

(BMI), alcohol drinking status, smoking status, sun sensitivity and time spent outdoors were excluded, making 9735

individuals included in the final analysis (**figure 1**).

To our knowledge, all participants provided informed consent for data collection and for the data to be publicly

disseminated in a de-identified format.

Psoriasis

The information was obtained from the medical conditions section of the questionnaire data in NHANES. The

participants aged 20 years and older were asked if they had ever been told by a doctor or other health care professional

that they had psoriasis. If the answer is "yes," he or she is considered to have psoriasis.

Sun-protective behaviors, sun sensitivity and time spent outdoors

We assessed three different sun-protective behaviors from the NHANES dermatology questionnaire section (DEQ), for

which the target group was participants aged 20-59 years. The question asked for sun protective behaviors was: "When

you go outside on a very sunny day, for more than one hour, how often do you (1) stay in the shade, (2) wear a long-

sleeved shirt, (3) use sunscreen?" The valid answers can be "always," "most of the time," "sometimes," "rarely," "never"

and "don't go out in the sun." We reclassified these different answers into 3 categories: frequent (always or most of the

time), moderate (sometimes), or rare (never, rarely or don't go out in the sun). Furthermore, overall sun protection was

classified into three levels according to a total score for three sun-protective behaviors. The total score for sun protection

ranging from 3 to 9 was further divided down into rare (3-4), moderate (5-7), and frequent (8-9) categories[24] after

every behavior was scored 1, 2 or 3 depending on their frequency of use (rare, moderate and frequent).

Sun sensitivity was defined based on the question about skin reaction to the sun without sunscreen or protective

clothing for half an hour after several months of not being exposed to the sun. According to their responses, survey

8

participants were then divided into three groups: no sun sensitivity ("nothing would happen"), mild sun sensitivity

("mildly burn with some tanning" or "turn darker without a sunburn") and severe sun sensitivity ("severe sunburn with

blisters" or "severe sunburn for a few days with peeling").

In NHANES 2009-2014 cycles, participants were questioned how many minutes they spent outdoors over the

previous 30 days between 9 a.m. and 5 p.m. on workdays and non-workdays. Considering a week with five working days

and two off, we calculated the average time (minutes/day) spent outdoors using the following formula: (minutes outdoors

9 a.m.-5 p.m. on working days×5+minutes outdoors 9 a.m.-5 p.m. on nonworking days×2)/7. If the response is "does not

work or go to school" for the working day or "at work or at school 9 to 5 seven days a week" for the nonworking day, the

counterpart will be regarded as the final average time.

Other covariates

In addition to sun sensitivity and time spent outdoors, the other covariates included age, gender, race or ethnicity,

education level, marital status, country of birth, BMI, alcohol drinking status, and smoking status. Race or ethnicity was

derived from responses to the survey questions on race and Hispanic origin in the demographics file. Respondents were

reclassified into four groups: non-Hispanic White, non-Hispanic Black, Hispanic and other (Mexican American or other

race [including multi-racial]). Marital status was categorized into the following 3 groups: never married, married or

living with a partner and widowed, divorced or separated. Country of birth was encoded as a binary variable (0, born in

another country; 1, born in the US). BMI was calculated as weight in kilograms divided by height in meters squared and

then was analyzed as a three-categorical variable (BMI<25, 25≤BMI<30, BMI≤30) in the multivariable models. The

survey question, "In any 1 year, have you had at least 12 drinks of any type of alcoholic beverage?" was used to establish

participants' alcohol drinking status. Participants who responded "yes" were considered to be alcohol drinkers. Smoking

status was divided into 3 categories: nonsmoker (smoked<100 cigarettes in a lifetime), former smoker (smoked≥100

cigarettes in a lifetime but has quit), and current smoker (smoked≥100 cigarettes in a lifetime and still on smoking),

9

according to data on cigarette use in the questionnaire.

Statistical analysis

All analyses were conducted in accordance with the NHANES analytic guidelines[25 26], taking into consideration the

complex sample design and appropriate sampling weights. In this study, we extracted three cycles of NHANES; thus the

sampling weight was calculated using the following equation: full sample 6-year mobile examination center (MEC) exam

weight=full sample 2-year MEC exam weight/3. Continuous data were reported as means, standard deviations and 95%

confidence intervals [CIs], whilst categorical data were expressed as numbers, weighted percentage frequencies and 95%

CIs. T-tests for comparing continuous data and χ^2 tests for comparing categorical data were used for comparing baseline

characteristics by the presence of psoriasis. Unadjusted and multivariable adjusted logistic regression analyses were

performed to calculate weighted odd ratios (ORs) and 95% CIs to explore the association between sun protection and

psoriasis. The multivariable model was adjusted for potential confounders (i.e., age, gender, race or ethnicity, education

level, marital status, country of birth, alcohol drinking status, smoking status, sun sensitivity and time spent outdoors).

Subgroup analyses stratified by age, gender, race or ethnicity, and smoking status were conducted to determine the

association in specific subgroups. Notably, in all models, staying in the shade, wearing long sleeves, using sunscreen and

overall sun protection were modeled separately. In all tests, p-values of less than 0.05 (2-sided) were considered to be

statistically significant. All statistical analyses were conducted in Stata (Stata Corp.), version 17.

Patient and public involvement

None.

RESULTS

10

Characteristics of the population

Baseline characteristics and comparisons of included and excluded participants were shown in **supplementary table 1**.

Of 9735 participants who were finally included in our study, 255 (2.8%) had psoriasis, while 9480 (97.2%) did not. As

shown in **table 1**, 50.3% of participants were male and the weighted mean age of the participants was 39.6 years (95%

CI: 39.3-39.9). Compared with participants without psoriasis, patients with psoriasis were more likely to be older (+3.2

years), non-Hispanic White, US-born and former smokers, but they did not differ significantly in gender, education level,

marital status, BMI and alcohol drinking status. Additionally, participants with psoriasis had a lower prevalence of severe

sun sensitivity, but no difference existed in the time spent outdoors. In terms of frequent staying in the shade, wearing

long sleeves, using sunscreen and overall sun protection, the percentages were 31.0% (95% CI: 29.8%-32.1%), 9.0%

(95% CI: 8.3%-9.7%), 29.8% (95% CI: 28.6%-31.0%), and 6.8% (95% CI: 6.2%-7.5%), respectively. There were

significantly different distributions in long sleeves (*P*=0.002), sunscreen use (*P*=0.04) and overall sun protection

(*P*<0.001) between the psoriasis group and the non-psoriasis group. Additionally, we presented the characteristics of

participants by the frequency of sun-protective behaviors including staying in the shade, wearing long sleeves, using

sunscreen and overall sun protection, as shown in **supplementary table 2~5**, respectively.

Table 1. Characteristics of participants with and without psoriasis

| Characteristic | Participants | | | *P* value |
	Total (N=9735)	Without psoriasis (n=9480)	With psoriasis (n=255)	
Age, mean±SD (95% CI), y	39.6±11.7 (39.3-39.9)	39.5±11.7 (39.2-39.8)	42.7±11.3 (40.9-44.5)	**<0.001**
Gender				
Female	4882 (49.7) [48.4-50.9]	4750 (49.7) [48.4-50.9]	132 (50.0) [42.2-57.8]	0.91
Male	4853 (50.3) [49.1-51.6]	4730 (50.3) [49.1-51.6]	123 (50.0) [42.2-57.8]	
Race or ethnicity				
Non-Hispanic White	4030 (64.5) [63.5-65.6]	3883 (64.2) [63.1-65.2]	147 (77.4) [72.0-82.0]	**<0.001**
Non-Hispanic Black	2048 (11.9) [11.3-12.4]	2021 (12.0) [11.5-12.6]	27 (5.4) [3.6-8.0]	
Hispanic	938 (6.2) [5.8-6.6]	915 (6.2) [5.8-6.7]	23 (5.3) [3.4-8.2]	
Other[a]	2719 (17.4) [16.7-18.2]	2661 (17.6) [16.8-18.4]	58 (11.9) [8.7-16.1]	
Education level				
Less than 9th grade	645 (4.0) [3.6-4.4]	631 (4.0) [3.7-4.4]	14 (2.3) [1.3-4.1]	0.06
9-11th grade	1363 (10.9) [10.2-11.6]	1336 (11.0) [10.3-11.7]	27 (6.7) [4.3-10.5]	

11

High school grad/GED or equivalent	2137 (21.1) [20.1-22.1]	2080 (21.1) [20.1-22.1]	57 (21.5) [15.8-28.6]	
Some college or AA degree	3115 (33.1) [31.9-34.3]	3035 (33.1) [31.9-34.3]	80 (33.0) [26.0-40.9]	
College graduate or above	2475 (31.0) [29.8-32.2]	2398 (30.8) [29.6-32.1]	77 (36.4) [29.1-44.4]	
Country of birth				
Not US born	2793 (18.5) [17.7-19.3]	2745 (18.7) [17.9-19.5]	48 (9.9) [7.1-13.6]	**<0.001**
US born	6942 (81.5) [80.7-82.3]	6735 (81.3) [80.5-82.1]	207 (90.1) [86.4-92.9]	
Marital status				
Never married	2563 (24.1) [23.1-25.2]	2507 (24.2) [23.1-25.2]	56 (22.9) [17.0-30.1]	
Married or living with partner	5719 (62.1) [60.8-63.3]	5571 (62.1) [60.9-63.3]	148 (61.4) [53.6-68.7]	0.64
Widowed or divorced or separated	1453 (13.8) [13.0-14.7]	1402 (13.8) [12.9-14.7]	51 (15.7) [10.9-22]	
BMI (kg/m^2)				
<25	3043 (31.4) [30.2-32.6]	2977 (31.5) [30.4-32.7]	66 (26.2) [20.0-33.5]	
≥25, <30	3071 (32.8) [31.6-34.0]	2991 (32.7) [31.5-34.0]	80 (35.4) [28.1-43.4]	0.17
≥30	3621 (35.8) [34.6-37.0]	3512 (35.7) [34.5-37.0]	109 (38.5) [31.3-46.2]	
Alcohol drinkers				
No	2279 (18.6) [17.7-19.5]	2226 (18.6) [17.7-19.5]	53 (17.7) [12.8-23.9]	0.70
Yes	7456 (81.4) [80.5-82.3]	7254 (81.4) [80.5-82.3]	202 (82.3) [76.1-87.2]	
Smoking status				
Nonsmokers	5670 (57.8) [56.6-59.1]	5547 (58.1) [56.8-59.3]	123 (49.2) [41.4-57.0]	
Former smokers	1647 (19.2) [18.2-20.3]	1587 (18.9) [17.9-20.0]	60 (30.1) [23.0-38.2]	**<0.001**
Current smokers	2418 (22.9) [21.9-24.0]	2346 (23.0) [22.0-24.1]	72 (20.8) [15.7-27.0]	
Sun sensitivity[b]				
None	956 (12.7) [11.9-13.7]	923 (12.7) [11.8-13.6]	33 (15.4) [10.3-22.4]	
Mild	4667 (52.1) [50.8-53.3]	4524 (51.9) [50.6-53.2]	143 (58.4) [50.6-65.9]	0.006
Severe	4112 (35.2) [34.0-36.3]	4033 (35.4) [34.3-36.6]	79 (26.2) [20.1-33.3]	
Time spent outdoors[c] (minute/d)				
<60	3891 (38.8) [37.6-40.1]	3790 (38.9) [37.7-40.2]	101 (35.2) [28.1-42.9]	0.21
≥60	5844 (61.2) [59.9-62.4]	5690 (61.1) [59.8-62.3]	154 (64.8) [57.1-71.9]	
Staying in the shade				
Rare	2546 (27.2) [26.0-28.3]	2489 (27.2) [26.1-28.4]	57 (24.8) [18.6-32.2]	
Moderate	3776 (41.9) [40.6-43.1]	3677 (42.0) [40.7-43.3]	99 (37.9) [30.7-45.7]	0.07
Frequent	3413 (31.0) [29.8-32.1]	3314 (30.8) [29.6-31.9]	99 (37.3) [30.0-45.2]	
Wearing long sleeves				
Rare	6742 (70.9) [69.8-72.1]	6557 (70.8) [69.6-71.9]	185 (76.0) [68.8-81.9]	
Moderate	1941 (20.1) [19.1-21.1]	1907 (20.3) [19.3-21.4]	34 (12.0) [7.9-17.9]	0.002
Frequent	1052 (9.0) [8.3-9.7]	1016 (8.9) [8.2-9.6]	36 (12.0) [7.9-17.9]	
Using sunscreen				
Rare	5579 (48.5) [47.2-49.7]	5449 (48.7) [47.4-50.0]	130 (41.8) [34.5-49.5]	
Moderate	1819 (21.8) [20.7-22.9]	1763 (21.6) [20.5-22.7]	56 (27.2) [20.5-35.2]	0.04
Frequent	2337 (29.8) [28.6-31.0]	2268 (29.7) [28.5-31.0]	69 (31.0) [24.2-38.8]	
Overall sun protection[d]				

12

Rare	3249 (31.9) [30.8-33.1]	3174 (31.9) [30.8-33.1]	75 (31.4) [24.5-39.1]	
Moderate	5850 (61.3) [60.0-62.5]	5698 (61.4) [60.2-62.6]	152 (56.1) [48.2-63.7]	**<0.001**
Frequent	636 (6.8) [6.2-7.5]	608 (6.7) [6.0-7.4]	28 (12.5) [7.9-19.3]	

Data are presented as unweighted number (weighted percentage) [95% CI] unless otherwise indicated.

Abbreviations: NHANES, National Health and Nutrition Examination Survey; BMI, body mass index (calculated as weight in kilograms divided by height in meters squared). Boldface indicates statistical significance.

[a] Included Mexican American and multiracial participants.

[b] Sun sensitivity was determined by the answer to the skin reaction to the sun without sunscreen or protective clothing for half an hour: none ("nothing would happen"), mild ("mildly burn with some tanning" or "turn darker without a sunburn"), and severe ("severe sunburn with blisters" or "severe sunburn for a few days with peeling").

[c] Time spent outdoors refers to the average minutes spent outdoors from 9:00 a.m. to 5:00 p.m. on each day of the week considering that there are 5 working days and 2 non-working days in a week.

[d] Overall sun protection reflects the general condition of sun protection, including staying in the shade, wearing long sleeves and sunscreen.

Multivariable regression analyses

Based on the limited information from NHANES and our understanding of related factors for psoriasis[27] and sun-protective behaviors[28], we included some covariates like some sociodemographic variables, smoking status, BMI and sun sensitivity in the regression models to control for confounding effects. In **table 2,** the results of an unadjusted and a sample-weighted adjusted regression model to evaluate the association between sun-protective behaviors and psoriasis are presented. In the unadjusted one, moderate wearing of long sleeves was associated with a decreased prevalence of psoriasis (OR, 0.55; 95% CI, 0.34-0.89). After adjustment for covariates, the association remained statistically significant (*P*<0.05). However, overall sun protection had a positive association with psoriasis in the unadjusted model (OR, 1.91; 95% CI, 1.08-3.39), but the relationship disappeared after adjustment. Meanwhile, the other two behaviors were not significantly associated with psoriasis in the unadjusted or adjusted model.

Table 2. Association between sun-protective behaviors and psoriasis

	Presence of psoriasis by sun-protective behaviors			
	Staying in the shade	Wearing long sleeves	Using sunscreen	Overall sun protection
Model	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Unadjusted				
Rare	1 [reference]	1 [reference]	1 [reference]	1 [reference]
Moderate	0.99 (0.66-1.50)	**0.55 (0.34-0.89)***	1.47 (0.98-2.20)	0.93 (0.65-1.32)
Frequent	1.33 (0.88-2.02)	1.26 (0.77-2.03)	1.22 (0.84-1.76)	**1.91 (1.08-3.39)***

13

Adjusted[a]			
Rare	1 [reference]	1 [reference]	1 [reference]	1 [reference]
Moderate	0.95 (0.62-1.45)	**0.55 (0.33-0.90)***	1.25 (0.82-1.91)	0.90 (0.62-1.31)
Frequent	1.42 (0.92-2.18)	1.36 (0.82-2.26)	0.96 (0.62-1.50)	1.67 (0.90-3.12)

Abbreviations: NHANES, National Health and Nutrition Examination Survey; OR, odds ratio. Boldface indicates statistical significance.

*$P<0.05$, **$P<0.01$

[a] Adjusted for sociodemographic variables, BMI, alcohol drinking status, smoking status, sun sensitivity, and time spent outdoors.

Subgroup analyses

The results of the subgroup analyses, stratified by age, gender, race or ethnicity, and smoking status, are presented in **table 3**. Among participants aged 20 to 39 years (OR, 0.42; 95% CI, 0.18-0.98), non-Hispanic White individuals (OR, 0.52; 95% CI, 0.28-0.97), and nonsmokers (OR, 0.49; 95% CI, 0.25-0.95), moderate wearing of long sleeves was associated with a lower prevalence of psoriasis, as it was among females in terms of overall sun protection (OR, 0.58; 95% CI, 0.35-0.97).

However, among former or current smokers, those with frequent stays in the shade (OR, 2.05; 95% CI, 1.11-3.78), long sleeves (OR, 3.02; 95% CI, 1.57-5.79) or overall sun protection (OR, 3.28; 95% CI, 1.41-7.63) had a higher prevalence of psoriasis. There were also slightly significant and positive relationships between frequent shade-seeking behavior and psoriasis among non-Hispanic White participants (OR, 1.69; 95% CI, 1.00-2.84).

Table 3. Association between sun-protective behaviors and psoriasis, stratified by age, gender, race or ethnicity, and smoking status

Subgroup	frequency	Staying in the shade OR (95% CI)	Wearing long sleeves OR (95% CI)	Using sunscreen OR (95% CI)	Overall sun protection OR (95% CI)
Overall					
Unadjusted	Rare	1 [reference]	1 [reference]	1 [reference]	1 [reference]
	Moderate	0.99 (0.66-1.50)	**0.55 (0.34-0.89)***	1.47 (0.98-2.20)	0.93 (0.65-1.32)
	Frequent	1.33 (0.88-2.02)	1.26 (0.77-2.03)	1.22 (0.84-1.76)	**1.91 (1.08-3.39)***
Adjusted	Rare	1 [reference]	1 [reference]	1 [reference]	1 [reference]
	Moderate	0.95 (0.62-1.45)	**0.55 (0.33-0.90)***	1.25 (0.82-1.91)	0.90 (0.62-1.31)
	Frequent	1.42 (0.92-2.18)	1.36 (0.82-2.26)	0.96 (0.62-1.50)	1.67 (0.90-3.12)
Age, y					
20-39	Rare	1 [reference]	1 [reference]	1 [reference]	1 [reference]

14

	Moderate	0.71 (0.40-1.25)	**0.42 (0.18-0.98)***	1.21 (0.66-2.19)	0.91 (0.53-1.55)
	Frequent	1.14 (0.61-2.13)	0.86 (0.31-2.42)	1.23 (0.66-2.29)	1.27 (0.41-3.93)
40-59	Rare	1 [reference]	1 [reference]	1 [reference]	1 [reference]
	Moderate	1.24 (0.67-2.27)	0.64 (0.34-1.20)	1.28 (0.73-2.27)	0.92 (0.55-1.53)
	Frequent	1.77 (0.96-3.24)	1.75 (0.97-3.16)	0.84 (0.46-1.53)	1.97 (0.92-4.20)
Gender					
Female	Rare	1 [reference]	1 [reference]	1 [reference]	1 [reference]
	Moderate	0.63 (0.35-1.16)	0.56 (0.28-1.12)	0.88 (0.48-1.59)	**0.58 (0.35-0.97)***
	Frequent	1.33 (0.74-2.39)	1.37 (0.62-3.03)	0.56 (0.31-1.02)	1.23 (0.55-2.76)
Male	Rare	1 [reference]	1 [reference]	1 [reference]	1 [reference]
	Moderate	1.28 (0.72-2.29)	0.53 (0.26-1.07)	1.71 (0.95-3.09)	1.32 (0.78-2.23)
	Frequent	1.40 (0.74-2.64)	1.30 (0.68-2.48)	1.75 (0.97-3.15)	1.95 (0.74-5.11)
Race or ethnicity					
Non-Hispanic White	Rare	1 [reference]	1 [reference]	1 [reference]	1 [reference]
	Moderate	0.93 (0.56-1.55)	**0.52 (0.28-0.97)***	1.28 (0.78-2.11)	0.80 (0.50-1.26)
	Frequent	**1.69 (1.00-2.84)***	1.43 (0.71-2.86)	0.83 (0.48-1.43)	1.73 (0.82-3.66)
Other	Rare	1 [reference]	1 [reference]	1 [reference]	1 [reference]
	Moderate	1.14 (0.64-2.03)	0.68 (0.37-1.22)	1.10 (0.59-2.06)	1.39 (0.83-2.32)
	Frequent	0.92 (0.52-1.61)	1.20 (0.68-2.12)	**1.94 (1.09-3.44)***	1.66 (0.72-3.82)
Smoking status					
nonsmokers	Rare	1 [reference]	1 [reference]	1 [reference]	1 [reference]
	Moderate	0.76 (0.42-1.35)	**0.49 (0.25-0.95)***	1.71 (0.93-3.14)	0.74 (0.43-1.26)
	Frequent	1.00 (0.55-1.82)	**0.42 (0.19-0.93)***	1.14 (0.58-2.21)	0.87 (0.36-2.09)
smokers[a]	Rare	1 [reference]	1 [reference]	1 [reference]	1 [reference]
	Moderate	1.20 (0.66-2.20)	0.62 (0.31-1.25)	1.00 (0.53-1.89)	1.12 (0.67-1.85)
	Frequent	**2.05 (1.11-3.78)***	**3.02 (1.57-5.79)****	0.91 (0.49-1.70)	**3.28 (1.41-7.63)****

Each stratification was adjusted for age, gender, race or ethnicity, country of birth, educational level, marital status, BMI, smoking and alcohol drinking status, sun sensitivity, and time spent outdoors except the stratification factor itself. All ORs and 95% CIs are based on data weighted to represent the US population.

*$P<0.05$, **$P<0.01$

Boldface indicates statistical significance.

[a] smokers refer to current smokers and former smokers.

DISCUSSION

To our knowledge, this is the first report to investigate the associations between sun-protective behaviors and psoriasis in

a population-based setting, specifically in the US adult population. The findings revealed that moderately wearing long

sleeves had a statistically significant association with a lower prevalence of psoriasis, even after adjusting for some

potential confounders. But no associations were found between psoriasis and either staying in the shade, using sunscreen,

15

or overall sun protection. In subsequent subgroup analysis, significant relationships between moderate sun protective

behaviors and a lower prevalence of psoriasis were observed among younger adults aged 20-39, females, non-Hispanic

White individuals, and smokers. Remarkably, among smokers, frequent staying in the shade, wearing of long sleeves,

and overall sun protection were associated with an increased prevalence of psoriasis, whereas moderate use was not.

Among non-Hispanic White participants, frequent sunscreen use was associated with an increased prevalence of

psoriasis, but moderate use was not.

Psoriasis is a chronic and immune-mediated skin disorder attributed to various genetic and environmental factors.

As reported in previous studies, physical trauma[29], lifestyle and habits[30], infection such as streptococcus[31], and

medication[32 33] are risk factors or triggers of psoriasis. The observed relationship between sun protection and a lower

prevalence of psoriasis might be due to sun protection preventing the traumatic effects of excessive UV rays on the skin,

or people practicing moderate sun protection possess higher health awareness, thereby reducing psoriasis triggers related

to infections, unhealthy lifestyles, or medication habits. Natural sunlight, with a wide variety of bands, is more likely to

cause negative skin effects in contrast to NB-UVB and targeted UVB with specific spectrum and controlled doses in the

clinic.

Additionally, although a sizable portion of psoriasis patients respond well to phototherapy (mainly at a UV wavelength of

311 nm), excessive UV exposure can lead to side effects like erythema, blistering and even deterioration of psoriasis. It

was reported that approximately 5.5% of psoriasis cases worsen or develop new lesions post-sun exposure due to

genetics, gender (female), and abnormal UV response, and some even experience symptoms after prolonged

sunbathing[34 35]. They are collectively referred to as photosensitive psoriasis (PP). Consequently, it's necessary for PP

patients to take some daily sun-protective measures. Meanwhile, the association remained after the adjustment of gender,

race or ethnicity, and sun sensitivity in our study, which may suggest the protective effects of moderate sun protection on

the general population as well as the potential predisposing effect of sunlight on psoriasis. However, further research is

16

warranted to explore the conjecture and the underlying mechanism of these associations.

In the past few years, the pathogenesis of psoriasis has been unveiled gradually. The persistence of skin inflammation due to cutaneous immune disorder is a hallmark of psoriasis. Dendritic cells (DCs), macrophages, different T cell sets and other cell types via various cytokines such as LL-37, tumor necrosis factor α (TNF-α) and interleukins play a major role in the initiation and maintenance phases[36], causing higher levels for IL-17, IL-23 and TNF-α, lower levels for IL-4 and IL-10, and other dysregulation of cytokine secretion[37]. In many studies, it has been found that sunlight or UV radiation can reduce the number of DCs[38], CD4+ T cells and CD8+ T cells, and modulate immune homeostasis and cytokine levels in psoriasis[7]. In our study, there was no difference in psoriasis prevalence between individuals with rare versus frequent sun protection, potentially due to excessive sun protection inhibiting UV's beneficial effects. The negative impact of insufficient sun protection, combined with excessive protection, links moderate sun protection to a lower prevalence of psoriasis.

The results of subgroup analyses indicated an opposing association between different frequencies of sun protection use and psoriasis. Among people aged 20-39, females, non-Hispanic White individuals, and smokers, moderate sun protection was linked to a lower prevalence of psoriasis. Conversely, frequent sun protection was linked to a higher prevalence among non-Hispanic White individuals and among smokers. The stronger association observed in younger adults and females may stem from greater attention to sun protection factor (SPF) in products. Unfortunately, the NHANES database did not record details on sunscreen such as SPF and usage per time. As for race or ethnicity, previous research discovered that sun-protective behaviors may significantly reduce the level of 25(OH)D in White individuals compared to Black and Hispanic individuals[24]. Currently, notable associations between low vitamin D status and psoriasis have been systematically found, and oral vitamin D supplementation is deemed to be an effective treatment of psoriasis[39]. So, the decrease in vitamin D caused by frequent sun protection may exacerbate the adverse skin effects brought on by insufficient UV exposure, which is speculated to be more obvious among White people.

17

Regarding smoking status, frequent sun protection was positively associated with psoriasis in smokers, whereas wearing long sleeves was negatively associated with psoriasis in nonsmokers. It is widely accepted that smoking can increase the risk of developing psoriasis[40 41] through several mechanisms[42], including oxidation, inflammation and genes. Therefore, when combined with the absence of UV immunosuppressive and anti-inflammatory properties due to excessive use of sun proof, the difference in the risk of developing psoriasis may be amplified.

We also found that over 30% of US adults aged 20-59 rarely engaged in sun protection practices. Especially when it comes to wearing long sleeves, less than 30% of participants opted to wear them while being outside in the sun for an hour. Although this phenomenon has been proven to be improving from 2010 to 2020[43], pent-up demand for travel or holidays is already delivering rapid growth in the US after the lockdown measures for the COVID-19 epidemic were fully lifted, which exerts a brand-new challenge for American people's consciousness of sun protection. We hope that our findings can draw public attention to appropriate sun protection measures and encourage further research for convincing evidence in this area.

This study has several strengths that deserve mentioning. The principal strength of this study is that this is the first attempt to explore the relationship between sun-protective behaviors and psoriasis. Furthermore, the NHANES database boasts a large and nationally representative sample size and was collected under strict control, ensuring that the results are generalizable to the adult population in the US. There are still some limitations that need to be acknowledged. First and foremost, this is a cross-sectional study that can only suggest association but not causation. Psoriasis may have been diagnosed years ago, and some sufferers may choose to conceal visible skin lesions through long sleeves or other means due to shame over their appearance[44 45]. But the collection of information on the frequency of long sleeves has clear sun protection targeting under specific contexts, which possibly minimizes such reverse causality bias. Therefore, additional results from well-designed cohort studies are required. Second, our data are from the 2009-2014 cycles of NHANES and, thus, might not provide a precise representation of present-day circumstances. To ensure that our analyses

18

and conclusions are aligned with the most recent trends and conditions, further studies that incorporate more recent data are recommended. Third, data on psoriasis diagnosis and sun-protective behaviors were all obtained in the form of questionnaire surveys, which were prone to recall bias and reporting bias. Fourth, variations in geographical locations, data collection timing, sun exposure intervals, and sunscreen type were not captured, which may hinder our capacity to accurately evaluate the association between sun protection frequency and psoriasis prevalence among individuals with varying UV exposure levels. Similarly, there may be other covariates that were not considered. Thus, future studies ought to collect and evaluate more detailed information on geographic location and sun protection, as well as other important covariates so as to better elucidate the potential relationship. Fifth, UV's dual effects at ~305 nm (sunburn) and 311 nm (psoriasis therapy) further complicate assessments of sun protection effects, which cannot be clearly distinguished in our study. Lastly, multiple tests may raise the probability of obtaining a significant result by chance.

CONCLUSION

The findings of this cross-sectional study suggested that moderate sun protection was negatively associated with psoriasis in the adult population of the US, particularly in White females aged 20 to 39 years and in nonsmokers, while frequent sun protection was linked to a higher prevalence of psoriasis in White individuals and smokers. Additional research is required to reach more convincing conclusions and propose practical recommendations on sun protection.

19

Patient consent for publication: Not applicable.

Ethics approval: This study involves human participants. All NHANES protocols have been approved by the National Center for Health Statistics Research Ethics Review Board. The specific protocol numbers involved in the study are: #2005-06, #2011-17. All participants in NHANES presented informed consent for data collection and publication. Since the study utilizes publicly accessible and anonymized NHANES data, it is exempt from additional ethical review by the Ethics Committee of Shuguang Hospital Affiliated to Shanghai University of TCM.

Data availability statement: The datasets used in this study are available in a public and open access repository via the NHANES website (https://www.cdc.gov/nchs/nhanes/index.htm).

20

References

[1] Langley RG, Krueger GG, Griffiths CE. Psoriasis: epidemiology, clinical features, and quality of life. *Ann Rheum Dis* 2005;64 Suppl 2:ii18-23; discussion ii24-5.

[2] Icen M, Crowson CS, McEvoy MT, et al. Trends in incidence of adult-onset psoriasis over three decades: a population-based study. *J Am Acad Dermatol* 2009;60:394-401.

[3] Armstrong AW, Mehta MD, Schupp CW, et al. Psoriasis Prevalence in Adults in the United States. *JAMA Dermatol* 2021;157:940-46.

[4] Menter A, Gelfand JM, Connor C, et al. Joint American Academy of Dermatology-National Psoriasis Foundation guidelines of care for the management of psoriasis with systemic nonbiologic therapies. *J Am Acad Dermatol* 2020;82:1445-86.

[5] Morita A. Current developments in phototherapy for psoriasis. *J Dermatol* 2018;45:287-92.

[6] Weatherhead SC, Farr PM, Jamieson D, et al. Keratinocyte apoptosis in epidermal remodeling and clearance of psoriasis induced by UV radiation. *J Invest Dermatol* 2011;131:1916-26.

[7] Søyland E, Heier I, Rodríguez-Gallego C, et al. Sun exposure induces rapid immunological changes in skin and peripheral blood in patients with psoriasis. *Br J Dermatol* 2011;164:344-55.

[8] Siiskonen H, Smorodchenko A, Krause K, et al. Ultraviolet radiation and skin mast cells: Effects, mechanisms and relevance for skin diseases. *Exp Dermatol* 2018;27:3-8.

[9] Hart PH, Norval M. More Than Effects in Skin: Ultraviolet Radiation-Induced Changes in Immune Cells in Human Blood. *Front Immunol* 2021;12:694086.

[10] Vacharanukrauh P, Meephansan J, Tangtanatakul P, et al. High-Throughput RNA Sequencing Reveals the Effect of NB-UVB Phototherapy on Major Inflammatory Molecules of Lesional Psoriasis. *Psoriasis (Auckl)* 2021;11:133-49.

[11] Osmancevic A, Landin-Wilhelmsen K, Larkö O, et al. Vitamin D status in psoriasis patients during different treatments with phototherapy. *J Photochem Photobiol B* 2010;101:117-23.

[12] Franken SM, Witte B, Pavel S, et al. Psoriasis and daily low-emission phototherapy: effects on disease and vitamin D level. *Photodermatol Photoimmunol Photomed* 2015;31:83-9.

[13] Charoenngam N, Holick MF. Immunologic effects of vitamin D on human health and disease. 2020;12:2097.

[14] Harvell JD, Selig DJ. Seasonal variations in dermatologic and dermatopathologic diagnoses: a retrospective 15-year analysis of dermatopathologic data. *International Journal of Dermatology* 2016;55:1115-18.

[15] Ammar-Khodja A, Benkaidali I, Bouadjar B, et al. EPIMAG: international cross-sectional epidemiological psoriasis study in the Maghreb. *Dermatology* 2015;231:134-44.

[16] Yang S, Dai F, Wang Z, et al. Association between sun-protective behaviors and hypertension: a cross-sectional study from National Health and Nutrition Examination Survey 2009 to 2014. *BMC Public Health* 2023;23:1862.

[17] Afarideh M, Sartori-Valinotti JC, Tollefson MM. Association of Sun-Protective Behaviors With Bone Mineral Density and Osteoporotic Bone Fractures in US Adults. *JAMA Dermatol* 2021;157:1437-46.

[18] Thyssen JP, Zirwas MJ, Elias PM. Potential role of reduced environmental UV exposure as a driver of the current epidemic of atopic dermatitis. *Journal of Allergy and Clinical Immunology* 2015;136:1163-69.

21

[19] Rosa P, Ireny YKI, Evangelos K, et al. National, regional, and worldwide epidemiology of psoriasis: systematic analysis and modelling study. *BMJ (Clinical research ed)* 2020;369:m1590.

[20] Valerie A, Sandra W, Matthias A, et al. Regional variations and prevalence of psoriasis in Germany from 2010 to 2017: a cross-sectional, spatio-epidemiological study on ambulatory claims data. *BMJ Open* 2021;11:e047806.

[21] Solberg SM. Psoriasis in Norway: A Prescription-based Registry Study of Incidence and Prevalence. *Acta Dermato-Venereologica* 2023;103:adv4591.

[22] Passeron T, Bouillon R, Callender V, et al. Sunscreen photoprotection and vitamin D status. *Br J Dermatol* 2019;181:916-31.

[dataset] [23] National Health and Nutrition Examination Survey, 2009-2014. National Center for Health Statistics, Centers for Disease Control and Prevention. Available: https://www.cdc.gov/nchs/nhanes/index.htm

[24] Linos E, Keiser E, Kanzler M, et al. Sun protective behaviors and vitamin D levels in the US population: NHANES 2003-2006. *Cancer Causes Control* 2012;23:133-40.

[25] National Health and Nutrition Examination Survey: Analytic Guidelines, 1999-2010. National Health and Nutrition Examination Survey. Available: https://wwwn.cdc.gov/nchs/data/nhanes/analyticguidelines/99-10-analytic-guidelines.pdf

[26] National Health and Nutrition Examination Survey: Analytic Guidelines, 2011-2016. National Health and Nutrition Examination Survey. Available: https://wwwn.cdc.gov/nchs/data/nhanes/analyticguidelines/11-16-analytic-guidelines.pdf

[27] Griffiths CEM, Armstrong AW, Gudjonsson JE, et al. Psoriasis. *The Lancet* 2021;397:1301-15.

[28] Haluza D, Simic S, Höltge J, et al. Gender aspects of recreational sun-protective behavior: results of a representative, population-based survey among Austrian residents. *Photodermatol Photoimmunol Photomed* 2016;32:11-21.

[29] Shams K, Kurowska-Stolarska M, Schütte F, et al. MicroRNA-146 and cell trauma down-regulate expression of the psoriasis-associated atypical chemokine receptor ACKR2. *J Biol Chem* 2018;293:3003-12.

[30] Madden SK, Flanagan KL, Jones G. How lifestyle factors and their associated pathogenetic mechanisms impact psoriasis. *Clin Nutr* 2020;39:1026-40.

[31] Garritsen FM, Kraag DE, de Graaf M. Guttate psoriasis triggered by perianal streptococcal infection. *Clinical and Experimental Dermatology* 2017;42:536-38.

[32] Fry L, Baker BS. Triggering psoriasis: the role of infections and medications. *Clinics in Dermatology* 2007;25:606-15.

[33] Wu S, Han J, Li W-Q, et al. Hypertension, antihypertensive medication use, and risk of psoriasis. *JAMA Dermatol* 2014;150:957-63.

[34] Ros A-M, Eklund G, D O. Photosensitive psoriasis: an epidemiologic study. *J Am Acad Dermatol* 1987;17:752-58.

[35] Rutter KJ, Watson RE, Cotterell LF, et al. Severely photosensitive psoriasis: a phenotypically defined patient subset. *J Invest Dermatol* 2009;129:2861-7.

[36] Rendon A, Schäkel K. Psoriasis Pathogenesis and Treatment. *Int J Mol Sci* 2019;20:1475.

[37] Li X, Xiao QQ, Li FL, et al. Immune Signatures in Patients with Psoriasis Vulgaris of Blood-Heat Syndrome: A Systematic Review and Meta-Analysis. *Evidence-based complementary and alternative medicine : eCAM* 2016;2016:9503652.

22

[38] Heier I, Søyland E, Krogstad AL, et al. Sun exposure rapidly reduces plasmacytoid dendritic cells and inflammatory dermal dendritic cells in psoriatic skin. *Br J Dermatol* 2011;165:792-801.

[39] Barrea L, Savanelli MC, Di Somma C, et al. Vitamin D and its role in psoriasis: An overview of the dermatologist and nutritionist. *Rev Endocr Metab Disord* 2017;18:195-205.

[40] Williams HC. Smoking and psoriasis. *BMJ (Clinical research ed)* 1994;308:428.

[41] Wei J, Zhu J, Xu H, et al. Alcohol consumption and smoking in relation to psoriasis: a Mendelian randomization study. *British Journal of Dermatology* 2022;187:684-91.

[42] Armstrong AW, Armstrong EJ, Fuller EN, et al. Smoking and pathogenesis of psoriasis: a review of oxidative, inflammatory and genetic mechanisms. *British Journal of Dermatology* 2011;165:1162-68.

[43] McKenzie C, Nahm WJ, Kearney CA, et al. Sun-protective behaviors and sunburn among US adults. *Archives of Dermatological Research* 2023;315:1665-74.

[44] Adesanya EI, Matthewman J, Schonmann Y, et al. Factors associated with depression, anxiety and severe mental illness among adults with atopic eczema or psoriasis: a systematic review and meta-analysis. *British Journal of Dermatology* 2023;188:460-70.

[45] Jankowiak B, Kowalewska B, Krajewska-Kułak E, et al. Stigmatization and Quality of Life in Patients with Psoriasis. *Dermatology and Therapy* 2020;10:285-96.

23

Figure legend

Figure 1. Flow diagram of the screening process for participant selection

Sun-protective behaviors include staying in the shade, wearing long sleeves, and using sunscreen. BMI,

body mass index.

24

11842 Participants aged 20-59 y

6 Excluded with unavailable self-reported psoriasis data

11836 With available psoriasis data

168 Excluded with unavailable sun-protective behaviors data

11668 With available sun-protective behaviors data

1933 Excluded with unavailable data of covariates (age, gender, race or ethnicity, education level, marital status, country of birth, BMI, alcohol drinking status, smoking status, sun sensitivity and time spent outdoors)

9735 included in the final analysis

Figure 1. Flow diagram of the screening process for the study participants' selection. Sun-protective behaviors include staying in the shade, wearing long sleeves, and using sunscreen. BMI, body mass index.

225x253mm (330 x 330 DPI)

Table S1 Characteristics of included and excluded participants

	Excluded	Included	*P* value
Number of participants, n (%)	2107 (17.8)	9735 (82.2)	
Age, Mean±SD, y	39.3±11.0	39.1 ± 11.5	0.33
Gender, n (%)			<0.001
Female	1227 (58.2)	4882 (50.1)	
Male	880 (41.8)	4853 (49.9)	
Race and ethnicity, n (%)			<0.001
Non-Hispanic White	676 (32.1)	4030 (41.4)	
Non-Hispanic Black	478 (22.7)	2048 (21.0)	
Hispanic	233 (11.1)	938 (9.6)	
Other[a]	720 (34.2)	2719 (27.9)	
Education level, n (%)			<0.001
Less than 9th grade	230 (10.9)	645 (6.6)	
9-11th grade	343 (16.3)	1363 (14.0)	
High school grad/GED or equivalent	467 (22.2)	2137 (22.0)	
Some college or AA degree	582 (27.6)	3115 (32.0)	
College graduate or above	472 (22.4)	2475 (25.4)	
Missing	13 (0.6)	0 (0)	
Country of birth, n (%)			<0.001
Not US born	844 (40.1)	2793 (28.7)	
US born	1257 (59.7)	6942 (71.3)	
Missing	6 (0.3)	0 (0)	
Marital status, n (%)			<0.001
Never married	533 (25.3)	2563 (26.3)	
Married or living with a partner	1233 (58.5)	5719 (58.7)	
Widowed or divorced or separated	334 (15.9)	1453 (14.9)	
Missing	7 (0.3)	0 (0)	
BMI (kg/m^2), n (%)			<0.001
<25	552 (26.2)	3043 (31.3)	
≥25, <30	500 (23.7)	3071 (31.5)	
≥30	605 (28.7)	3621 (37.2)	
Missing	450 (21.4)	0 (0)	
Alcohol drinkers, n (%)			<0.001
No	112 (5.3)	2279 (23.4)	
Yes	227 (10.8)	7456 (76.6)	
Missing	1768 (83.9)	0 (0)	
Smoking status, n (%)			<0.001
Nonsmokers	1280 (60.7)	5670 (58.2)	
Former smokers	298 (14.1)	1647 (16.9)	
Current smokers	523 (24.8)	2418 (24.8)	
Missing	6 (0.3)	0 (0)	
Sun sensitivity[b], n (%)			<0.001
None	146 (6.9)	956 (9.8)	

Mild	858 (40.7)	4667 (47.9)	
Severe	957 (45.4)	4112 (42.2)	
Missing	146 (6.9)	0 (0)	
Time spent outdoors[c], n (%)			<0.001
<60 min/d	950 (45.1)	3891 (40.0)	
≥60 min/d	1114 (52.9)	5844 (60.0)	
Missing	43 (2.0)	0 (0)	

[a] Included Mexican American and multiracial participants.

[b] Sun sensitivity was divided into three levels according to skin reaction to sun without sunscreen or protective clothing for half an hour: none (defined as "nothing would happen"), mild (defined as "mildly burn with some tanning" and "turn darker without a sunburn"), and severe (defined as "severe sunburn with blisters" and "severe sunburn for a few days with peeling").

[c] Time spent outdoors was recalculated based on minutes spent outdoors from 9:00 am to 5:00 pm on working days and non-working days, considering that there are 5 working days and 2 non-working days in a week.

Table S2 Characteristics of participants by the frequency of staying in the shade

	Total (N=9735)	Staying in the shade			P value
		Rare (N=2546)	Moderate (N=3776)	Frequent (N=3413)	
Age, mean ± SD (95% CI), y	39.6±11.7 (39.3-39.9)	39.1±11.9 (38.5-39.7)	39.2±11.8 (38.7-39.7)	40.5±11.5 (40.0-41.0)	<0.001
Gender					<0.001
Female	4882 (49.7) [48.4-50.9]	1012 (41.0) [38.6-43.5]	1770 (46.8) [44.8-48.8]	2100 (61.1) [59.0-63.2]	
Male	4853 (50.3) [49.1-51.6]	1534 (59.0) [56.5-61.4]	2006 (53.2) [51.2-55.2]	1313 (38.9) [36.8-41.0]	
Race or ethnicity					<0.001
Non-Hispanic White	4030 (64.5) [63.5-65.6]	1199 (68.7) [66.7-70.6]	1793 (70.3) [68.8-71.8]	1038 (53.1) [51.0-55.1]	
Non-Hispanic Black	2048 (11.9) [11.3-12.4]	419 (8.9) [8.1-9.9]	715 (9.9) [9.1-10.7]	914 (17.1) [15.9-18.3]	
Hispanic	938 (6.2) [5.8-6.6]	244 (6.0) [5.2-6.8]	284 (4.6) [4.0-5.2]	410 (8.6) [7.7-9.5]	
Other	2719 (17.4) [16.7-18.2]	684 (16.4) [15.0-17.9]	984 (15.3) [14.2-16.4]	1051 (21.3) [19.9-22.8]	
Education level					<0.001
Less than 9th grade	645 (4.0) [3.6-4.4]	207 (4.9) [4.2-5.8]	177 (2.9) [2.4-3.5]	261 (4.7) [4.1-5.3]	
9-11th grade	1363 (10.9) [10.2-11.6]	435 (12.6) [11.3-14.0]	416 (8.3) [7.4-9.4]	512 (12.8) [11.5-14.2]	
High school grad/GED or equivalent	2137 (21.1) [20.1-22.1]	584 (23.0) [21.0-25.1]	833 (20.9) [19.3-22.5]	720 (19.7) [18.1-21.4]	
Some college or AA degree	3115 (33.1) [31.9-34.3]	796 (33.1) [30.9-35.5]	1253 (33.8) [31.9-35.7]	1066 (32.0) [30.0-34.0]	
College graduate or above	2475 (31) [29.8-32.2]	524 (26.4) [24.1-28.7]	1097 (34.1) [32.2-36.0]	854 (30.9) [28.8-33.0]	
Country of birth					<0.001
Not US born	2793 (18.5) [17.7-19.3]	757 (18.2) [16.7-19.7]	917 (15.0) [13.8-16.2]	1119 (23.4) [21.9-25.0]	
US born	6942 (81.5) [80.7-82.3]	1789 (81.8) [80.3-83.3]	2859 (85.0) [83.8-86.2]	2294 (76.6) [75.0-78.1]	
Marital status					0.10
Never married	2563 (24.1) [23.1-25.2]	671 (25.6) [23.6-27.8]	1017 (24.3) [22.7-26.0]	875 (22.6) [20.9-24.3]	
Married or living with partner	5719 (62.1) [60.8-63.3]	1509 (60.8) [58.4-63.2]	2205 (62.2) [60.3-64.1]	2005 (62.9) [60.9-64.9]	
Widowed or divorced or separated	1453 (13.8) [13-14.7]	366 (13.6) [12.0-15.4]	554 (13.5) [12.2-14.9]	533 (14.5) [13.0-16.1]	
BMI (kg/m²)					<0.001
<25	3043 (31.4) [30.2-32.6]	848 (32.7) [30.5-35.0]	1219 (32.1) [30.3-34.0]	976 (29.2) [27.3-31.2]	
≥25, <30	3071 (32.8) [31.6-34]	861 (34.7) [32.3-37.1]	1195 (33.4) [31.5-35.3]	1015 (30.4) [28.5-32.5]	
≥30	3621 (35.8) [34.6-37]	837 (32.6) [30.4-35.0]	1362 (34.5) [32.7-36.4]	1422 (40.3) [38.3-42.4]	
Alcohol drinkers					<0.001
No	2279 (18.6) [17.7-19.5]	524 (16.3) [14.7-18.0]	764 (16.3) [15.0-17.8]	991 (23.6) [22.0-25.3]	
Yes	7456 (81.4) [80.5-82.3]	2022 (83.7) [82.0-85.3]	3012 (83.7) [82.2-85.0]	2422 (76.4) [74.7-78.0]	
Smoking status					<0.001

	Total	Rare	Moderate	Frequent	P value
Nonsmokers	5670 (57.8) [56.6-59.1]	1382 (55.1) [52.6-57.5]	2197 (57.3) [55.3-59.2]	2091 (61.0) [58.9-63.1]	
Former smokers	1647 (19.2) [18.2-20.3]	439 (19.5) [17.6-21.6]	659 (19.7) [18.1-21.4]	549 (18.3) [16.6-20.1]	
Current smokers	2418 (22.9) [21.9-24]	725 (25.4) [23.4-27.5]	920 (23.0) [21.4-24.7]	773 (20.7) [19.1-22.4]	
Sun sensitivity					<0.001
None	956 (12.7) [11.9-13.7]	147 (7.6) [6.3-9.1]	327 (10.7) [9.5-12.1]	482 (20.0) [18.1-21.9]	
Mild	4667 (52.1) [50.8-53.3]	1145 (50.0) [47.5-52.4]	1924 (56.3) [54.3-58.2]	1598 (48.3) [46.2-50.4]	
Severe	4112 (35.2) [34-36.3]	1254 (42.4) [40.1-44.9]	1525 (33.0) [31.2-34.8]	1333 (31.7) [29.9-33.6]	
Time spent outdoors (minute/d)					<0.001
<60	3891 (38.8) [37.6-40.1]	856 (31.6) [29.4-33.9]	1399 (36.9) [35.0-38.9]	1636 (47.7) [45.6-49.9]	
≥60	5844 (61.2) [59.9-62.4]	1690 (68.4) [66.1-70.6]	2377 (63.1) [61.1-65.0]	1777 (52.3) [50.1-54.4]	
Psoriasis					0.07
No	9480 (97.2) [96.7-97.6]	2489 (97.4) [96.5-98.1]	3677 (97.4) [96.7-98.0]	3314 (96.6) [95.6-97.4]	
Yes	255 (2.8) [2.4-3.3]	57 (2.6) [1.9-3.5]	99 (2.6) [2.0-3.3]	99 (3.4) [2.6-4.4]	

Table S3 Characteristics of participants by the frequency of wearing of long sleeves

	Total (N=9735)	Wearing long sleeves			P value
		Rare (N=6742)	Moderate (N=1941)	Frequent (N=1052)	
Age, mean±SD (95% CI), y	39.6±11.7 (39.3-39.9)	39.1±11.7 (38.7-39.5)	40.2±11.7 (39.5-40.9)	42.1±11.3 (41.2-43.0)	<0.001
Gender					0.005
Female	4882 (49.7) [48.4-50.9]	3437 (49.9) [48.4-51.4]	982 (51.0) [48.2-53.9]	463 (44.6) [40.7-48.5]	
Male	4853 (50.3) [49.1-51.6]	3305 (50.1) [48.6-51.6]	959 (49.0) [46.1-51.8]	589 (55.4) [51.5-59.3]	
Race or ethnicity					<0.001
Non-Hispanic White	4030 (64.5) [63.5-65.6]	2955 (66.2) [65.0-67.4]	796 (65.9) [63.6-68.2]	279 (48.0) [44.0-52.0]	
Non-Hispanic Black	2048 (11.9) [11.3-12.4]	1453 (11.9) [11.3-12.6]	408 (11.8) [10.6-13.1]	187 (11.6) [10.0-13.5]	
Hispanic	938 (6.2) [5.8-6.6]	688 (6.5) [6.0-7.0]	138 (4.3) [3.6-5.1]	112 (8.2) [6.7-10.0]	
Other	2719 (17.4) [16.7-18.2]	1646 (15.4) [14.6-16.3]	599 (17.9) [16.3-19.7]	474 (32.2) [29.0-35.5]	
Education level					<0.001
Less than 9th grade	645 (4.0) [3.6-4.4]	335 (3.0) [2.7-3.4]	141 (4.3) [3.5-5.3]	169 (10.7) [9.0-12.8]	
9-11th grade	1363 (10.9) [10.2-11.6]	1011 (11.6) [10.8-12.5]	211 (8.1) [6.8-9.5]	141 (11.3) [9.3-13.6]	
High school grad/GED or equivalent	2137 (21.1) [20.1-22.1]	1537 (21.8) [20.6-23.0]	397 (19.7) [17.6-22.0]	203 (18.8) [15.9-21.9]	
Some college or AA degree	3115 (33.1) [31.9-34.3]	2248 (34.4) [33.0-35.8]	589 (30.8) [28.2-33.5]	278 (27.8) [24.4-31.4]	
College graduate or above	2475 (31) [29.8-32.2]	1611 (29.2) [27.8-30.6]	603 (37.1) [34.3-40.0]	261 (31.5) [27.7-35.5]	

Country of birth					<0.001
Not US born	2793 (18.5) [17.7-19.3]	1678 (15.9) [15.0-16.8]	603 (19.2) [17.4-21.1]	512 (37.4) [33.9-41.0]	
US born	6942 (81.5) [80.7-82.3]	5064 (84.1) [83.2-85.0]	1338 (80.8) [78.9-82.6]	540 (62.6) [59.0-66.1]	
Marital status					<0.001
Never married	2563 (24.1) [23.1-25.2]	1858 (25.0) [23.8-26.3]	491 (21.4) [19.3-23.7]	214 (23.2) [20.0-26.8]	
Married or living with partner	5719 (62.1) [60.8-63.3]	3847 (60.7) [59.2-62.1]	1195 (65.7) [63.1-68.3]	677 (64.7) [60.9-68.3]	
Widowed or divorced or separated	1453 (13.8) [13-14.7]	1037 (14.3) [13.3-15.4]	255 (12.8) [11.0-14.9]	161 (12.1) [10.0-14.5]	
BMI (kg/m^2)					0.006
<25	3043 (31.4) [30.2-32.6]	2073 (30.9) [29.5-32.3]	673 (34.3) [31.6-37.0]	297 (28.7) [25.2-32.4]	
≥25, <30	3071 (32.8) [31.6-34]	2105 (32.6) [31.2-34.0]	595 (32.8) [30.1-35.5]	371 (34.6) [31.1-38.4]	
≥30	3621 (35.8) [34.6-37]	2564 (36.5) [35.1-38.0]	673 (33.0) [30.4-35.7]	384 (36.7) [33.0-40.6]	
Alcohol drinkers					<0.001
No	2279 (18.6) [17.7-19.5]	1482 (17.4) [16.4-18.5]	503 (20.4) [18.4-22.5]	294 (23.5) [20.5-26.7]	
Yes	7456 (81.4) [80.5-82.3]	5260 (82.6) [81.5-83.6]	1438 (79.6) [77.5-81.6]	758 (76.5) [73.3-79.5]	
Smoking status					<0.001
Nonsmokers	5670 (57.8) [56.6-59.1]	3791 (55.9) [54.4-57.4]	1205 (62.1) [59.2-64.8]	674 (63.8) [60.0-67.5]	
Former smokers	1647 (19.2) [18.2-20.3]	1146 (19.4) [18.2-20.7]	321 (18.8) [16.6-21.3]	180 (18.6) [15.6-22.0]	
Current smokers	2418 (22.9) [21.9-24]	1805 (24.7) [23.5-26.0]	415 (19.1) [17.0-21.4]	198 (17.6) [14.9-20.7]	
Sun sensitivity					0.003
None	956 (12.7) [11.9-13.7]	649 (12.6) [11.6-13.7]	176 (11.6) [9.8-13.7]	131 (16.2) [13.2-19.7]	
Mild	4667 (52.1) [50.8-53.3]	3297 (52.7) [51.3-54.2]	889 (51.8) [48.9-54.6]	481 (47.7) [43.8-51.6]	
Severe	4112 (35.2) [34-36.3]	2796 (34.6) [33.3-36.0]	876 (36.6) [34.0-39.3]	440 (36.1) [32.6-39.7]	
Time spent outdoors (minute/d)					<0.001
<60	3891 (38.8) [37.6-40.1]	2588 (36.8) [35.4-38.3]	880 (45.4) [42.5-48.2]	423 (40.0) [36.2-43.9]	
≥60	5844 (61.2) [59.9-62.4]	4154 (63.2) [61.7-64.6]	1061 (54.6) [51.8-57.5]	629 (60.0) [56.1-63.8]	
Psoriasis					0.002
No	9480 (97.2) [96.7-97.6]	6557 (97.0) [96.4-97.5]	1907 (98.3) [97.4-98.9]	1016 (96.2) [94.2-97.6]	
Yes	255 (2.8) [2.4-3.3]	185 (3.0) [2.5-3.6]	34 (1.7) [1.1-2.6]	36 (3.8) [2.4-5.8]	

Table S4 Characteristics of participants by the frequency of using sunscreen

Using sunscreen		

	Total (N=9735)	Rare (N=5579)	Moderate (N=1819)	Frequent (N=2337)	*P* value
Age, mean±SD (95% CI), y	39.6±11.7 (39.3-39.9)	39.3 ± 11.9 (38.8-39.7)	39.1 ± 11.7 (38.3-39.8)	40.5 ± 11.3 (39.9-41.1)	<0.001
Gender					<0.001
Female	4882 (49.7) [48.4-50.9]	2282 (39.0) [37.4-40.6]	1001 (50.9) [48.1-53.8]	1599 (66.2) [63.8-68.5]	
Male	4853 (50.3) [49.1-51.6]	3297 (61.0) [59.4-62.6]	818 (49.1) [46.2-51.9]	738 (33.8) [31.5-36.2]	
Race or ethnicity					<0.001
Non-Hispanic White	4030 (64.5) [63.5-65.6]	1771 (51.8) [50.2-53.5]	947 (74.6) [72.6-76.6]	1312 (77.8) [76.1-79.4]	
Non-Hispanic Black	2048 (11.9) [11.3-12.4]	1694 (20.1) [19.1-21.2]	196 (5.4) [4.6-6.2]	158 (3.1) [2.6-3.7]	
Hispanic	938 (6.2) [5.8-6.6]	516 (7.0) [6.4-7.7]	180 (5.5) [4.7-6.4]	242 (5.3) [4.6-6.1]	
Other	2719 (17.4) [16.7-18.2]	1598 (21.0) [19.8-22.2]	496 (14.5) [13.0-16.1]	625 (13.8) [12.6-15.2]	
Education level					<0.001
Less than 9th grade	645 (4.0) [3.6-4.4]	515 (6.5) [5.9-7.2]	57 (1.7) [1.2-2.3]	73 (1.5) [1.2-1.9]	
9-11th grade	1363 (10.9) [10.2-11.6]	1028 (16.2) [15.1-17.4]	155 (6.0) [5.0-7.3]	180 (5.8) [4.9-6.9]	
High school grad/GED or equivalent	2137 (21.1) [20.1-22.1]	1454 (26.9) [25.4-28.4]	344 (17.8) [15.7-20.0]	339 (14.0) [12.4-15.8]	
Some college or AA degree	3115 (33.1) [31.9-34.3]	1710 (32.9) [31.3-34.5]	646 (35.8) [33.1-38.5]	759 (31.3) [29.1-33.7]	
College graduate or above	2475 (31) [29.8-32.2]	872 (17.5) [16.2-18.8]	617 (38.7) [36.0-41.6]	986 (47.4) [44.9-49.8]	
Country of birth					<0.001
Not US born	2793 (18.5) [17.7-19.3]	1649 (21.3) [20.2-22.5]	491 (15.7) [14.1-17.4]	653 (15.8) [14.4-17.3]	
US born	6942 (81.5) [80.7-82.3]	3930 (78.7) [77.5-79.8]	1328 (84.3) [82.6-85.9]	1684 (84.2) [82.7-85.6]	
Marital status					<0.001
Never married	2563 (24.1) [23.1-25.2]	1585 (27.3) [25.8-28.7]	465 (23.8) [21.5-26.2]	513 (19.3) [17.5-21.2]	
Married or living with partner	5719 (62.1) [60.8-63.3]	3096 (57.5) [55.8-59.1]	1109 (62.8) [60.1-65.5]	1514 (69.0) [66.7-71.2]	
Widowed or divorced or separated	1453 (13.8) [13-14.7]	898 (15.3) [14.1-16.5]	245 (13.4) [11.5-15.5]	310 (11.7) [10.3-13.4]	
BMI (kg/m²)					<0.001
<25	3043 (31.4) [30.2-32.6]	1527 (27.0) [25.6-28.5]	615 (32.1) [29.5-34.7]	901 (38.0) [35.6-40.4]	
≥25, <30	3071 (32.8) [31.6-34]	1776 (32.6) [31.0-34.2]	565 (33.4) [30.8-36.2]	730 (32.7) [30.4-35.1]	
≥30	3621 (35.8) [34.6-37]	2276 (40.4) [38.7-42.0]	639 (34.5) [31.9-37.3]	706 (29.3) [27.1-31.6]	
Alcohol drinkers					<0.001
No	2279 (18.6) [17.7-19.5]	1367 (20.3) [19.1-21.6]	377 (16.4) [14.5-18.4]	535 (17.3) [15.6-19.1]	
Yes	7456 (81.4) [80.5-82.3]	4212 (79.7) [78.4-80.9]	1442 (83.6) [81.6-85.5]	1802 (82.7) [80.9-84.4]	

	Total	Rare	Moderate	Frequent	P value
Smoking status					<0.001
Nonsmokers	5670 (57.8) [56.6-59.1]	2946 (50.8) [49.2-52.5]	1188 (64.2) [61.4-66.9]	1536 (64.6) [62.2-67.0]	
Former smokers	1647 (19.2) [18.2-20.3]	889 (18.4) [17.0-19.8]	296 (18.0) [15.8-20.3]	462 (21.5) [19.5-23.7]	
Current smokers	2418 (22.9) [21.9-24]	1744 (30.8) [29.3-32.4]	335 (17.9) [15.8-20.1]	339 (13.9) [12.2-15.6]	
Sun sensitivity					<0.001
None	956 (12.7) [11.9-13.7]	356 (8.2) [7.2-9.3]	198 (13.1) [11.3-15.3]	402 (19.8) [17.9-22.0]	
Mild	4667 (52.1) [50.8-53.3]	2385 (47.0) [45.3-48.7]	995 (58.2) [55.4-60.9]	1287 (55.9) [53.5-58.4]	
Severe	4112 (35.2) [34-36.3]	2838 (44.8) [43.2-46.4]	626 (28.7) [26.3-31.3]	648 (24.2) [22.2-26.3]	
Time spent outdoors (minute/d)					<0.001
<60	3891 (38.8) [37.6-40.1]	2059 (35.0) [33.5-36.6]	753 (39.7) [37.0-42.6]	1079 (44.3) [41.9-46.8]	
≥60	5844 (61.2) [59.9-62.4]	3520 (65.0) [63.4-66.5]	1066 (60.3) [57.4-63.0]	1258 (55.7) [53.2-58.1]	
Psoriasis					0.04
No	9480 (97.2) [96.7-97.6]	5449 (97.6) [97.0-98.0]	1763 (96.5) [95.1-97.4]	2268 (97.1) [96.1-97.8]	
Yes	255 (2.8) [2.4-3.3]	130 (2.4) [2.0-3.0]	56 (3.5) [2.6-4.9]	69 (2.9) [2.2-3.9]	

Table S5 Characteristics of participants by the frequency of overall sun protection

	Total (N=9735)	Overall sun protection			P value
		Rare (N=3249)	Moderate (N=5850)	Frequent (N=636)	
Age, mean±SD (95% CI), y	39.6±11.7 (39.3-39.9)	38.7±11.9 (38.2-39.3)	39.7±11.6 (39.3-40.0)	42.8±10.9 (41.7-43.9)	<0.001
Gender					<0.001
Female	4882 (49.7) [48.4-50.9]	1238 (36.5) [34.5-38.6]	3209 (54.7) [53.1-56.3]	435 (65.8) [60.9-70.5]	
Male	4853 (50.3) [49.1-51.6]	2011 (63.5) [61.4-65.5]	2641 (45.3) [43.7-46.9]	201 (34.2) [29.5-39.1]	
Race or ethnicity					<0.001
Non-Hispanic White	4030 (64.5) [63.5-65.6]	1387 (63.7) [61.9-65.6]	2365 (64.4) [63.1-65.8]	278 (69.2) [65.3-72.9]	
Non-Hispanic Black	2048 (11.9) [11.3-12.4]	762 (13.9) [12.9-15.0]	1232 (11.6) [10.9-12.3]	54 (4.9) [3.7-6.4]	
Hispanic	938 (6.2) [5.8-6.6]	295 (6.2) [5.4-7.0]	573 (6.2) [5.7-6.8]	70 (6.3) [4.9-8.1]	
Other	2719 (17.4) [16.7-18.2]	805 (16.2) [15.0-17.6]	1680 (17.8) [16.8-18.8]	234 (19.6) [16.8-22.9]	
Education level					<0.001
Less than 9th grade	645 (4.0) [3.6-4.4]	201 (4.1) [3.5-4.9]	406 (4.1) [3.6-4.6]	38 (2.7) [1.9-3.7]	
9-11th grade	1363 (10.9) [10.2-11.6]	575 (14.6) [13.3-16.1]	733 (9.4) [8.6-10.2]	55 (6.9) [5.1-9.4]	
High school grad/GED or equivalent	2137 (21.1) [20.1-22.1]	838 (26.2) [24.4-28.2]	1217 (19.4) [18.2-20.7]	82 (12.0) [9.2-15.6]	
Some college or AA degree	3115 (33.1) [31.9-34.3]	1056 (34.2) [32.1-36.3]	1871 (33.1) [31.6-34.7]	188 (27.1) [23.0-31.7]	

College graduate or above	2475 (31) [29.8-32.2]	579 (20.8) [19.0-22.7]	1623 (34.0) [32.5-35.6]	273 (51.2) [46.2-56.2]	
Country of birth					<0.001
Not US born	2793 (18.5) [17.7-19.3]	837 (16.5) [15.3-17.9]	1699 (18.6) [17.6-19.7]	257 (26.3) [22.6-30.4]	
US born	6942 (81.5) [80.7-82.3]	2412 (83.5) [82.1-84.7]	4151 (81.4) [80.3-82.4]	379 (73.7) [69.6-77.4]	
Marital status					<0.001
Never married	2563 (24.1) [23.1-25.2]	910 (26.3) [24.5-28.2]	1535 (23.8) [22.5-25.1]	118 (17.1) [13.7-21.0]	
Married or living with partner	5719 (62.1) [60.8-63.3]	1824 (58.8) [56.6-60.9]	3482 (62.9) [61.4-64.5]	413 (69.6) [64.9-73.9]	
Widowed or divorced or separated	1453 (13.8) [13-14.7]	515 (14.9) [13.4-16.5]	833 (13.3) [12.2-14.4]	105 (13.3) [10.4-16.9]	
BMI (kg/m²)					<0.001
<25	3043 (31.4) [30.2-32.6]	973 (28.8) [26.9-30.8]	1845 (32.3) [30.8-33.8]	225 (35.2) [30.5-40.1]	
≥25, <30	3071 (32.8) [31.6-34]	1060 (33.9) [31.9-36.1]	1808 (32.1) [30.6-33.7]	203 (33.6) [29.0-38.5]	
≥30	3621 (35.8) [34.6-37]	1216 (37.2) [35.1-39.4]	2197 (35.6) [34.1-37.1]	208 (31.3) [26.8-36.1]	
Alcohol drinkers					<0.001
No	2279 (18.6) [17.7-19.5]	691 (17.2) [15.7-18.7]	1399 (18.7) [17.6-19.9]	189 (23.3) [19.5-27.6]	
Yes	7456 (81.4) [80.5-82.3]	2558 (82.8) [81.3-84.3]	4451 (81.3) [80.1-82.4]	447 (76.7) [72.4-80.5]	
Smoking status					<0.001
Nonsmokers	5670 (57.8) [56.6-59.1]	1685 (50.9) [48.7-53.1]	3553 (60.3) [58.7-61.9]	432 (67.8) [62.9-72.3]	
Former smokers	1647 (19.2) [18.2-20.3]	545 (19.2) [17.5-21.1]	977 (18.9) [17.6-20.3]	125 (21.6) [17.6-26.3]	
Current smokers	2418 (22.9) [21.9-24]	1019 (29.9) [27.9-31.9]	1320 (20.7) [19.5-22.0]	79 (10.5) [8.1-13.6]	
Sun sensitivity					<0.001
None	956 (12.7) [11.9-13.7]	195 (7.5) [6.4-8.9]	615 (13.7) [12.6-15.0]	146 (28.1) [23.7-33.1]	
Mild	4667 (52.1) [50.8-53.3]	1492 (51.4) [49.2-53.5]	2845 (52.5) [50.9-54.1]	330 (52.1) [47.1-57.1]	
Severe	4112 (35.2) [34-36.3]	1562 (41.1) [39.0-43.2]	2390 (33.8) [32.3-35.3]	160 (19.7) [16.3-23.7]	
Time spent outdoors (minute/d)					<0.001
<60	3891 (38.8) [37.6-40.1]	1068 (31.2) [29.2-33.2]	2486 (41.4) [39.8-43.0]	337 (51.4) [46.4-56.4]	
≥60	5844 (61.2) [59.9-62.4]	2181 (68.8) [66.8-70.8]	3364 (58.6) [57.0-60.2]	299 (48.6) [43.6-53.6]	
Psoriasis					<0.001
No	9480 (97.2) [96.7-97.6]	3174 (97.2) [96.3-97.9]	5698 (97.4) [96.8-97.9]	608 (94.8) [91.8-96.8]	
Yes	255 (2.8) [2.4-3.3]	75 (2.8) [2.1-3.7]	152 (2.6) [2.1-3.2]	28 (5.2) [3.2-8.2]	