

Table SI. Characteristics of Survey Participants According to Their Survival Status in NHANES, 2003-2006, 2009-2012, 2015-2018 (N = 12,065)

Characteristic	Survival, N = 11,646 ¹	Death, N = 419 ¹	p-value ²
Age			<0.001
20-40 years	5,713 (49%)	78 (19%)	
40-60 years	5,933 (51%)	341 (81%)	
Gender			<0.001
Female	5,771 (50%)	166 (40%)	
Male	5,875 (50%)	253 (60%)	
Race			<0.001
Mexican American	2,085 (18%)	50 (12%)	
Non-Hispanic Black	2,309 (20%)	115 (27%)	
Non-Hispanic White	5,036 (43%)	212 (51%)	
Other Hispanic	944 (8.1%)	18 (4.3%)	
Other/multiracial	1,272 (11%)	24 (5.7%)	
Income			<0.001
high	3,900 (33%)	98 (23%)	
middle	2,744 (24%)	82 (20%)	
low	5,002 (43%)	239 (57%)	

Characteristic	Survival, N = 11,646 ¹	Death, N = 419 ¹	p-value ²
Education			<0.001
below 9th Grade	817 (7.0%)	50 (12%)	
9-11th Grade	1,512 (13%)	83 (20%)	
high school	2,644 (23%)	119 (28%)	
above high school	6,673 (57%)	167 (40%)	
BMI			0.056
normal	2,972 (26%)	95 (23%)	
obesity	4,679 (40%)	183 (44%)	
high	3,840 (33%)	130 (31%)	
low	155 (1.3%)	11 (2.6%)	
Marital status			<0.001
married	6,130 (53%)	175 (42%)	
unmarried	3,814 (33%)	128 (31%)	
divorced	1,702 (15%)	116 (28%)	
Sun sensitivity			0.355
sun sensitive	1,261 (11%)	52 (12%)	
mildly sun sensitive	5,673 (49%)	191 (46%)	
not sun sensitive	4,712 (40%)	176 (42%)	
Vitamin D			<0.001

Characteristic	Survival, N = 11,646 ^I	Death, N = 419 ^I	p-value ²
normal	2,989 (26%)	77 (18%)	
insufficient	4,580 (39%)	153 (37%)	
deficient	3,541 (30%)	153 (37%)	
severely deficient	536 (4.6%)	36 (8.6%)	
Drinking alcohol status			0.682
current drinking	8,885 (76%)	324 (77%)	<0.001
never drinking	2,761 (24%)	95 (23%)	
Smoking status			
current smoking	2,792 (24%)	204 (49%)	
former smoking	2,277 (20%)	77 (18%)	<0.001
never smoking	6,577 (56%)	138 (33%)	
Chronic kidney disease			
Yes	967 (8.3%)	111 (26%)	
Not	10,679 (92%)	308 (74%)	0.002
Hyperlipidemia			
Yes	8,857 (76%)	346 (83%)	
Not	2,789 (24%)	73 (17%)	
Hypertension			<0.001
Yes	2,780 (24%)	199 (47%)	

Characteristic	Survival, N = 11,646 ^I	Death, N = 419 ^I	p-value ²
Not	8,866 (76%)	220 (53%)	<0.001
Diabetes			
Yes	858 (7.4%)	81 (19%)	0.001
Not	10,788 (93%)	338 (81%)	
Shade			
frequent	3,964 (34%)	179 (43%)	
moderate	4,627 (40%)	144 (34%)	0.830
rare	3,055 (26%)	96 (23%)	
Shirt			<0.001
frequent	1,256 (11%)	49 (12%)	
moderate	2,342 (20%)	83 (20%)	
rare	8,048 (69%)	287 (68%)	
Sunscreen			<0.001
frequent	2,623 (23%)	48 (11%)	
moderate	2,268 (19%)	64 (15%)	
rare	6,755 (58%)	307 (73%)	
Follow-up time (months)			<0.001
Mean (SD)	109.32 (58.11)	81.21 (50.43)	
Median (IQR)	111.00 (51.00, 166.00)	76.00 (38.00, 119.00)	

Characteristic	Survival, N = 11,646 ¹	Death, N = 419 ¹	p-value ²
Range	12.00, 205.00	2.00, 192.00	

The p-value < 0.05 is considered significant.

¹ n (%)

² Fisher’s exact test; Welch Two Sample t-test

This study systematically assessed three characteristic sun-protective behaviors using interview data from the NHANES dermatology module: (1) staying in the shade, (2) wearing long-sleeved clothing, and (3) using sunscreen on a very sunny day. Based on response distributions, each behavior was categorized into three groups: “frequent” (always/most of the time), “moderate” (sometimes), and “rare” (rarely/never). The primary outcome was all-cause mortality, ascertained through linkage with the National Death Index (NDI) through December 31, 2019. Covariates include age (20-40 years, 40-60 years), sex (female, male), race (non-Hispanic White, non-Hispanic Black, Mexican American, other Hispanic, other races), marital status (married, divorced, unmarried), and family poverty income ratio (PIR), categorized as PIR < 1.30, 1.30–3.49, or ≥ 3.50. Body mass index (BMI) is calculated as weight (kg) divided by height squared (m²), serving as an indicator of body fat. Education level is classified as above high school, high school, 9-11th grade, or below 9th grade. Smoking status is categorized into three groups: current smokers (those who smoke daily or have smoked more than 100 cigarettes in their lifetime), former smokers (currently non-smokers who previously smoked over 100 cigarettes), and never smokers (fewer than 100 cigarettes in their lifetime). Drinking status is defined as consuming at least 12 alcoholic beverages of any type within the past year. Serum 25-hydroxyvitamin D levels are categorized as normal (≥75 nmol/mL), insufficient (50-74.9 nmol/mL), deficient (25-49.9 nmol/mL), or severely deficient (<25 nmol/mL). Skin reaction to sun exposure is classified as sun sensitive (experiencing severe sunburn with blisters or peeling), mildly sun sensitive (mild burns with some tanning), or not sun sensitive. Other covariates include diabetes, hyperlipidemia (identified when total cholesterol exceeds 200 mg/dL, triglycerides are above 200 mg/dL, HDL is below 40 mg/dL, LDL is above 130 mg/dL, a healthcare professional has made a diagnosis, or lipid-lowering medications are being used), and chronic kidney disease (CKD), characterized by reduced kidney function, either diagnosed by a healthcare provider or indicated by an estimated glomerular filtration rate (eGFR) below 60 ml/min/1.73 m² and/or a urinary albumin-to-creatinine ratio (ACR) greater than 30 mg/g.

Table SII. Association Between Sun-Protective Behaviors and All-Cause Mortality in Different Subgroups in NHANES, 2003-2006, 2009-2012, 2015-2018

Subgroups		Refer to “frequent”	Shade	Shirt	Sunscreen
Total	none	moderate	0.80 (0.63-1.01, p=.055)	1.09 (0.76-1.58, p=.631)	1.43 (0.98-2.09, p=.067)
		rare	0.66 (0.50-0.86, p=.002)	0.93 (0.67-1.27, p=.631)	1.42 (1.02-1.99, p=.038)
Age	20-40 years	moderate	0.72 (0.43-1.23, p=.230)	0.66 (0.27-1.62, p=.359)	1.53 (0.63-3.71, p=.342)
		rare	0.38 (0.19-0.75, p=.005)	0.74 (0.35-1.56, p=.428)	1.51 (0.68-3.35, p=.306)
	40-60 years	moderate	0.80 (0.62-1.04, p=.096)	1.22 (0.82-1.83, p=.326)	1.43 (0.94-2.19, p=.096)
		rare	0.73 (0.55-0.98, p=.038)	0.97 (0.69-1.38, p=.876)	1.44 (0.99-2.08, p=.053)
Gender	Female	moderate	0.87 (0.60-1.26, p=.468)	1.06 (0.59-1.89, p=.851)	1.82 (1.11-2.96, p=.017)
		rare	0.64 (0.40-1.05, p=.075)	0.80 (0.48-1.34, p=.399)	1.37 (0.87-2.14, p=.171)
	Male	moderate	0.76 (0.56-1.03, p=.077)	1.14 (0.71-1.85, p=.581)	1.17 (0.64-2.15, p=.614)
		rare	0.65 (0.47-0.91, p=.012)	1.06 (0.71-1.60, p=.768)	1.45 (0.86-2.44, p=.168)
Race	Mexican American	moderate	1.10 (0.55-2.17, p=.794)	2.23 (0.86-5.81, p=.100)	1.77 (0.56-5.65, p=.333)
		rare	0.69 (0.30-1.57, p=.375)	1.43 (0.61-3.38, p=.409)	1.13 (0.42-3.07, p=.813)
	Non-Hispanic Black	moderate	0.84 (0.54-1.31, p=.453)	1.18 (0.61-2.30, p=.619)	0.58 (0.18-1.85, p=.362)
		rare	0.46 (0.26-0.81, p=.007)	0.82 (0.45-1.48, p=.504)	0.82 (0.34-1.94, p=.644)
	Non-Hispanic White	moderate	0.74 (0.53-1.04, p=.079)	1.01 (0.56-1.82, p=.974)	1.64 (1.02-2.63, p=.039)

Subgroups		Refer to “frequent”	Shade	Shirt	Sunscreen
Income	Others	rare	0.69 (0.47-1.01, p=.053)	0.90 (0.54-1.48, p=.672)	1.62 (1.06-2.48, p=.026)
		moderate	0.66 (0.30-1.43, p=.288)	0.46 (0.15-1.45, p=.185)	1.16 (0.36-3.82, p=.802)
		rare	0.81 (0.36-1.85, p=.623)	0.68 (0.30-1.53, p=.352)	0.99 (0.37-2.66, p=.989)
	high	moderate	0.79 (0.49-1.27, p=.325)	0.61 (0.28-1.34, p=.217)	1.16 (0.63-2.13, p=.643)
		rare	0.61 (0.35-1.07, p=.085)	0.74 (0.39-1.41, p=.365)	1.12 (0.63-1.99, p=.700)
	middle	moderate	0.96 (0.55-1.67, p=.873)	1.61 (0.72-3.61, p=.247)	1.13 (0.48-2.64, p=.776)
		rare	0.89 (0.49-1.62, p=.714)	0.86 (0.42-1.76, p=.681)	1.03 (0.49-2.15, p=.936)
	low	moderate	0.74 (0.54-1.01, p=.059)	1.28 (0.78-2.09, p=.331)	1.98 (1.07-3.69, p=.031)
		rare	0.59 (0.41-0.85, p=.005)	1.04 (0.67-1.60, p=.869)	1.93 (1.13-3.30, p=.017)
	Education	below 9th Grade	moderate	0.70 (0.34-1.41, p=.319)	1.21 (0.43-3.44, p=.717)
rare			0.53 (0.21-1.31, p=.168)	1.40 (0.61-3.19, p=.426)	0.48 (0.15-1.52, p=.211)
moderate			0.76 (0.44-1.33, p=.340)	1.40 (0.58-3.37, p=.450)	0.86 (0.26-2.88, p=.805)
9-11th Grade		rare	0.59 (0.33-1.05, p=.073)	1.13 (0.52-2.45, p=.756)	1.00 (0.40-2.45, p=.992)
		moderate	0.85 (0.55-1.31, p=.462)	0.73 (0.35-1.51, p=.395)	2.78 (1.24-6.23, p=.013)
high school		rare	0.53 (0.31-0.90, p=.018)	0.78 (0.43-1.40, p=.397)	2.15 (1.04-4.43, p=.038)
		above high school	moderate	0.77 (0.53-1.11, p=.160)	1.16 (0.64-2.08, p=.629)

Subgroups		Refer to “frequent”	Shade	Shirt	Sunscreen	
BMI	normal	rare	0.81 (0.53-1.25, p=.349)	0.85 (0.50-1.45, p=.544)	1.37 (0.86-2.17, p=.187)	
		moderate	0.71 (0.43-1.17, p=.180)	0.62 (0.28-1.36, p=.234)	2.49 (1.06-5.82, p=.035)	
		rare	0.61 (0.35-1.06, p=.082)	0.67 (0.35-1.31, p=.247)	2.21 (1.02-4.78, p=.044)	
	obesity	moderate	0.82 (0.58-1.16, p=.262)	1.35 (0.77-2.38, p=.290)	1.53 (0.85-2.77, p=.154)	
		rare	0.59 (0.38-0.92, p=.020)	0.97 (0.59-1.60, p=.914)	1.47 (0.88-2.45, p=.146)	
	high	moderate	0.77 (0.50-1.18, p=.230)	1.10 (0.55-2.19, p=.782)	1.05 (0.55-2.02, p=.876)	
		rare	0.72 (0.45-1.16, p=.176)	1.03 (0.57-1.86, p=.916)	1.05 (0.60-1.84, p=.868)	
	low	moderate	NA	NA	NA	
		rare				
Marital status	married	moderate	0.75 (0.52-1.08, p=.124)	1.02 (0.58-1.78, p=.954)	0.96 (0.54-1.69, p=.884)	
		rare	0.62 (0.41-0.93, p=.021)	0.98 (0.61-1.57, p=.930)	1.03 (0.63-1.69, p=.905)	
	unmarried	moderate	0.79 (0.52-1.19, p=.259)	1.15 (0.59-2.23, p=.686)	2.39 (1.06-5.39, p=.037)	
		rare	0.38 (0.22-0.67, p=.001)	0.80 (0.45-1.43, p=.457)	2.54 (1.23-5.28, p=.012)	
	divorced	moderate	0.83 (0.52-1.32, p=.426)	1.24 (0.58-2.64, p=.582)	1.65 (0.82-3.32, p=.161)	
		rare	1.05 (0.64-1.72, p=.862)	1.15 (0.57-2.28, p=.699)	1.40 (0.75-2.59, p=.289)	
	Sun sensitivity	sun sensitive	moderate	0.22 (0.09-0.53, p=.001)	2.06 (0.78-5.46, p=.145)	1.40 (0.57-3.47, p=.467)

Subgroups		Refer to “frequent”	Shade	Shirt	Sunscreen	
Vitamin D	mildly sun sensitive	rare	0.50 (0.18-1.34, p=.165)	1.16 (0.50-2.71, p=.731)	1.25 (0.57-2.73, p=.571)	
		moderate	0.66 (0.47-0.93, p=.017)	1.09 (0.64-1.84, p=.754)	1.37 (0.83-2.28, p=.220)	
		rare	0.75 (0.50-1.11, p=.148)	0.77 (0.48-1.24, p=.288)	1.37 (0.88-2.16, p=.167)	
	not sun sensitive	moderate	1.29 (0.89-1.88, p=.172)	0.93 (0.50-1.74, p=.826)	2.03 (0.85-4.87, p=.111)	
		rare	0.67 (0.44-1.00, p=.052)	1.12 (0.66-1.87, p=.679)	2.25 (1.03-4.94, p=.042)	
	normal	moderate	0.67 (0.38-1.19, p=.174)	1.48 (0.56-3.93, p=.430)	1.32 (0.59-2.95, p=.506)	
		rare	0.62 (0.33-1.16, p=.135)	1.06 (0.44-2.60, p=.892)	1.42 (0.69-2.92, p=.338)	
	insufficient	moderate	0.76 (0.52-1.12, p=.169)	0.79 (0.40-1.56, p=.503)	1.55 (0.81-2.97, p=.182)	
		rare	0.60 (0.38-0.93, p=.022)	1.04 (0.59-1.81, p=.904)	1.68 (0.95-2.98, p=.074)	
	deficient	moderate	0.83 (0.56-1.22, p=.335)	1.42 (0.81-2.49, p=.219)	1.22 (0.65-2.28, p=.539)	
		rare	0.77 (0.49-1.20, p=.244)	0.91 (0.55-1.49, p=.704)	0.95 (0.55-1.64, p=.850)	
	Drinking status	severely deficient	moderate	1.28 (0.54-3.03, p=.579)	0.42 (0.12-1.51, p=.182)	7.31 (0.67-79.34, p=.102)
			rare	0.42 (0.11-1.60, p=.205)	0.38 (0.13-1.10, p=.074)	5.07 (0.59-43.67, p=.139)
		current drinking	moderate	0.75 (0.58-0.98, p=.038)	1.05 (0.68-1.62, p=.813)	1.56 (1.01-2.39, p=.045)
rare			0.62 (0.46-0.84, p=.002)	0.92 (0.64-1.34, p=.680)	1.39 (0.94-2.06, p=.094)	
never drinking		moderate	1.00 (0.61-1.64, p=.984)	1.16 (0.57-2.35, p=.686)	0.96 (0.41-2.25, p=.918)	

Subgroups		Refer to “frequent”	Shade	Shirt	Sunscreen
Smoke status	current smoking	rare	0.82 (0.46-1.48, p=.515)	0.85 (0.46-1.58, p=.609)	1.56 (0.80-3.01, p=.188)
		moderate	0.72 (0.51-1.02, p=.066)	1.03 (0.57-1.86, p=.914)	1.23 (0.67-2.25, p=.510)
		rare	0.64 (0.44-0.94, p=.023)	1.03 (0.62-1.72, p=.898)	1.20 (0.72-2.01, p=.482)
	former smoking	moderate	0.71 (0.40-1.24, p=.225)	1.38 (0.64-2.98, p=.410)	1.03 (0.44-2.43, p=.951)
		rare	0.33 (0.16-0.69, p=.003)	0.74 (0.36-1.53, p=.418)	1.19 (0.57-2.48, p=.646)
	never smoking	moderate	0.91 (0.61-1.37, p=.659)	0.89 (0.48-1.65, p=.718)	1.88 (1.02-3.49, p=.044)
CKD	Yes	rare	0.81 (0.51-1.29, p=.384)	0.85 (0.50-1.42, p=.526)	1.68 (0.95-2.96, p=.073)
		moderate	0.76 (0.48-1.21, p=.253)	1.67 (0.82-3.40, p=.161)	1.54 (0.66-3.59, p=.314)
		rare	0.36 (0.19-0.67, p=.001)	1.02 (0.56-1.88, p=.940)	1.69 (0.85-3.37, p=.134)
	Not	moderate	0.78 (0.59-1.03, p=.075)	0.97 (0.63-1.50, p=.902)	1.50 (0.97-2.30, p=.067)
		rare	0.75 (0.55-1.01, p=.061)	0.90 (0.62-1.30, p=.572)	1.35 (0.92-1.99, p=.123)
	Yes	moderate	0.77 (0.59-0.99, p=.045)	1.24 (0.83-1.86, p=.293)	1.31 (0.87-1.98, p=.198)
Hyperlipidemia	Yes	rare	0.67 (0.50-0.91, p=.009)	0.98 (0.69-1.40, p=.931)	1.38 (0.97-1.96, p=.078)
		moderate	0.96 (0.53-1.72, p=.880)	0.67 (0.27-1.69, p=.397)	2.61 (0.89-7.63, p=.080)
	Not	rare	0.66 (0.34-1.27, p=.215)	0.74 (0.35-1.58, p=.441)	1.52 (0.56-4.13, p=.412)
		moderate	0.98 (0.70-1.38, p=.924)	0.85 (0.50-1.45, p=.556)	1.67 (0.95-2.93, p=.077)
Hypertension	Yes	moderate	0.98 (0.70-1.38, p=.924)	0.85 (0.50-1.45, p=.556)	1.67 (0.95-2.93, p=.077)

Subgroups		Refer to “frequent”	Shade	Shirt	Sunscreen
Diabetes	Not	rare	0.51 (0.33-0.80, p=.003)	0.84 (0.55-1.31, p=.446)	1.19 (0.73-1.96, p=.486)
		moderate	0.67 (0.48-0.93, p=.018)	1.40 (0.83-2.36, p=.211)	1.26 (0.75-2.12, p=.388)
	Yes	rare	0.76 (0.54-1.07, p=.115)	1.04 (0.65-1.67, p=.859)	1.65 (1.05-2.61, p=.030)
		moderate	0.98 (0.57-1.68, p=.930)	1.45 (0.56-3.72, p=.440)	1.16 (0.36-3.79, p=.802)
	Not	rare	0.39 (0.18-0.84, p=.016)	1.22 (0.53-2.83, p=.640)	1.51 (0.57-4.04, p=.408)
		moderate	0.76 (0.58-0.98, p=.038)	0.98 (0.66-1.47, p=.932)	1.43 (0.95-2.15, p=.084)
		rare	0.69 (0.52-0.92, p=.012)	0.84 (0.60-1.19, p=.338)	1.35 (0.94-1.93, p=.104)

Adjusted for the following factors: age group, gender, race, income, education level, BMI, marital status, sun sensitivity, vitamin D levels, drinking status, smoking status, chronic kidney disease (CKD), hyperlipidemia, hypertension and diabetes. The reference group is "frequent".