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Alcohol consumption and risk of melanoma and non-melanoma skin cancer in the Women's Health Initiative

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Abstract

Purpose—The relationship between alcohol consumption and preference of alcohol type with hazard of melanoma (MM) and risk of non-melanoma skin cancer (NMSC) was examined in the Women's Health Initiative (WHI) Observational Study (OS).

Methods—A prospective cohort of 59,575 White postmenopausal women in the WHI OS (mean age 63.6) was analyzed. Cox proportional hazards models and logistic regression techniques were used to assess the hazard and risk of physician-adjudicated MM and self-reported NMSC, respectively, after adjusting for potential confounders including measures of sun exposure and skin type.

Results—Over 10.2 mean years of follow-up, 532 MM cases and 9,593 NMSC cases occurred. A significant relationship between amount of alcohol consumed and both MM and NMSC was observed, with those who consume 7+ drinks per week having a higher hazard of MM (HR 1.64 (1.09, 2.49), $p_{\text{global}} = 0.0013$) and higher risk of NMSC (OR 1.23 (1.11, 1.36), $p_{\text{global}} < 0.0001$) compared to non-drinkers. Lifetime alcohol consumption was also positively associated with hazard of MM ($p = 0.0011$) and risk of NMSC ($p < 0.0001$). Further, compared to non-drinkers, a

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preference for either white wine or liquor was associated with an increased hazard of MM (HR 1.52 (1.02, 2.27) for white wine; HR 1.65 (1.07, 2.55) for liquor) and risk of NMSC (OR 1.16 (1.05, 1.28) for white wine; OR 1.26 (1.13, 1.41) for liquor).

Conclusions—Higher current alcohol consumption, higher lifetime alcohol consumption, and a preference for white wine or liquor were associated with increased hazard of MM and risk of NMSC.

Keywords

Alcohol; Melanoma; Non-melanoma skin cancer; Women's Health Initiative

Introduction

Skin cancer is the most common malignancy in the USA, with well over two million new diagnoses each year [1]. Over the past 40 years, there has been a dramatic increase in the incidence of both malignant melanoma (MM) and non-melanoma skin cancer (NMSC), especially among women [2–4]. The etiology of NMSC and melanoma is unclear, although sun exposure and host factors such as skin color and lifestyle factors have been shown to play a critical role [2]. Alcohol consumption is a key risk factor for many malignancies [5–8], and both amount and type consumed may potentially affect risk for skin cancers. However, the literature surrounding alcohol consumption and skin cancer points to a conflicting relationship [9–12], and a larger cohort study is needed.

A prospective study using the Nurses' Health Study showed a statistically significant relationship between certain types of alcohol consumption and basal cell carcinoma (BCC) [9]. This study found positive associations for total alcohol intake ($p < 0.0001$), alcohol from liquor ($p = 0.003$), and white wine intake ($p = 0.01$), and risk of BCC [9]. Interestingly, alcohol from beer had no association with NMSC, and red wine had an inverse association in women but not in men. The study authors concluded that further studies were needed to verify their results.

There has been little agreement among other studies regarding the relationship between alcohol consumption and BCC [10, 11]. Further, some evidence suggests that alcohol intake may be associated with risk of melanoma [13]; however, this relationship remains largely unstudied.

The underlying factors that might contribute to a relationship between alcohol consumption and skin cancer are many, including the production of free radicals. Alcohol consumption has been linked to a number of cancers, including hepatocellular carcinoma, esophageal, breast, oral, and pharynx cancers [5–8], and a similar association might be present in skin cancer [9]. However, alcohol may be a proxy for high-risk behavior such as intentional tanning/sunburning that would increase MM and NMSC risk. We used the Women's Health Initiative (WHI) cohort as women are recruited from geographically diverse areas (low/high UV exposure) and reported information on sun exposure habits.

The impact of alcohol consumption on the risk of skin cancer is largely unknown. If alcohol consumption is associated with skin cancer, the importance of management of alcohol intake for prevention of skin cancer may be a strategy for decreasing the prevalence of skin cancer, particularly for those identified as high risk.

Methods

Participants

Data from participants in the WHI Observational Study (OS, $n = 93,676$) were analyzed to address the question of interest. The WHI OS enrolled women aged 50–79 between 1993 and 1996 at 40 clinical centers across the USA. Close out for the main trials occurred in 2004–2005; the Extension Study extended follow-up through 2005–2010 for consenting participants. As skin cancer is rare in other ethnic groups, analyses were restricted to White participants ($n = 78,016$). As important sun exposure variables were collected on the year 4 questionnaire, participants who did not fill out a year 4 questionnaire were excluded from analysis ($n = 7,370$). Participants missing any of the covariates in the scientific model were excluded to yield an analytic cohort of 59,575. Those who were eligible but excluded were older, more obese, and had less education, and a higher percentage of these women died during follow-up than included participants. Further, a higher percentage of those who were excluded were non-and past drinkers compared to those who were included (9.5 vs. 8.8 % for non-drinkers and 19.4 vs. 16.3 % for past drinkers).

Definition of main exposure

Alcohol use was defined from self-report at baseline. Participants were classified as non-drinkers if they reported consuming less than 100 alcoholic beverages in their lifetime. Of those who reported consuming more than 100 alcoholic beverages, those who reported that they did not currently consume alcohol were classified as past drinkers. Categories of current consumption (<1 drink per month, <1 drink per week, 1 to <7 drinks per week, and 7+ drinks per week) were constructed based on the reported consumption of beer, wine, and liquor on the FFQ.

Mutually exclusive categories of alcohol preference at baseline were created based on the alcohol consumption, reported intake of beer, wine and liquor, and reported intake of red and white wine. More specifically, participants were divided into non-drinkers, past drinkers, and current drinkers; current drinkers were further categorized as preferring beer, wine, or liquor if consumption of that particular type of alcohol accounted for 60 % or more of total consumption. We further categorized participants who reported being current alcohol consumers but did not report consumption on their FFQ as current infrequent drinkers, and participants who did not have a strong preference for one alcohol type as having no preference. Participants who preferred wine were divided into three categories: red, white, and both based on the reported intake of red and white wine.

To determine the association with lifetime alcohol consumption, we used self-reported consumption at age 14–17, 18–22, 23–29, and 30–49 along with reported consumption from FFQ data at the participant's current age to construct a variable, drink-years. Drink-years is

the sum of drinks per day multiplied by years in the interval, and hence, one drink-year corresponds to 365 drinks during 1 year. We also assessed reported preference at year 3 to see whether preferences changed significantly from baseline.

Definition of outcomes

The two primary outcomes were time to incident melanoma and occurrence of incident NMSC during follow-up. For the former, participants who did not develop melanoma or who died during the study period were censored at death, last follow-up date, or end of study, whichever occurred first. Melanoma was centrally adjudicated as described in previous studies [14, 15]; NMSC was obtained from self-report from yearly follow-up.

Statistical analysis

Chi-square tests of association for categorical variables and one-way ANOVA for continuous variables were used to assess associations of the variables of interest with alcohol consumption. Cox proportional hazards models were used to examine the relationships between alcohol consumption and melanoma and between alcohol preference and melanoma. As time to event data was heavily interval censored for NMSC due to the data being from yearly self-report, logistic regression models were employed to explore the relationships between the alcohol variables and NMSC.

To further explore the relationship between amount of alcohol consumed and skin cancer, we also modeled alcohol consumption continuously (as alcohol servings per week). To assess potential moderators, interaction terms between known skin cancer risk factors (including age, sun exposure, and skin type) and the exposure of interest (alcohol consumption and alcohol preference) were considered separately.

Sensitivity analyses

A sensitivity analysis excluded those with a history of NMSC or MM at study baseline. A second sensitivity analysis employed multiple imputation using SAS PROC MI with a joint modeling approach on the entire eligible cohort ($n = 78,016$). Cox proportional hazards models using year to self-report of NMSC were used to assess logistic regression models of incident NMSC. Further, as alcohol preference and consumption were available at year 3, along with self-reported change in drinking habits, a final sensitivity analysis adjusted for time-varying alcohol consumption and preference. Lastly, a sensitivity analysis was performed that restricted melanoma cases to invasive cancers only ($n = 280$).

Both age-adjusted models and models that adjust for clinically important confounders and those identified by prior analyses of skin cancer were fitted. The adjusted models included age group, education, smoking status and pack-year category, BMI category, physical activity in total MET hours per week, having a last medical visit within 1 year of study baseline, having insurance, having a current care provider, history of NMSC, and history of melanoma, as well as variables measuring sun exposure: usually use sunscreen, exposure in Langley's of the participant's clinical center, summer sun exposure as a child and currently, and skin reaction to sun exposure (tan vs. burn). All potential confounders were defined using baseline values.

All analyses were performed with SAS software, version 9.3 (SAS Institute Inc., Cary, NC) of the SAS System for Windows.

Results

Baseline characteristics and incident outcomes of participants are shown in Table 1 by alcohol consumption. With the exception of history of melanoma, all baseline characteristics are associated with alcohol consumption and alcohol preference. For example, only 1.8 % of non-drinkers report current smoking and 10.1 % report past smoking, compared to 8.8 and 59.3 % for those who consume 7+ drinks per week. Also, those who reported drinking more than one drink per week were less obese and more physically active than those who consumed less than one drink per week. A higher percentage of participants who consume 7+ drinks per week reported having a skin type that was less likely to burn compared to participants who did not consume alcohol (34.9 vs. 42.9 %), and reported more current summer sun exposure (23.9 vs. 16.4 % reporting 2+ h per week). Baseline characteristics and incident outcomes by alcohol preference are shown in Supplementary Table 1.

Over a mean follow-up time of 10.2 years, 532 incident cases of MM and 9,593 incident cases of NMSC occurred. We note an increase in melanoma incidence with increasing alcohol consumption; 0.6 % of non-drinkers reported an incident melanoma compared to 1.3 % in participants who consume 7+ drinks per week. This trend is also noticeable in rates of incident NMSC. Further, white wine drinkers and liquor drinkers have the highest rates of incident MM and NMSC; non-drinkers, past drinkers, and infrequent drinkers have the lowest rates of both types of skin cancer.

Alcohol consumption is significantly associated with the hazard of melanoma ($p = 0.0013$) and risk of incident NMSC ($p < 0.0001$). Those who consume 7+ drinks per week have a higher hazard [HR 1.64 (1.09, 2.49)] of melanoma and a higher risk [OR 1.23 (1.11, 1.36)] of NMSC compared to non-drinkers (Table 2). Further, modeling alcohol servings per week as a continuous variable results in a HR of 1.16 (1.06, 1.27) ($p = 0.0011$) for each seven additional servings for MM and an OR of 1.08 (1.05, 1.11) ($p < 0.0001$) for each seven additional servings for NMSC (Table 2).

Lifetime alcohol consumption was also positively associated with hazard of melanoma ($p = 0.0046$) and risk of NMSC ($p < 0.0001$). Compared to those with zero drink-years, those with less than five drink-years had an increased hazard of melanoma of 35 % and an increased risk of NMSC of 8 %. Those in the highest category of more than 50 drink-years, which corresponds to over 18,000 drinks over the course of one's lifetime, had a HR of 1.98 (1.32, 2.95) for melanoma and an OR of 1.34 (1.20, 1.48) of NMSC (Table 2).

Alcohol preference was also significantly associated with both time to incident melanoma ($p = 0.0059$) and occurrence of incident NMSC ($p < 0.0001$). Compared to non-drinkers, white wine drinkers and liquor drinkers had an elevated hazard of melanoma [HR 1.52 (1.02, 2.27) for white wine and HR 1.65 (1.07, 2.55) for liquor] compared to non-drinkers. Similar results were observed for NMSC with white wine having an OR of 1.16 (1.05, 1.28) and

liquor having an OR of 1.26 (1.13, 1.41). For both NMSC and MM, HR/ORs for current infrequent drinkers and past drinkers were close to one (Table 2).

None of the risk factors for skin cancer we considered (age, smoking status, last medical visit within 1 year, sun exposure as an adult, sun exposure as a child, Langleys of exposure, skin reaction to the sun, history of NMSC, and history of MM) significantly modified the association of either alcohol consumption or alcohol preference on NMSC or MM (all p values >0.05). A sensitivity analysis excluding those with a history of MM or NMSC showed similar results for baseline consumption and baseline preference, with elevated HRs/ORs for the highest category of consumption compared to non-drinkers and for white wine and liquor drinkers compared to non-drinkers. A second sensitivity analysis employing multiple imputation on the entire eligible cohort found no differences in these results. Also, interpretation and directions of associations were unchanged in Cox proportional hazards models of time to year of self-report of NMSC. Incorporating alcohol as a time-varying variable using baseline and year 3 values for consumption and preference did not affect results or interpretation. Lastly, restricting the analyses to invasive melanoma did not change the direction of associations; confidence intervals were wider due to the decreased number of events.

Preference remained fairly stable from baseline to year 3. For those who preferred red wine at baseline, 81.3 % still preferred red wine at year 3. For white wine, this was 80.7 %, for liquor, 60.4 %, and for beer, 45.8 %. The mean number of servings of alcohol consumed daily decreased 0.14 servings per week from baseline at year 3. A total of 11.9 % of participants at year 3 reported a change in their drinking habits. Of these participants, 14.4 % stopped drinking, 67.4 % decreased their alcohol consumption, 15.0 % increased consumption, and 3.2 % started drinking.

Discussion

We found a positive association between increasing amount of current alcohol consumption and both melanoma and NMSC. For melanoma, we observed a 65 % increase in hazard for those who reported consuming 7+ drinks per week compared to non-drinkers; the corresponding increase in risk for NMSC was 23 %. Increasing lifetime alcohol consumption, measured in drink-years, was positively associated with NMSC and melanoma. Further, an increase in the hazard of melanoma was observed in participants with a preference for white wine and for liquor compared to those who did not drink alcohol (52 and 65 %, respectively). Similarly, we found an increased risk of NMSC in those who prefer white wine and liquor compared to non-drinkers (16 and 26 %, respectively).

Our results largely agree with Fung et al.'s [9] analysis of the Nurses' Health Study. We found an increasing risk of NMSC with increasing alcohol consumption with elevated hazards/risks for women who preferred alcohol and women who preferred white wine compared to non-drinkers. Fung et al. found the same relationship between alcohol and BCC, the most common type of NMSC. Importantly, we also found a similar positive association with alcohol and melanoma, which has not been previously reported.

Although Jensen et al. [16] did not find an association between risk of basal cell carcinoma and squamous cell carcinoma and overall alcohol intake in a cohort of Danish men and women, they did find an increasing hazard for BCC for wine consumption and liquor consumption. This is similar to our finding of an increased risk for NMSC for liquor and white wine preference compared to non-drinkers.

Freedman et al.'s [13] analyses of skin cancers in radiological technologists also support our findings. They found a significant association between increasing alcohol consumption with basal cell carcinoma, although they did not collect information on the type of alcohol consumed. Similarly, risk of melanoma increased with increasing alcohol consumption, in models adjusted for history of melanoma, sun exposure, and skin color.

In a cohort of Australian adults, Ansem et al. [17] did not find a relationship between BCC and SCC risk with total alcohol intake, or consumption of beer, white wine, red wine, sherry, or port. Also, Kune et al. [10] did not find a significant relationship between intake of alcohol and NMSC in a case-control study of adult men in Melbourne. Reasons for these differences may include differences in cohorts in terms of geography, age, gender, and mean amount of alcohol consumed.

The key question is whether this strong positive association reflects a truly detrimental effect of alcohol on the risk of developing melanoma and NMSC, or whether there are alternative, non-causal explanations. Several biological theories that are consistent with alcohol increasing skin cancer risk include (1) alcohol increases oxidative stress leading to DNA damage and carcinogenesis [18–20]. (2) Ethanol produces the most free radicals and is highest in liquor compared to wine or beer and thus those who prefer liquor may be exposed to higher levels of ethanol and acetaldehyde.

Proposed alternative explanations to the positive association between alcohol consumption and risk of skin cancer are that (1) heavy alcohol use may represent a high-risk behavior and may act as a proxy for other high-risk behaviors such as sunburn, indoor tanning, and lack of use of sun protection (confounding) [21–24], (2) there is increased mortality of younger alcohol drinkers such that they are not diagnosed with skin cancer (selection bias), (3) heavy alcohol users may have more health problems and may be more likely to receive a skin cancer diagnosis (information bias), (4) patients predisposed to develop skin cancer are more likely to drink alcohol (reverse causation). Adjusting for the confounders in (1) and addressing the biases in (2–4) would potentially attenuate the association of alcohol with skin cancer. However, strengths of this study include detailed information on participant skin type, sun exposure and sun protection habits, geographic sunlight, and prior history of skin cancer, which are important NMSC and MM risk factors that other studies may not have adequately captured. We also adjusted for healthcare utilization using insurance status, medical visit timing, and current care provider variables. Additional strengths of the study include the large cohort with wide geographic diversity (high versus low UV exposure sites), a relatively large number of melanoma cases that were physician-adjudicated, and the lengthy follow-up time.

This study had several limitations. Non-melanoma skin cancer was not adjudicated centrally by the WHI and relies on self-report data; however, several studies have found self-reported skin cancer to be highly accurate [25, 26]. Further, no information on type of NMSC was available. Also, alcohol consumption and preference were obtained from self-report data from food frequency questionnaires (FFQ) and lifestyle questionnaires at baseline. Patterson et al. [27] suggest that the data on alcohol in the FFQ are reliable, with a correlation of 0.86 between FFQ alcohol consumption and eight days of intake data (four from recall, four from food records) and a test-retest reliability of 0.92. Further, FFQ data from year 3 suggest that alcohol preference is relatively stable. Potential confounders were also assessed at baseline only. In addition, recall bias may apply to measures of lifetime alcohol consumption assessed at baseline.

Alcohol consumption in this cohort was low; we were unable to assess the association between large amounts of alcohol consumption and skin cancer and results from this analysis may not be generalizable to other cohorts. Further, our analysis consisted of postmenopausal White women, and results may not apply to men, younger women, or women of other ethnicities.

In a large cohort of postmenopausal White women, we found that increasing alcohol consumption is associated with increased risk of NMSC and hazard of melanoma. This association was also observed for reported lifetime alcohol consumption. Further, participants who preferred white wine and who preferred liquor were at an increased risk of NMSC and hazard of melanoma compared to those who were non-drinkers. Management of alcohol use may be one strategy to consider for decreasing the incidence of NMSC and melanoma among postmenopausal White women.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1
Baseline demographics, risk factors, and reported sun exposure and incident events by amount of alcohol consumption in analytic cohort of White WHI OS participants

	Amount of alcohol consumption						Total	p value
	Non-drinker	Past drinker	<1 drink/month	<1 drink/week	1 to 7 drinks/week	7 + drinks/week		
<i>Overall</i>	5,255	9,701	6,843	12,338	16,960	8,478	59,575	
<i>Age group at baseline</i>	8.8	16.3	11.5	20.7	28.5	14.2		
<50–59	1,231	2,850	2,395	3,964	5,753	2,508	18,701	<0.0001
60–69	23.4	29.4	35.0	32.1	33.9	29.6		
	2,424	4,262	2,991	5,591	7,594	4,043	26,905	
70–79+	46.1	43.9	43.7	45.3	44.8	47.7		
	1,600	2,589	1,457	2,783	3,613	1,927	13,969	
	30.5	26.7	21.3	22.6	21.3	22.7		
<i>BMI category</i>								
<25	2,039	3,556	2,338	5,049	8,303	4,590	25,875	<0.0001
25 to <30	38.8	36.7	34.2	40.9	49.0	54.1		
	1,714	3,188	2,279	4,338	5,959	2,791	20,269	
30	32.6	32.9	33.3	35.2	35.1	32.9		
	1,502	2,957	2,226	2,951	2,698	1,097	13,431	
	28.6	30.5	32.5	23.9	15.9	12.9		
<i>Physical activity in METs per week</i>								
0–100	1,257	2,194	1,582	2,057	2,052	1,092	10,234	<0.0001
100–500	23.9	22.6	23.1	16.7	12.1	12.9		
	1,559	2,676	1,831	3,231	4,053	1,861	15,211	
500–1,200	29.7	27.6	26.8	26.2	23.9	22.0		
	1,504	2,671	2,055	3,928	5,615	2,809	18,582	
1,200+	28.6	27.5	30.0	31.8	33.1	33.1		
	935	2,160	1,375	3,122	5,240	2,716	15,548	
	17.8	22.3	20.1	25.3	30.9	32.0		
<i>Lengths of exposure</i>								
								<0.0001

	Amount of alcohol consumption						Total	p value
	Non-drinker	Past drinker	<1 drink/month	<1 drink/week	1 to 7 drinks/week	7 + drinks/week		
300–325	1,281	3,063	2,359	4,218	5,876	2,487	19,284	
	24.4	31.6	34.5	34.2	34.7	29.3		
350	988	2,068	1,632	2,880	3,512	1,639	12,719	
	18.8	21.3	23.9	23.3	20.7	19.3		
375–380	1,111	1,022	655	1,141	1,599	938	6,466	
	21.1	10.5	9.6	9.3	9.4	11.1		
400–430	1,087	1,537	992	1,836	2,616	1,461	9,529	
	20.7	15.8	14.5	14.9	15.4	17.2		
475–500	788	2,011	1,205	2,263	3,357	1,953	11,577	
	15.0	20.7	17.6	18.3	19.8	23.0		
<i>Skin reaction to the sun</i>								<0.0001
Does not burn	2,254	3,492	2,404	4,312	5,831	2,956	21,249	
	42.9	36.0	35.1	35.0	34.4	34.9		
Burns and tans	901	2,266	1,674	3,186	4,665	2,472	15,164	
	17.2	23.4	24.5	25.8	27.5	29.2		
Burns and tans minimally	1,313	2,630	1,888	3,385	4,718	2,286	16,220	
	25.0	27.1	27.6	27.4	27.8	27.0		
Burns, does not tan	787	1,313	877	1,455	1,746	764	6,942	
	15.0	13.5	12.8	11.8	10.3	9.0		
<i>Education</i>								<0.0001
HS	1,608	2,503	1,521	2,310	2,443	1,062	11,447	
	30.6	25.8	22.2	18.7	14.4	12.5		
Some college	1,920	3,846	2,693	4,368	5,873	2,822	21,522	
	36.5	39.7	39.4	35.4	34.6	33.3		
College	1,727	3,352	2,629	5,660	8,644	4,594	26,606	
	32.9	34.6	38.4	45.9	51.0	54.2		
<i>History of NMSC</i>								0.0004
No	4,776	8,820	6,242	11,186	15,263	7,583	53,870	
	90.9	90.9	91.2	90.7	90.0	89.4		
Yes	479	881	601	1,152	1,697	895	5,705	

	Amount of alcohol consumption						Total	p value
	Non-drinker	Past drinker	<1 drink/month	<1 drink/week	1 to 7 drinks/week	7 + drinks/week		
History of melanoma	9.1	9.1	8.8	9.3	10.0	10.6		0.4577
	No	5,177	9,544	6,746	12,179	16,727	8,358	58,731
	Yes	98.5	98.4	98.6	98.7	98.6	98.6	
		78	157	97	159	233	120	844
Has current care provider	1.5	1.6	1.4	1.3	1.4	1.4		0.0767
	No	252	436	308	519	676	345	2,536
	Yes	4.8	4.5	4.5	4.2	4.0	4.1	
		5,003	9,265	6,535	11,819	16,284	8,133	57,039
Has insurance	95.2	95.5	95.5	95.8	96.0	95.9		<0.0001
	No	150	353	200	239	329	140	1,411
	Yes	2.9	3.6	2.9	1.9	1.9	1.7	
		5,105	9,348	6,643	12,099	16,631	8,338	58,164
Last medical visit within one year	97.2	96.4	97.1	98.1	98.1	98.4		0.0001
	No	837	1,362	1,121	1,948	2,680	1,382	9,330
	Yes	15.9	14.0	16.4	15.8	15.8	16.3	
		4,418	8,339	5,722	10,390	14,280	7,096	50,245
Summer sun exposure as a child	84.1	86.0	83.6	84.2	84.2	83.7		0.0105
	<30 min	139	245	142	271	353	186	1,336
	30 min to 2 h	2.7	2.5	2.1	2.2	2.1	2.2	
		1,439	2,426	1,744	3,175	4,458	2,181	15,423
Summer sun exposure as an adult	27.4	25.0	25.5	25.7	26.3	25.7		
	2+ h	3,677	7,030	4,957	8,892	12,149	6,111	42,816
		70.0	72.5	72.4	72.1	71.6	72.1	
								<0.0001
<30 min	1,841	3,543	2,325	3,804	4,492	2,178		18,183

	Amount of alcohol consumption						Total	p value
	Non-drinker	Past drinker	<1 drink/month	<1 drink/week	1 to 7 drinks/week	7 + drinks/week		
30 min to 2 h	35.0	36.5	34.0	30.8	26.5	25.7	29,938	
	2,555	4,555	3,347	6,303	8,906	4,272		
	48.6	47.0	48.9	51.1	52.5	50.4		
2+ h	859	1,603	1,171	2,231	3,562	2,028	11,454	
	16.4	16.5	17.1	18.1	21.0	23.9		
Usually use sunscreen outdoors								<0.0001
No	3,051	5,009	3,516	5,648	6,777	3,516	27,517	
	58.1	51.6	51.4	45.8	40.0	41.5		
Yes	2,204	4,692	3,327	6,690	10,183	4,962	32,058	
	41.9	48.4	48.6	54.2	60.0	58.5		
Smoking status								<0.0001
Never smoked	4,630	4,829	3,955	6,707	7,695	2,707	30,523	
	88.1	49.8	57.8	54.4	45.4	31.9		
Past smoker, <20 pack years	372	2,510	1,504	3,319	5,619	2,933	16,257	
	7.1	25.9	22.0	26.9	33.1	34.6		
Past smoker, 20+ pack years	161	1,795	935	1,709	2,801	2,093	9,494	
	3.1	18.5	13.7	13.9	16.5	24.7		
Current smoker, <20 pack years	33	147	140	211	397	268	1,196	
	0.6	1.5	2.1	1.7	2.3	3.2		
Current smoker, 20+ pack years	59	420	309	392	448	477	2,105	
	1.1	4.3	4.5	3.2	2.6	5.6		
Melanoma during follow-up								<0.0001
No	5,223	9,637	6,802	12,238	16,774	8,369	59,043	
	99.4	99.3	99.4	99.2	98.9	98.7		
Yes	32	64	41	100	186	109	532	
	0.6	0.7	0.6	0.8	1.1	1.3		
NMSC during follow-up								<0.0001
No	4,516	8,262	5,880	10,400	14,023	6,901	49,982	

	Amount of alcohol consumption						Total	p value
	Non-drinker	Past drinker	<1 drink/month	<1 drink/week	1 to 7 drinks/week	7 + drinks/week		
Yes	85.9	85.2	85.9	84.3	82.7	81.4	9,593	
	739	1,439	963	1,938	2,937	1,577		
	14.1	14.8	14.1	15.7	17.3	18.6		
<i>Death during follow-up</i>								
No	4,779	8,740	6,323	11,435	15,799	7,775	54,851	<0.0001
	90.9	90.1	92.4	92.7	93.2	91.7		
Yes	476	961	520	903	1,161	703	4,724	
	9.1	9.9	7.6	7.3	6.9	8.3		

Table 2
Cox proportional hazards models (MM) and logistic regression models (NMSC) of alcohol consumption and preference variables for White WHI OS Cohort

Alcohol variable (variables assessed in separate models)	MM (HR (95 % CI))		NMSC (OR (95 % CI))	
	Age-adjusted model	Adjusted model	Age-adjusted model	Adjusted model
<i>Alcohol consumption at baseline</i>	$p < 0.0001$	$p = 0.0013$	$p < 0.0001$	$p < 0.0001$
Non-drinker	Ref	Ref	Ref	Ref
Past drinker	1.08 (0.70, 1.65)	0.99 (0.64, 1.52)	1.09 (0.99, 1.20)	1.05 (0.95, 1.16)
<1 drink per month	0.95 (0.60, 1.51)	0.88 (0.55, 1.40)	1.05 (0.95, 1.17)	1.03 (0.92, 1.14)
<1 drink per week	1.28 (0.86, 1.90)	1.10 (0.74, 1.66)	1.19 (1.08, 1.30)	1.08 (0.98, 1.20)
1 to <7 drinks per week	1.72 (1.18, 2.50)	1.40 (0.95, 2.06)	1.35 (1.23, 1.47)	1.15 (1.05, 1.27)
7+ drinks per week	2.01 (1.35, 2.98)	1.64 (1.09, 2.49)	1.44 (1.31, 1.59)	1.23 (1.11, 1.36)
<i>Alcohol servings per week at baseline</i>	$p < 0.0001$	$p = 0.0011$	$p < 0.0001$	$p < 0.0001$
Seven additional servings per week	1.19 (1.10, 1.28)	1.16 (1.06, 1.27)	1.12 (1.09, 1.15)	1.08 (1.05, 1.11)
<i>Lifetime alcohol consumption</i>	$p < 0.0001$	$p = 0.0046$	$p < 0.0001$	$p < 0.0001$
Non-drinker	Ref	Ref	Ref	Ref
>0–5 drink-years	1.47 (1.08, 1.99)	1.35 (0.99, 1.83)	1.15 (1.07, 1.23)	1.08 (1.01, 1.16)
>5–10 drink-years	1.91 (1.38, 2.65)	1.66 (1.19, 2.33)	1.24 (1.15, 1.34)	1.12 (1.03, 1.22)
>10–20 drink-years	1.79 (1.27, 2.52)	1.55 (1.09, 2.21)	1.30 (1.20, 1.41)	1.15 (1.06, 1.26)
>20–50 drink-years	2.09 (1.52, 2.86)	1.79 (1.29, 2.50)	1.47 (1.36, 1.58)	1.28 (1.18, 1.39)
>50–200 drink-years	2.25 (1.54, 3.30)	1.98 (1.32, 2.95)	1.55 (1.41, 1.71)	1.34 (1.20, 1.48)
<i>Lifetime alcohol consumption</i>	$p < 0.0001$	$p = 0.0008$	$p < 0.0001$	$p < 0.0001$
Five drink-years	1.04 (1.02, 1.06)	1.03 (1.01, 1.05)	1.03 (1.02, 1.03)	1.02 (1.01, 1.02)
<i>Alcohol preference at baseline</i>	$p < 0.0001$	$p = 0.0059$	$p < 0.0001$	$p = 0.0002$
Non-drinker	Ref	Ref	Ref	Ref
Past drinker	1.08 (0.70, 1.64)	0.98 (0.64, 1.51)	1.09 (0.99, 1.20)	1.05 (0.95, 1.16)
Current beer	1.34 (0.78, 2.30)	1.18 (0.68, 2.04)	1.25 (1.10, 1.43)	1.16 (1.01, 1.33)
Current liquor	1.87 (1.23, 2.85)	1.65 (1.07, 2.55)	1.36 (1.23, 1.51)	1.26 (1.13, 1.41)
Current mixed	1.44 (0.94, 2.20)	1.18 (0.76, 1.82)	1.28 (1.15, 1.41)	1.12 (1.00, 1.24)
Current infrequent	0.95 (0.60, 1.51)	0.87 (0.55, 1.39)	1.05 (0.95, 1.17)	1.02 (0.92, 1.14)
Current wine (both)	1.30 (0.84, 1.99)	1.06 (0.69, 1.65)	1.26 (1.14, 1.40)	1.11 (1.00, 1.23)
Current wine (red)	1.71 (1.11, 2.64)	1.34 (0.86, 2.10)	1.25 (1.12, 1.39)	1.06 (0.94, 1.18)
Current wine (white)	1.93 (1.31, 2.85)	1.52 (1.02, 2.27)	1.40 (1.27, 1.53)	1.16 (1.05, 1.28)

Adjusted models are adjusted for age group, education, BMI category, Langleys of exposure, physical activity, history of NMSC, history of MM, smoking, sunscreen use, current summer sun exposure, childhood sun exposure, skin reaction to the sun, last medical visit within 1 year, having a current care provider, and having insurance