

Supplementary information for

Disease risk scores for skin cancers

Pierre Fontanillas, Babak Alipanahi, Nicholas A. Furlotte, Michaela Johnson, Catherine Wilson, 23andMe Research Team, Steve Pitts, Robert Gentleman, Adam Auton

Supplementary Table 1: Training and validation set statistics and demographics.

Percentages are computed for each column based on the sample size of the column. Longitudinal data were collected with a yearly followup survey in 2018 and 2019.

		TRAINING SET			VALIDATION SET					
					<i>At baseline</i>			<i>Prospective</i>		
		All	Females	Males	All	Females	Males	All	Females	Males
Sample size		103,008	57.4%	42.6%	88,924	61.1%	38.9%	49,501	63.9%	36.1%
BCC		14.5%	13.7%	15.5%	18.2%	16.9%	20.1%	18.8%	17.3%	21.4%
SCC		7.3%	6.6%	8.1%	8.9%	8.1%	10.2%	9.3%	8.4%	11.0%
Melanoma		3.9%	3.4%	4.5%	4.7%	4.1%	5.6%	4.6%	4.0%	5.6%
Incident BCC		-	-	-	-	-	-	2.3%	1.9%	3.0%
Incident SCC		-	-	-	-	-	-	1.7%	1.4%	2.3%
Incident Melanoma		-	-	-	-	-	-	0.6%	0.5%	0.8%
Family history of skin cancer		17.7%	19.8%	14.9%	16.4%	18.3%	13.4%	17.4%	19.2%	14.2%
Family history of other cancers		44.6%	44.7%	44.4%	46.8%	46.4%	47.3%	48.1%	47.4%	49.3%
Age	30-50 years	30.6%	29.4%	32.1%	30.3%	31.9%	27.9%	27.8%	29.9%	24.1%
	50-70	47.6%	50.6%	43.4%	49.1%	50.3%	47.1%	50.5%	51.5%	48.8%
	70-90	21.9%	20.0%	24.4%	20.6%	17.8%	25.0%	21.7%	18.6%	27.1%
BMI	<25	38.1%	44.8%	29.1%	33.9%	41.0%	23.0%	34.5%	40.8%	23.6%
	25-30	35.3%	28.8%	43.9%	35.6%	29.8%	44.4%	35.1%	29.9%	44.3%
	30-35	16.3%	14.8%	18.3%	18.5%	16.3%	22.0%	18.1%	16.2%	21.4%
	>35	10.3%	11.5%	8.7%	12.0%	12.9%	10.7%	12.2%	13.2%	10.6%
Education	High school	5.0%	5.7%	4.0%	5.7%	6.4%	4.9%	5.3%	6.2%	4.0%
	College	53.7%	56.1%	50.5%	53.9%	57.6%	48.6%	54.4%	57.3%	49.8%
	Graduate	41.3%	38.2%	45.4%	40.3%	36.1%	46.5%	40.2%	36.5%	46.2%
Smoking	Ever	40.9%	40.0%	42.2%	42.5%	40.6%	45.3%	41.4%	39.8%	44.2%
	Current	6.4%	6.6%	6.2%	7.9%	8.2%	7.5%	6.7%	7.1%	6.0%
Live in metropolitan area		90.7%	89.8%	91.9%	88.4%	88.0%	89.1%	88.6%	88.0%	89.5%

Supplementary Table 2: Skin (and blood) cancer survey.

Only the questions related to skin cancer were used in this study.

Personal History of Cancer:

- 1) In what year were you born?
- 2) What is your sex?
- 3) Have you ever been diagnosed with or treated for any form of blood cancer including the following?
- 4) Have you ever been diagnosed with or treated for any form of skin cancer or skin pre-cancer including the following?
- 5) Have you ever had an abnormal pap smear?
- 6) Have you ever had 10 or more polyps in your colon?
- 7) Have you ever been diagnosed with or treated for another type of cancer?
- 8) What other form(s) of cancer were you diagnosed with or treated for?
- 9) Have you ever been diagnosed with or treated for another type of cancer?
- 10) What other form(s) of cancer were you diagnosed with or treated for?
- 11) Have you ever been diagnosed with any of these hereditary cancer syndromes?
- 12) Which of the following blood cancers were you diagnosed with or treated for?
- 13) Have you ever been diagnosed with or treated for basal cell carcinoma?
- 14) Where on your body are/were your basal cell carcinomas located?
- 15) What treatments have you received for basal cell carcinoma?
- 16) How many basal cell carcinomas have you had in the last 2 years?
- 17) How old were you when you were first diagnosed with basal cell carcinoma?
- 18) By whom were you diagnosed with basal cell carcinoma?
- 19) Have you ever been diagnosed with or treated for squamous cell carcinoma?
- 20) Where on your body are/were your squamous cell carcinomas located?
- 21) What treatments have you received for squamous cell carcinoma?
- 22) How many squamous cell carcinomas have you had in the last 2 years?
- 23) How old were you when you were first diagnosed with squamous cell carcinoma?
- 24) By whom were you diagnosed with squamous cell carcinoma?
- 25) Have you ever been diagnosed with or treated for melanoma?
- 26) Where on your body are/were your melanomas located?
- 27) What types of moles did your melanoma(s) develop from?
- 28) What treatments have you received for melanoma?
- 29) How many melanomas have you had in the last 2 years?
- 30) How old were you when you were first diagnosed with melanoma?
- 31) By whom were you diagnosed with melanoma?
- 32) Have you ever been diagnosed with or treated for actinic keratosis?
- 33) Where on your body are/were your actinic keratoses located?
- 34) Have you ever had any of the following treatments for actinic keratosis?
- 35) How many actinic keratoses have you had treated in the past 2 years?
- 36) How old were you when you were first diagnosed with actinic keratosis?
- 37) By whom were you diagnosed with actinic keratosis?
- 38) Prior to your cancer diagnosis, how would you rate your general health?
- 39) Prior to your cancer diagnosis, how would you rate your stress level?

Risk Factors:

- 1) Which of the following best describes your skin color?
- 2) Which best describes the natural color of your hair?
- 3) How much lighter does your hair become when directly exposed to sun for 3-4 hours?
- 4) Which best describes the amount of red in your hair?
- 5) Which of the following best describes your natural eye color?
- 6) How many freckles total do you have on your face and body?
- 7) How does your skin respond when directly exposed to sun for 3-4 hours?
- 8) Have you ever had several large moles (1/4 inch or 6mm, flat or raised)?
- 9) Have you ever had a mole removed or biopsied that tested positive for abnormal cells (dysplasia)?
- 10) How many moles do you have on your right arm?
- 11) In what country and postal code do you currently live?
- 12) In what country and postal code did you spend the majority of your adulthood, age of 18 and older?
- 13) In what country and postal code did you spend the majority of your childhood, before the age of 18?
- 14) How often did you sunbathe before the age of 30?
- 15) On a typical weekday, how many hours or minutes (select one) of sun exposure do you get?
- 16) On a typical weekend day, how many hours or minutes (select one) of sun exposure do you get?
- 17) How many sunburns that caused blisters have you had?
- 18) How many times have you used indoor tanning equipment?
- 19) Have you ever been employed for a year or more in a job where you worked outdoors in the sunlight?
- 20) How many years were you employed in a job where you worked outdoors in the sunlight?
- 21) Have you smoked at least 100 cigarettes in your entire life?
- 22) Do you typically smoke cigarettes every day, some days, or not at all?
- 23) Is your family's history of cancer completely unknown to you for some reason, such as being adopted?

Family History of Cancer:

- 1) Your mother?
- 2) Your father?
- 3) Your sibling(s)?
- 4) Your child(ren)?
- 5) How many biological siblings do you have?
- 6) How many biological children do you have?
- 7) What type(s) of cancer was your biological mother diagnosed with or treated for?
- 8) What type(s) of skin cancer was your biological mother diagnosed with?
- 9) What type(s) of cancer was your biological father diagnosed with or treated for?
- 10) What type(s) of skin cancer was your biological father diagnosed with?
- 11) How many of your biological siblings have ever had cancer?
- 12) What type(s) of cancer was your biological sibling(s) diagnosed with or treated for?
- 13) What type(s) of skin cancer was your biological sibling(s) diagnosed with?
- 14) How many of your biological children have ever had cancer?
- 15) What type(s) of cancer was your biological child(ren) diagnosed with or treated for?
- 16) What type(s) of skin cancer was your biological child(ren) diagnosed with?
- 17) Have any of your biological parents, siblings, or children ever been diagnosed with any of these hereditary cancer syndromes?

Supplementary Table 3: Additional tested phenotypes from 23andMe database.

A total of 608 phenotypes were selected, with a maximum of 50% of missing data for the participants in the training set.

Addiction: current tobacco user ever tobacco user hp alcohol 2wks hp smoked 1000 cigarettes	varicose veins legs	mosquito severe	otosclerosis	haircolor				
Autoimmune: alopecia areata ankylosing spondylitis antiphospholipid syndrome any autoimmune autoimmune hepatitis canker sore canker sore pastyear canker sores qt celiac celiac w biopsy crohns crohns or ulcerative colitis juvenile t1d lupus multiple sclerosis pediatric ibd polymyalgia rheumatica psoriasis psoriatic arthritis psoriatic arthritis unfiltered rheumatoid arthritis sarcoidosis scleroderma sjogrens syndrome t1d ulcerative colitis vitiligo	Cognitive: clap to beat education meta education years math class play music before age 8 plays a musical instrument self rated math ability sing back musical note	mycin drug allergy clean no allergies nonallergic asthma peanut allergy clean penicillin allergy clean poison oak pollen allergy pollen allergy clean pollen allergy meta red ants allergy clean rhinitis seasonal allergies broad severe asthma shellfish allergy clean soy allergy clean sulfa drug allergy clean tree nuts allergy clean trees allergy clean weary loss weeds allergy clean wheat allergy clean yellow jackets allergy clean	pagets scoliosis surgery shoulder dislocation tmj	haircolor rough red hair amount red hair cc red hair vs blond and light brown c				
Blood: anemia blood clots bleeds thinner meds bruise easily deep vein thrombosis hypocoagulation nose bleeds pulmonary embolism	Diet: daily fruit servings fruit juice frequency hp diet quality leafy greens frequency pastry frequency red meat servings vegan vegetable servings vegetarian yogurt frequency	Infection: bacterial meningitis chicken pox childhood ear infections chronic sinus infections cold sores colds last year gingivitis hepatitis hepatitis a hepatitis b hepatitis c hwiz hepatitis ebv intestinal parasite lyme disease lyme disease malaria meds mononucleosis mumps plantar warts plantar warts pneumonia pneumonia frequency positive tb test scarlet fever shingles strep throat toenail fungus tonsillectomy tuberculosis untreated tract inf uti frequency whooping cough	Neurological: alzheimers alzheimers fh childhood febrile seizures chronic fatigue cluster headaches db neuropathy dyslexia epilepsy essential tremor HIP chronic pain leg jiggle lou gehrigs memory loss migraine diagnosis migraine diagnosis broad migraine ICHD migraine ICHD with aura migraine ICHD without aura numb extremities photc sneeze prognosis restless leg syndrome restless leg syndrome sma dx trigeminal neuralgia	Pregnancy: gestational diabetes pc hbp or preeclampsia pc preeclampsia or hbp				
Cancer: any cancer any non melanoma skin cancer any non skin cancer any recurrent somatic any skin cancer barretts esophagus basal cell carcinoma bladder cancer bladder cancer dx or fh bladder cancer fh brain cancer brain cancer dx or fh brain cancer fh breast cancer breast cancer dx or fh breast cancer fh breast or ovarian cancer cervical cancer chemotherapy meds colon polyps colorectal cancer colorectal cancer dx or fh colorectal cancer fh dmm3a r82x v4 er positive breast cancer hodgkins lymphoma hodgkins lymphoma dx or fh hodgkins lymphoma fh jak2 v617f cc kidney cancer leukemia leukemia dx or fh leukemia fh lipoma lung cancer lung cancer dx or fh lung cancer fh melanoma melanoma dx or fh melanoma fh mpn or v617f non hodgkins lymphoma non hodgkins lymphoma dx or fh non hodgkins lymphoma fh ovarian cancer ovarian cancer dx or fh ovarian cancer fh pancreatic cancer pancreatic cancer dx or fh pancreatic cancer fh prostate cancer dx or fh prostate cancer fh prostate cancer fh radiation therapy squamous cell carcinoma stomach cancer stomach cancer dx or fh stomach cancer fh thyroid cancer thyroid cancer dx or fh thyroid cancer fh	Endocrine: graves hashimotos hyperthyroidism hypothyroidism	Lifestyle: breakfast frequency hp exercise intake short of breath from stairs tanning bed use	Personality: ability handle stress adventurous amount of stress appreciates art music or literature can be cold and aloof can be moody can be somewhat careless can be tense car accidents center of attention coffee spilled anger comfort taking risks criticized anger cry easily cut off freeway anger desk clean does a thorough job does things efficiently extraversion combined fear of speaking generates a lot of enthusiasm gets nervous easily has a forgiving nature has an active imagination has an assertive personality has few artistic interests heated argments frequency hothead interruptions anger is considerate and kind to almost everyone is depressed often feels sad is easily distracted is emotionally stable not easily upset is full of energy is generally trusting is ingenious a deep thinker is inventive is original comes up with new ideas is outgoing sociable is relaxed handles stress well is reserved is sometimes rude to others is sometimes shy inhibited is talkative left out social activity life satisfaction life satisfaction likes to cooperate with others likes to reflect play with ideas makes plans and follows through with them nail biting frequency narcissism organizer perseveres until the task is finished personality activity personality aesthetics personality agreeableness personality altruism personality anxiety personality assertiveness personality compliance personality conscientiousness personality depression personality extraversion personality ideas personality neuroticism personality openness personality order personality self discipline prefers work that is routine recharge by socializing remains calm in tense situations se failure se positive attitude se satisfaction with self self rated attractiveness shyness social support stammer starts quarrels with others talks with friends tends to be disorganized tends to be lazy tends to be quiet tends to find fault with others values artistic aesthetic experiences worries a lot	Renal: chronic kidney disease db nephritis HIP urinary condition HIP urinary condition type OAB HIP urinary condition type SUI kidney disease kidney infection kidney stones	Reproductive: endometriosis ever pregnant female infertility fraternal twin identical twin ivf pcos three plus losses	Respiratory: bronchitis frequency chronic bronchitis COPD cystic fibrosis ear of speaking epistaxia HIP IPP	Sensation: ability to smell anosmia carsick congenital deafness good sense of direction hearing aid misophonia motionsick combined tinnitus	Skin: acne as teenager actinic keratosis dandruff frequency dry skin frequency foot odor hidradenitis lichen planus moles rosacea all severe acne shampoo type skin tags stretch marks stretch marks any sweat during workout sweaty feet sweaty palms
Cardiovascular: angina any cad any cvd aortic aneurysm aortic stenosis arrhythmia atrial fibrillation blood pressure meds brain aneurysm carotid artery dis chest pain exercise congenital heart defect early onset heart attack fainted giving blood heart attack heart failure high blood pressure long qt syndrome myocarditis orthostatic hypotension peripheral artery dis raynauds stroke	Eyes: astigmatism cataract cry cutting onions db retinopathy dry eyes treatment farsightedness glaucoma HIP iritis HIP macular degen type dry HIP macular degen type wet myopia v hyperopia nearsightedness optic neuritis retinal detachment retinal vein occlusion retinitis pigmentosa strabismus	Longevity: centenarian family general health healthy old wasp metabolic disease burden nonagenarian nonagenarian parent trouble walking	Metabolic: altitude sickness birth weight blood sugar meds bmi bmi res tx dairy products indigestion gout hemochromatosis high chol high cholesterol high cholesterol broad high cholesterol dx high cholesterol meds high plasma glucose hyperglycemia lactose intolerant loose lost 20lbs low hdl modtosevere altitude sickness nafld nash spit frequency t2d t2d broad weight weight description weight res tx	Morphology: braces cleft lip cleft palate extra toe forward splits height height res tx overbite third nipple tongue curl wiggle ears	Musculoskeletal: back pain frequency bunions carpal tunnel dupuytrens contracture fibromyalgia fibromyalgia chronic fatigue fracture ganglion cyst foot ganglion cyst wrist hirs chlers danlos muscular dystrophy myasthenia gravis osteoarthritis osteoarthritis broad osteoporosis osteoporosis broad	Pigmentation: age gray any freckles eyecolor eyecolor simple freckle combined qt gray amount	Teeth: biting with teeth cavities many dental superstar flossing frequency number of cavities teeth grinding	

Supplementary Table S4: General linear model (GLM with binomial response) results for the best model (20-risk factor model) including factors from the cancer survey.

All the linear coefficients were converted to Odds Ratios (OR) after fixing to OR=1 the first level for binary or categorical factors, or the minimum class for continuous factors. The 95% CI, P-values (*: <0.05; **: <0.01; ***: <0.001), and the deviance explained are shown. For continuous factors (Age and Typical sun exposure per week), distributions were sliced per class and a OR is recomputed per class (P-value were not recomputed for each class). Models also include the five first principal components (PCs) controlling for ancestry.

Variable	Level	BCC	SCC	Melanoma
Age		9.87%	10.7%	3.27%
	30	1	1	1
	40	3.42 [2.89-4.04]	2.52 [1.94-3.28]	1.54 [1.31-1.8]
	50	8.65 [7.12-10.5]	6.46 [4.75-8.8]	2.4 [1.99-2.9]
	60	18.01 [14.63-22.16]	16.13 [11.54-22.55]	3.78 [3.09-4.63]
	70	36.94 [29.93-45.59]	40.7 [28.9-57.33]	6.29 [5.11-7.74]
Sex		0.05%	0.09%	0.21%
	M	1	1	1
	F	0.67 *** [0.67-0.67]	0.65 *** [0.65-0.65]	0.59 *** [0.59-0.59]
Dysplastic moles		3.05%	2.08%	11.91%
	no	1	1	1
	yes	2.62 *** [2.59-2.65]	2.24 *** [2.21-2.27]	6.81 *** [6.8-6.82]
Family history of skin cancer		1.33%	1.14%	0.08%
	Risk 0	1	1	1
	Risk 1	1.54 [1.51-1.56]	1.44 [1.42-1.47]	1.18 [1.14-1.21]
	Risk 2	2.4 [2.27-2.53]	2.2 [2.08-2.33]	1.26 [1.15-1.38]
	Risk 3	3.76 [3.21-4.4]	3.27 [2.78-3.84]	1.48 [1.17-1.88]
Skin color		0.8%	0.79%	0.61%
	extremely fair	1	1	1
	light	0.94 * [0.92-0.96]	0.9 ** [0.88-0.93]	0.98 [0.94-1.01]
	medium	0.79 *** [0.78-0.8]	0.74 *** [0.73-0.75]	0.8 ** [0.79-0.81]
	olive	0.62 *** [0.59-0.64]	0.65 *** [0.61-0.68]	0.81 * [0.76-0.87]
Freckling tendency		0.77%	0.7%	0.51%
	none	1	1	1
	few	1.2 *** [1.19-1.22]	1.19 *** [1.18-1.21]	1.18 *** [1.16-1.2]
	lots	1.57 *** [1.56-1.57]	1.57 *** [1.57-1.57]	1.48 *** [1.47-1.48]
	many	2.06 *** [1.98-2.14]	1.98 *** [1.89-2.07]	1.67 *** [1.59-1.76]
Sunbathing frequency before age of 30		0.9%	0.79%	0.3%
	never	1	1	1
	rarely	1.05 [1.01-1.09]	1.03 [0.98-1.08]	0.91 [0.86-0.96]
	sometimes	1.41 *** [1.35-1.49]	1.29 *** [1.21-1.37]	1.03 [0.96-1.11]
	frequently	1.81 *** [1.73-1.89]	1.73 *** [1.63-1.84]	1.27 ** [1.18-1.35]
	very frequently	2.21 [2.14-2.28]	2.08 [1.99-2.17]	1.43 [1.37-1.5]
Actinic keratosis before age of 40		0.52%	0.7%	0.03%
	no	1	1	1
	yes	3.66 *** [3.35-4.01]	3.95 *** [3.62-4.31]	1.41 *** [1.22-1.61]
Blisters caused by sunburns		0.26%	0.23%	0.07%
	0	1	1	1
	1-2	1.13 *** [1.12-1.13]	1.22 *** [1.21-1.24]	1 [0.99-1.02]
	3-4	1.25 *** [1.25-1.26]	1.37 *** [1.36-1.39]	1.11 [1.1-1.12]
	5+	1.42 *** [1.41-1.43]	1.43 *** [1.41-1.44]	1.21 *** [1.2-1.22]
Skin response to 3-4 hours of sun exposure		0.18%	0.17%	0.19%
	always burns	1	1	1
	usually burns	0.95 [0.93-0.97]	0.93 [0.91-0.95]	0.87 [0.85-0.9]
	sometimes burns tans	0.77 [0.75-0.79]	0.74 [0.72-0.77]	0.72 [0.69-0.75]
	rarely burns	0.62 [0.62-0.63]	0.61 [0.6-0.61]	0.59 [0.59-0.59]
	never burns	0.57 [0.49-0.66]	0.59 [0.49-0.71]	0.74 [0.58-0.95]
Typical sun exposure per week		0.12%	0.1%	0.07%
	0	1	1	1
	320	1.19 [1.18-1.19]	1.2 [1.19-1.21]	1.14 [1.13-1.16]
	640	1.35 [1.34-1.36]	1.35 [1.34-1.36]	1.27 [1.26-1.29]
	960	1.49 [1.45-1.52]	1.43 [1.39-1.48]	1.39 [1.33-1.45]
	1280	1.57 [1.48-1.67]	1.44 [1.32-1.56]	1.48 [1.34-1.63]
	1600	1.6 [1.4-1.81]	1.36 [1.14-1.62]	1.54 [1.25-1.88]
	1920	1.56 [1.25-1.96]	1.21 [0.88-1.65]	1.56 [1.09-2.24]
Hair color		0.08%	0.02%	0.25%
	light blond	1	1	1
	dark blond	0.93 [0.9-0.96]	0.94 [0.9-0.98]	0.8 [0.77-0.84]
	red	1.02 [1.02-1.02]	1.05 [1.05-1.05]	1.13 [1.13-1.13]
	light brown	0.83 [0.8-0.87]	0.89 [0.85-0.94]	0.73 [0.69-0.77]
	dark brown	0.8 [0.76-0.83]	0.87 [0.83-0.92]	0.67 [0.63-0.71]
	black	0.72 *** [0.69-0.74]	0.78 * [0.75-0.82]	0.7 ** [0.66-0.75]
Eye color		0.05%	0.08%	0.02%
	blue	1	1	1
	blue gray	0.89 [0.87-0.9]	0.87 [0.85-0.89]	0.94 [0.91-0.96]
	gray	0.71 ** [0.59-0.86]	0.78 [0.61-0.99]	1 [0.75-1.33]
	gray green	0.91 [0.89-0.93]	0.86 [0.84-0.88]	1.01 [0.98-1.04]
	green	0.97 [0.96-0.98]	0.97 [0.96-0.98]	1 [0.98-1.01]
	light brown	0.88 [0.84-0.91]	0.9 [0.85-0.94]	0.9 [0.85-0.97]
	medium brown	0.87 [0.86-0.88]	0.83 [0.82-0.84]	0.92 [0.91-0.94]
	dark brown black	0.85 [0.82-0.88]	0.8 [0.76-0.84]	0.85 [0.8-0.91]
Presence of large moles		0.03%	0.02%	0.2%
	no	1	1	1
	yes	1.14 *** [1.13-1.14]	1.09 ** [1.08-1.11]	1.33 *** [1.32-1.34]
Moles in your right arm		0.03%	0.07%	0.52%
	less than 3	1	1	1
	3 to 6	0.91 [0.9-0.93]	0.89 [0.86-0.91]	1.14 [1.11-1.18]
	7 to 11	0.9 [0.87-0.94]	0.85 [0.81-0.89]	1.36 [1.3-1.43]
	12 to 18	0.84 [0.8-0.89]	0.76 [0.7-0.82]	1.51 [1.42-1.6]
	19 to 28	0.98 [0.91-1.05]	0.82 [0.74-0.91]	1.55 [1.42-1.68]
	29 to 39	0.84 [0.75-0.93]	0.75 [0.64-0.88]	1.64 [1.45-1.85]
	more than 39	0.98 [0.89-1.09]	0.79 [0.67-0.92]	2.11 [1.9-2.33]
Sun hair lightening		0.02%	0.03%	0.02%
	very much	1	1	1
	somewhat	0.96 [0.92-1]	0.91 [0.86-0.96]	0.89 [0.83-0.94]
	a little bit	0.98 [0.93-1.03]	0.95 [0.89-1.01]	0.96 [0.89-1.04]
	unchanged	1.07 [1.02-1.12]	1.04 [0.98-1.11]	1.01 [0.94-1.08]
Skin response to sun exposure without sun protection		0.02%	0.02%	0.01%
	painful blister	1	1	1
	blister	1.03 [1.03-1.04]	1 [1-1]	1.08 [1.08-1.09]
	burns sometimes	1.11 [1.08-1.15]	1.1 [1.06-1.14]	1.06 [1.02-1.11]
	rarely burns	1.03 [1.02-1.05]	1.02 [1.01-1.04]	1.05 [1.02-1.09]
	never burns	0.82 [0.66-1.01]	0.77 [0.57-1.03]	1.09 [0.76-1.56]
Tanning bed		0.02%	0.03%	0.03%
	never	1	1	1
	1-4times	1.03 [1.01-1.05]	1.03 [1.01-1.06]	1.04 [1.01-1.07]
	5-10times	1.1 * [1.06-1.14]	1.06 [1-1.11]	0.99 [0.93-1.06]
	11-20times	1.14 ** [1.09-1.2]	1.11 [1.04-1.19]	1.11 [1.02-1.2]
	21-30times	1.05 [0.98-1.13]	1.07 [0.97-1.18]	0.98 [0.87-1.11]
	30+times	1.08 [1.04-1.12]	1.24 *** [1.19-1.3]	1.23 ** [1.16-1.29]
Outdoor job		0.01%	0.01%	0.01%
	no	1	1	1
	yes	1.08 ** [1.07-1.09]	1.08 * [1.06-1.1]	1.09 * [1.07-1.12]
Total deviance explained:		19.07%	18.76%	18.73%
Numbers of cases - controls:		14898/88110	7479/95529	3998/99010

Supplementary Table 5: General linear model (GLM with binomial response) results for the best model (20-risk factor model) including factors from the cancer survey, without phenotype imputation.

See Supplementary Table 4 for a detailed description. Missing phenotype data were imputed using Hmisc library in R.

Variable	Level	BCC	SCC	Melanoma
Age		9.92%	10.48%	2.9%
	30	1	1	1
	40	4.07 [3.25-5.1]	2.79 [2-3.89]	1.6 [1.29-1.98]
	50	10.75 [8.31-13.91]	6.79 [4.63-9.96]	2.45 [1.91-3.14]
	60	22.65 [17.25-29.73]	16.34 [10.82-24.69]	3.87 [2.97-5.03]
Sex	70	48.1 [36.61-63.21]	43.09 [28.34-65.51]	6.7 [5.14-8.73]
		0.06%	0.05%	0.12%
Dysplastic moles	M	1	1	1
	F	0.63 *** [0.63-0.63]	0.65 *** [0.65-0.65]	0.59 *** [0.59-0.59]
Family history of skin cancer		2.8%	1.97%	13.1%
	no	1	1	1
Skin color	yes	2.5 *** [2.46-2.53]	2.18 *** [2.15-2.22]	7.67 *** [7.67-7.68]
		1.64%	1.37%	0.11%
	Risk 0	1	1	1
	Risk 1	1.61 [1.58-1.64]	1.5 [1.48-1.54]	1.23 [1.19-1.27]
Freckling tendency	Risk 2	2.54 [2.4-2.69]	2.24 [2.11-2.39]	1.29 [1.17-1.43]
	Risk 3	3.92 [3.31-4.66]	3.46 [2.9-4.13]	1.48 [1.13-1.95]
		0.86%	0.9%	0.7%
	extremely fair	1	1	1
Sunbathing frequency before age of 30	light	0.96 [0.93-0.99]	0.91 * [0.88-0.94]	1 [0.96-1.05]
	medium	0.81 *** [0.8-0.82]	0.73 *** [0.72-0.74]	0.78 ** [0.76-0.79]
	olive	0.6 *** [0.57-0.63]	0.59 *** [0.55-0.63]	0.76 * [0.7-0.82]
		0.85%	0.89%	0.68%
Actinic keratosis before age of 40	none	1	1	1
	few	1.22 *** [1.21-1.24]	1.23 *** [1.21-1.25]	1.25 *** [1.22-1.28]
	lots	1.61 *** [1.61-1.61]	1.73 *** [1.72-1.73]	1.62 *** [1.61-1.64]
	many	2.17 *** [2.07-2.27]	2.15 *** [2.04-2.26]	1.84 *** [1.74-1.95]
		0.93%	0.9%	0.4%
Blisters caused by sunburns	never	1	1	1
	rarely	0.98 [0.94-1.03]	0.94 [0.88-1]	0.79 * [0.74-0.85]
	sometimes	1.33 *** [1.26-1.42]	1.24 ** [1.15-1.34]	0.99 [0.9-1.08]
	frequently	1.75 *** [1.65-1.85]	1.69 *** [1.57-1.82]	1.22 [1.12-1.33]
	very frequently	2.09 [2-2.18]	2.02 [1.91-2.13]	1.33 [1.25-1.41]
Skin response to 3-4 hours of sun exposure		0.62%	0.8%	0.02%
	no	1	1	1
	yes	3.94 *** [3.55-4.37]	4.03 *** [3.65-4.45]	1.28 * [1.09-1.51]
		0.22%	0.22%	0.08%
	0	1	1	1
Typical sun exposure per week	1-2	1.08 * [1.07-1.09]	1.18 ** [1.16-1.2]	0.94 [0.93-0.96]
	3-4	1.19 *** [1.19-1.2]	1.34 *** [1.32-1.36]	1.06 [1.05-1.07]
	5+	1.33 *** [1.32-1.35]	1.41 *** [1.39-1.43]	1.16 * [1.14-1.18]
		0.21%	0.17%	0.2%
	always burns	1	1	1
Hair color	usually burns	0.98 [0.96-1.01]	0.89 [0.87-0.92]	0.87 [0.84-0.9]
	sometimes burns tans	0.78 [0.75-0.8]	0.72 [0.69-0.74]	0.68 [0.65-0.71]
	rarely burns	0.6 [0.6-0.61]	0.59 [0.59-0.59]	0.57 [0.57-0.57]
	never burns	0.62 [0.52-0.73]	0.62 [0.49-0.79]	0.74 [0.55-1]
		0.16%	0.14%	0.15%
Eye color	0	1	1	1
	320	1.21 [1.2-1.22]	1.23 [1.22-1.24]	1.22 [1.2-1.24]
	640	1.42 [1.4-1.43]	1.42 [1.41-1.44]	1.43 [1.41-1.45]
	960	1.59 [1.54-1.63]	1.55 [1.49-1.6]	1.6 [1.53-1.67]
	1280	1.71 [1.6-1.83]	1.58 [1.45-1.73]	1.72 [1.55-1.91]
	1600	1.77 [1.54-2.03]	1.52 [1.26-1.83]	1.77 [1.42-2.2]
	1920	1.76 [1.38-2.24]	1.37 [0.98-1.92]	1.74 [1.17-2.6]
		0.09%	0.02%	0.27%
	light blond	1	1	1
	dark blond	0.92 [0.89-0.96]	0.93 [0.89-0.98]	0.81 [0.76-0.85]
	red	1.06 [1.06-1.06]	1.07 [1.06-1.07]	1.21 [1.2-1.21]
light brown	0.83 [0.79-0.88]	0.92 [0.86-0.98]	0.73 [0.68-0.79]	
dark brown	0.79 [0.75-0.84]	0.9 [0.84-0.96]	0.68 [0.63-0.73]	
black	0.71 *** [0.68-0.75]	0.81 [0.76-0.86]	0.66 * [0.6-0.73]	
	0.04%	0.08%	0.02%	
Presence of large moles	blue	1	1	1
	blue gray	0.88 [0.87-0.9]	0.84 [0.81-0.86]	0.94 [0.91-0.97]
	gray	0.79 [0.62-0.99]	0.84 [0.63-1.13]	1.02 [0.7-1.48]
	gray green	0.93 [0.91-0.95]	0.86 [0.84-0.89]	1.02 [0.98-1.06]
	green	0.99 [0.98-1]	0.97 [0.96-0.98]	1.02 [1-1.03]
	light brown	0.87 [0.83-0.92]	0.93 [0.87-0.98]	0.96 [0.88-1.03]
	medium brown	0.9 [0.89-0.91]	0.82 [0.81-0.83]	0.98 [0.96-1]
	dark brown black	0.86 [0.83-0.9]	0.82 [0.78-0.87]	0.86 [0.79-0.93]
		0.03%	0.02%	0.2%
	no	1	1	1
Moles in your right arm	yes	1.13 *** [1.12-1.14]	1.1 ** [1.09-1.11]	1.34 *** [1.33-1.36]
		0.03%	0.08%	0.57%
	less than 3	1	1	1
	3 to 6	0.93 [0.9-0.95]	0.89 [0.86-0.92]	1.1 [1.06-1.14]
	7 to 11	0.95 [0.91-1]	0.84 [0.79-0.9]	1.36 [1.28-1.44]
	12 to 18	0.84 [0.79-0.9]	0.72 [0.65-0.79]	1.53 [1.42-1.65]
	19 to 28	1.06 [0.97-1.15]	0.82 [0.72-0.93]	1.55 [1.4-1.72]
	29 to 39	0.9 [0.79-1.03]	0.78 [0.64-0.95]	1.6 [1.37-1.86]
	more than 39	1.05 [0.93-1.19]	0.73 [0.6-0.89]	2.31 [2.06-2.6]
		0.01%	0.02%	0.03%
Sun hair lightening	very much	1	1	1
	somewhat	0.95 [0.91-1]	0.96 [0.9-1.02]	0.89 [0.82-0.95]
	a little bit	0.96 [0.91-1.02]	1 [0.92-1.07]	0.95 [0.87-1.04]
	unchanged	1.04 [0.98-1.1]	1.08 [1-1.16]	1.04 [0.96-1.13]
	0.01%	0.03%	0.01%	
Skin response to sun exposure without sun protection	painful blister	1	1	1
	blister	1.01 [1.01-1.01]	0.93 [0.93-0.93]	1.04 [1.04-1.05]
	burns sometimes	1.06 [1.03-1.1]	1.04 [1-1.08]	1.02 [0.97-1.07]
	rarely burns	0.99 [0.98-1.01]	0.96 [0.93-0.98]	1.13 [1.09-1.18]
	never burns	0.77 [0.6-1]	0.6 [0.41-0.88]	1.31 [0.87-1.98]
	0.03%	0.06%	0.06%	
Tanning bed	never	1	1	1
	1-4times	1.06 [1.04-1.08]	1.03 [1-1.06]	1.07 [1.04-1.11]
	5-10times	1.13 ** [1.08-1.18]	1.13 [1.07-1.19]	0.98 [0.91-1.06]
	11-20times	1.16 ** [1.09-1.23]	1.09 [1.01-1.19]	1.16 [1.05-1.27]
	21-30times	1.14 * [1.05-1.24]	1.17 [1.05-1.3]	1.1 [0.96-1.26]
	30+times	1.16 ** [1.11-1.21]	1.32 *** [1.26-1.39]	1.32 *** [1.24-1.4]
	0.01%	0.02%	0.04%	
Outdoor job	no	1	1	1
	yes	1.09 ** [1.07-1.1]	1.1 * [1.08-1.13]	1.17 ** [1.14-1.2]
Total deviance explained:		19.44%	19.23%	20.08%
Numbers of cases - controls:		10043/64660	4871/69832	2534/72169

Supplementary Table 6: General linear model (GLM with binomial response) results for the best model (20-risk factor model) including factors from the cancer survey, after age matching.

See Supplementary Table 4 for a detailed description. We used semi-parametric and non-parametric matching methods implemented in MatchIt library in R, with a ratio of one case for two controls.

Variable	Level	BCC	SCC	Melanoma
Age	30	1	1	1
	40	1.48 [1.46-1.51]	0.78 [0.76-0.8]	0.98 [0.96-1]
	50	1.53 [1.5-1.56]	0.84 [0.82-0.87]	1.09 [1.07-1.12]
	60	1.59 [1.56-1.62]	1.05 [1.02-1.09]	1.37 [1.34-1.41]
	70	2.05 [2.01-2.1]	1.35 [1.31-1.4]	1.87 [1.82-1.91]
		0.35%	0.01%	0%
Sex	M	1	1	1
	F	0.6 *** [0.6-0.6]	0.53 *** [0.53-0.53]	0.49 *** [0.49-0.49]
		5.82%	6.04%	23.03%
Dysplastic moles	no	1	1	1
	yes	3.88 *** [3.88-3.88]	3.99 *** [3.99-3.99]	12.36 *** [12.35-12.36]
		2.13%	2.34%	0.47%
Family history of skin cancer	Risk 0	1	1	1
	Risk 1	1.67 [1.67-1.67]	1.71 [1.71-1.72]	1.37 [1.37-1.38]
	Risk 2	2.96 [2.95-2.97]	2.88 [2.87-2.89]	2.17 [2.15-2.19]
	Risk 3	4.94 [4.86-5.02]	4.74 [4.66-4.83]	2.92 [2.75-3.1]
		1.46%	1.83%	1.37%
Skin color	extremely fair	1	1	1
	light	0.89 *** [0.89-0.89]	0.89 * [0.89-0.89]	0.92 [0.92-0.93]
	medium	0.71 *** [0.71-0.71]	0.69 *** [0.69-0.69]	0.71 *** [0.71-0.71]
	olive	0.59 *** [0.59-0.59]	0.63 *** [0.63-0.63]	0.75 * [0.75-0.76]
		1.43%	1.81%	1.51%
Freckling tendency	none	1	1	1
	few	1.28 *** [1.28-1.28]	1.33 *** [1.33-1.33]	1.34 *** [1.34-1.34]
	lots	1.83 *** [1.83-1.83]	1.94 *** [1.94-1.94]	1.96 *** [1.96-1.96]
	many	2.57 *** [2.57-2.58]	2.75 *** [2.75-2.76]	2.64 *** [2.62-2.66]
		1.5%	1.68%	0.77%
Sunbathing frequency before age of 30	never	1	1	1
	rarely	1.1 [1.1-1.1]	1.04 [1.03-1.04]	0.95 [0.95-0.96]
	sometimes	1.53 *** [1.52-1.53]	1.4 *** [1.39-1.4]	1.19 [1.18-1.19]
	frequently	2.14 *** [2.13-2.14]	2.07 *** [2.07-2.07]	1.47 *** [1.46-1.48]
	very frequently	2.65 [2.65-2.66]	2.72 [2.71-2.72]	1.9 [1.89-1.9]
		1.63%	2.11%	1.04%
Actinic keratosis before age of 40	no	1	1	1
	yes	>100 [0->100]	>100 [0->100]	>100 [0->100]
		0.46%	0.55%	0.27%
Blisters caused by sunburns	0	1	1	1
	1-2	1.18 *** [1.18-1.18]	1.23 *** [1.23-1.23]	1.03 [1.03-1.03]
	3-4	1.3 *** [1.3-1.3]	1.41 *** [1.41-1.42]	1.26 ** [1.26-1.26]
	5+	1.55 *** [1.55-1.55]	1.64 *** [1.64-1.64]	1.44 *** [1.44-1.44]
			0.33%	0.5%
Skin response to 3-4 hours of sun exposure	always burns	1	1	1
	usually burns	0.92 [0.92-0.92]	0.93 [0.93-0.93]	0.91 [0.91-0.91]
	sometimes burns tans	0.73 [0.73-0.73]	0.66 [0.66-0.66]	0.7 [0.7-0.7]
	rarely burns	0.56 [0.56-0.56]	0.48 [0.48-0.48]	0.57 [0.57-0.57]
	never burns	0.49 [0.49-0.5]	0.47 [0.47-0.48]	0.71 [0.69-0.73]
		0.18%	0.21%	0.26%
Typical sun exposure per week	0	1	1	1
	320	1.22 [1.22-1.22]	1.26 [1.26-1.27]	1.33 [1.33-1.33]
	640	1.42 [1.42-1.42]	1.5 [1.5-1.5]	1.66 [1.66-1.66]
	960	1.56 [1.56-1.56]	1.67 [1.66-1.67]	1.93 [1.93-1.94]
	1280	1.63 [1.62-1.63]	1.73 [1.73-1.74]	2.11 [2.09-2.13]
	1600	1.61 [1.6-1.63]	1.69 [1.67-1.71]	2.15 [2.09-2.21]
	1920	1.52 [1.49-1.55]	1.55 [1.5-1.59]	2.06 [1.92-2.2]
			0.13%	0.08%
Hair color	light blond	1	1	1
	dark blond	0.93 [0.93-0.94]	0.93 [0.93-0.93]	0.84 [0.84-0.84]
	red	1.04 [1.04-1.04]	1.19 [1.19-1.19]	1.24 [1.24-1.24]
	light brown	0.8 [0.8-0.81]	0.86 [0.86-0.87]	0.74 [0.73-0.74]
	dark brown	0.76 [0.76-0.76]	0.84 [0.84-0.84]	0.64 [0.64-0.64]
	black	0.73 *** [0.73-0.73]	0.73 ** [0.73-0.73]	0.65 ** [0.64-0.65]
		0.06%	0.19%	0.06%
Eye color	blue	1	1	1
	blue gray	0.89 [0.89-0.89]	0.83 [0.83-0.83]	0.95 [0.94-0.95]
	gray	0.67 ** [0.66-0.68]	0.69 [0.68-0.7]	0.82 [0.78-0.85]
	gray green	0.92 [0.91-0.92]	0.79 [0.79-0.79]	1.06 [1.06-1.06]
	green	0.98 [0.98-0.98]	0.91 [0.91-0.91]	0.99 [0.99-0.99]
	light brown	0.88 [0.88-0.88]	0.76 [0.76-0.76]	0.81 [0.8-0.81]
	medium brown	0.85 [0.85-0.86]	0.78 [0.78-0.78]	0.91 [0.91-0.91]
	dark brown black	0.83 [0.83-0.83]	0.72 [0.72-0.72]	0.79 [0.79-0.8]
			0.05%	0.05%
Presence of large moles	no	1	1	1
	yes	1.15 *** [1.15-1.15]	1.14 *** [1.14-1.14]	1.39 *** [1.39-1.39]
		0.03%	0.09%	0.44%
Moles in your right arm	less than 3	1	1	1
	3 to 6	0.91 [0.91-0.91]	0.86 [0.86-0.86]	1.2 [1.2-1.2]
	7 to 11	0.92 [0.92-0.92]	0.84 [0.84-0.85]	1.32 [1.32-1.33]
	12 to 18	0.94 [0.94-0.94]	0.79 [0.79-0.79]	1.38 [1.37-1.39]
	19 to 28	0.97 [0.96-0.97]	0.8 [0.79-0.8]	1.52 [1.51-1.53]
	29 to 39	0.93 [0.93-0.94]	0.65 [0.64-0.65]	1.57 [1.55-1.59]
	more than 39	1.14 [1.14-1.15]	1.01 [1-1.02]	1.93 [1.91-1.95]
			0.05%	0.06%
Sun hair lightening	very much	1	1	1
	somewhat	0.92 [0.91-0.92]	0.92 [0.92-0.92]	0.82 [0.82-0.83]
	a little bit	0.96 [0.96-0.96]	0.98 [0.98-0.98]	0.94 [0.93-0.94]
	unchanged	1.08 [1.08-1.08]	1.1 [1.1-1.11]	1.07 [1.07-1.08]
		0.05%	0.05%	0.03%
Skin response to sun exposure without sun protection	painful blister	1	1	1
	blister	1.05 [1.05-1.05]	1.06 [1.06-1.06]	1.11 [1.11-1.11]
	burns sometimes	1.15 [1.15-1.15]	1.17 [1.17-1.18]	1.1 [1.1-1.1]
	rarely burns	1.01 [1.01-1.01]	1.06 [1.06-1.06]	0.96 [0.96-0.96]
	never burns	0.73 [0.72-0.75]	0.74 [0.73-0.76]	0.76 [0.72-0.8]
		0.02%	0.05%	0.1%
Tanning bed	never	1	1	1
	1-4times	1.02 [1.02-1.03]	1.09 [1.08-1.09]	1.12 [1.12-1.12]
	5-10times	1.11 * [1.11-1.12]	1.14 [1.14-1.14]	1.07 [1.07-1.08]
	11-20times	1.15 * [1.14-1.15]	1.19 * [1.18-1.19]	1.28 * [1.27-1.29]
	21-30times	1 [1-1.01]	0.98 [0.98-0.99]	0.98 [0.97-0.99]
	30+times	1.11 * [1.11-1.11]	1.21 ** [1.2-1.21]	1.44 *** [1.44-1.45]
		0.02%	0.02%	0.03%
Outdoor job	no	1	1	1
	yes	1.1 *** [1.1-1.1]	1.08 * [1.08-1.09]	1.16 ** [1.16-1.16]
Total deviance explained:		15.93%	17.99%	30.88%
Numbers of cases - controls:		14672/29288	7307/14513	3933/11739

Supplementary Table 7: General linear model (GLM with binomial response) results for the best model (20-risk factor model) including factors from the cancer survey, and the polygenic risk score (PRS).

See Supplementary Table 4 for a detailed description.

Variable	Level	BCC	SCC	Melanoma
Age		9.88%	10.69%	3.27%
	30	1	1	1
	40	3.38 [2.86-4]	2.49 [1.91-3.24]	1.51 [1.29-1.77]
	50	8.57 [7.06-10.41]	6.36 [4.67-8.65]	2.35 [1.95-2.83]
	60	17.96 [14.6-22.1]	15.83 [11.33-22.11]	3.71 [3.03-4.54]
Sex	70	37.15 [30.11-45.84]	39.84 [28.31-56.08]	6.18 [5.02-7.6]
		0.05%	0.09%	0.2%
Polygenic risk score (PRS)	M	1	1	1
	F	0.68 *** [0.68-0.68]	0.66 *** [0.66-0.66]	0.6 *** [0.6-0.6]
Dysplastic moles		3.16%	1.6%	1.99%
	-1.71	1	1	1
	-0.57	3.89 [3.66-4.14]	2.23 [2.06-2.41]	3.03 [2.72-3.37]
	0.57	15.16 [14.26-16.11]	4.96 [4.53-5.42]	9.16 [7.9-10.62]
Family history of skin cancer	1.71	59.01 [58.98-59.04]	11.04 [10.86-11.22]	27.72 [26.15-29.39]
		2.94%	2.06%	11.53%
Skin color	no	1	1	1
	yes	2.63 *** [2.6-2.66]	2.25 *** [2.22-2.27]	6.75 *** [6.74-6.76]
		1.08%	0.97%	0.06%
	Risk 0	1	1	1
Freckling tendency	Risk 1	1.5 [1.48-1.53]	1.42 [1.4-1.45]	1.16 [1.13-1.19]
	Risk 2	2.29 [2.17-2.42]	2.16 [2.03-2.29]	1.24 [1.14-1.36]
	Risk 3	3.58 [3.05-4.21]	3.18 [2.71-3.74]	1.45 [1.15-1.84]
Sunbathing frequency before age of 30		0.31%	0.38%	0.31%
	extremely fair	1	1	1
	light	0.97 [0.95-0.99]	0.93 [0.91-0.96]	0.99 [0.95-1.03]
Actinic keratosis before age of 40	medium	0.86 *** [0.85-0.87]	0.8 *** [0.79-0.81]	0.84 ** [0.82-0.85]
	olive	0.72 *** [0.69-0.75]	0.74 *** [0.7-0.78]	0.91 [0.86-0.97]
		0.39%	0.38%	0.37%
Blister caused by sunburns	none	1	1	1
	few	1.13 *** [1.12-1.14]	1.13 *** [1.12-1.15]	1.16 ** [1.14-1.18]
	lots	1.36 *** [1.35-1.36]	1.39 *** [1.39-1.39]	1.42 *** [1.41-1.42]
	many	1.66 *** [1.59-1.72]	1.65 *** [1.58-1.73]	1.58 *** [1.5-1.66]
		1%	0.87%	0.32%
Skin response to 3-4 hours of sun exposure	never	1	1	1
	rarely	1.07 [1.03-1.11]	1.05 [1-1.1]	0.92 [0.87-0.98]
	sometimes	1.46 *** [1.39-1.54]	1.32 *** [1.24-1.41]	1.05 [0.98-1.13]
	frequently	1.88 *** [1.8-1.97]	1.79 *** [1.69-1.9]	1.3 ** [1.21-1.39]
	very frequently	2.35 [2.27-2.43]	2.17 [2.08-2.27]	1.48 [1.41-1.55]
Typical sun exposure per week		0.45%	0.64%	0.03%
	no	1	1	1
	yes	3.45 *** [3.15-3.78]	3.75 *** [3.43-4.1]	1.38 ** [1.2-1.59]
		0.19%	0.18%	0.06%
	0	1	1	1
Presence of large moles	1-2	1.11 *** [1.1-1.12]	1.21 *** [1.2-1.23]	1 [0.98-1.01]
	3-4	1.23 *** [1.22-1.23]	1.35 *** [1.34-1.36]	1.1 [1.09-1.1]
	5+	1.38 *** [1.37-1.38]	1.39 *** [1.38-1.41]	1.19 ** [1.18-1.21]
		0.1%	0.11%	0.14%
	always burns	1	1	1
Moles in your right arm	usually burns	0.98 [0.96-1]	0.95 [0.93-0.98]	0.88 [0.86-0.9]
	sometimes burns tans	0.84 [0.81-0.86]	0.79 [0.77-0.82]	0.74 [0.72-0.78]
	rarely burns	0.7 [0.69-0.71]	0.66 [0.66-0.67]	0.63 [0.63-0.63]
	never burns	0.66 [0.57-0.76]	0.65 [0.54-0.79]	0.79 [0.62-1.01]
		0.11%	0.1%	0.07%
Hair color	0	1	1	1
	320	1.17 [1.17-1.18]	1.19 [1.18-1.2]	1.14 [1.13-1.15]
	640	1.33 [1.32-1.34]	1.34 [1.33-1.35]	1.28 [1.26-1.29]
	960	1.46 [1.43-1.5]	1.42 [1.38-1.47]	1.4 [1.35-1.46]
	1280	1.55 [1.46-1.65]	1.43 [1.32-1.55]	1.51 [1.37-1.66]
	1600	1.59 [1.39-1.81]	1.36 [1.14-1.62]	1.59 [1.3-1.95]
	1920	1.57 [1.25-1.97]	1.21 [0.89-1.66]	1.64 [1.15-2.36]
		0.1%	0.05%	0.12%
	light blond	1	1	1
	dark blond	0.91 [0.88-0.94]	0.92 [0.89-0.96]	0.81 [0.77-0.84]
Eye color	red	0.92 [0.92-0.92]	0.95 [0.95-0.95]	0.98 [0.98-0.99]
	light brown	0.79 [0.76-0.82]	0.85 [0.8-0.89]	0.75 [0.7-0.79]
	dark brown	0.73 [0.7-0.76]	0.79 [0.75-0.84]	0.71 [0.67-0.75]
	black	0.63 *** [0.61-0.65]	0.68 *** [0.65-0.71]	0.8 [0.74-0.85]
		0.02%	0.07%	0.01%
	blue	1	1	1
	blue gray	0.92 [0.91-0.93]	0.89 [0.87-0.91]	0.94 [0.91-0.96]
	gray	0.75 * [0.62-0.91]	0.81 [0.64-1.03]	1.03 [0.77-1.36]
	gray green	0.98 [0.96-1]	0.88 [0.86-0.91]	1.02 [0.99-1.06]
	green	1.05 [1.05-1.06]	1.01 [1-1.02]	1.01 [1-1.03]
Sun hair lightening	light brown	1 [0.96-1.04]	0.93 [0.88-0.97]	0.94 [0.88-1]
	medium brown	1 [0.99-1.01]	0.87 [0.86-0.88]	0.96 [0.94-0.97]
	dark brown black	1.01 [0.97-1.04]	0.85 [0.81-0.89]	0.9 [0.84-0.96]
		0.05%	0.03%	0.2%
	no	1	1	1
Sun hair lightening	yes	1.17 *** [1.16-1.18]	1.12 *** [1.11-1.13]	1.33 *** [1.32-1.34]
		0.02%	0.05%	0.53%
	less than 3	1	1	1
	3 to 6	0.93 [0.91-0.95]	0.9 [0.87-0.92]	1.14 [1.11-1.17]
	7 to 11	0.93 [0.9-0.97]	0.87 [0.83-0.92]	1.37 [1.3-1.43]
	12 to 18	0.89 [0.84-0.94]	0.79 [0.73-0.85]	1.53 [1.44-1.63]
	19 to 28	1.02 [0.95-1.09]	0.85 [0.76-0.94]	1.56 [1.44-1.7]
	29 to 39	0.88 [0.79-0.99]	0.79 [0.67-0.92]	1.64 [1.45-1.84]
	more than 39	1.04 [0.94-1.15]	0.83 [0.71-0.97]	2.12 [1.91-2.35]
Skin response to sun exposure without sun protection		0.01%	0.02%	0.02%
	very much	1	1	1
	somewhat	0.95 [0.91-0.99]	0.9 [0.86-0.95]	0.89 [0.84-0.95]
	a little bit	0.96 [0.92-1.01]	0.94 [0.88-1]	0.97 [0.9-1.04]
Tanning bed	unchanged	1.03 [0.98-1.08]	1.01 [0.95-1.07]	1.01 [0.95-1.09]
		0.03%	0.02%	0.01%
	painful blister	1	1	1
	blister	1.04 [1.03-1.04]	1 [0.99-1]	1.08 [1.08-1.09]
	burns sometimes	1.13 [1.1-1.16]	1.1 [1.07-1.14]	1.07 [1.02-1.11]
Outdoor job	rarely burns	1.05 [1.04-1.07]	1.03 [1.01-1.05]	1.07 [1.03-1.1]
	never burns	0.83 [0.67-1.03]	0.79 [0.59-1.05]	1.11 [0.77-1.59]
		0.01%	0.03%	0.03%
	never	1	1	1
	1-4times	1.03 [1.01-1.05]	1.03 [1.01-1.05]	1.05 [1.02-1.08]
	5-10times	1.1 * [1.06-1.14]	1.05 [1-1.11]	0.99 [0.93-1.06]
Sun hair lightening	11-20times	1.13 ** [1.08-1.19]	1.1 [1.03-1.18]	1.1 [1.01-1.19]
	21-30times	1.03 [0.96-1.11]	1.06 [0.96-1.16]	0.98 [0.87-1.1]
	30+times	1.06 [1.02-1.1]	1.22 *** [1.17-1.28]	1.21 ** [1.14-1.27]
		0.01%	0.01%	0.01%
Total deviance explained:	no	1	1	1
	yes	1.08 ** [1.06-1.09]	1.07 * [1.05-1.09]	1.09 * [1.07-1.11]
		20.85%	19.33%	19.72%
Numbers of cases - controls:		14893/88090	7476/95507	3997/98986

Supplementary Table 8: General linear model (GLM with binomial response) results for the best model (31-risk factor model) including factors from the cancer survey, and the additional phenotypes from 23andMe database. See Supplementary Table 4 for a detailed description.

Variable	Level	BCC	SCC	Melanoma
Age		9.87%	10.7%	3.27%
	30			
	40	3.57 [3.02-4.21]	2.59 [1.99-3.36]	1.56 [1.33-1.82]
	50	9.33 [7.69-11.31]	6.79 [5-9.22]	2.45 [2.03-2.95]
	60	20.07 [16.34-24.67]	17.31 [12.41-24.15]	3.91 [3.2-4.79]
	70	42.49 [34.48-52.35]	44.57 [31.73-62.63]	6.64 [5.4-8.17]
Sex		0.05%	0.09%	0.21%
	M			
	F	0.77 *** [0.76-0.77]	0.71 *** [0.71-0.71]	0.65 *** [0.65-0.66]
Dysplastic moles		3.05%	2.08%	11.91%
	no			
	yes	2.57 *** [2.54-2.6]	2.19 *** [2.16-2.22]	6.76 *** [6.74-6.77]
Family history of skin cancer		1.33%	1.14%	0.22%
	Risk 0			
	Risk 1	1.54 [1.52-1.57]	1.45 [1.42-1.48]	1.18 [1.15-1.22]
	Risk 2	2.38 [2.26-2.51]	2.18 [2.06-2.31]	1.26 [1.15-1.38]
	Risk 3	3.69 [3.16-4.32]	3.23 [2.75-3.79]	1.48 [1.17-1.87]
Skin color		0.8%	0.79%	0.56%
	extremely fair			
	light	0.92 ** [0.9-0.94]	0.89 ** [0.86-0.91]	0.96 [0.93-1]
	medium	0.77 *** [0.76-0.78]	0.72 *** [0.71-0.73]	0.78 *** [0.77-0.8]
	olive	0.59 *** [0.57-0.61]	0.62 *** [0.58-0.65]	0.79 * [0.74-0.84]
Freckling tendency		0.77%	0.7%	0.51%
	none			
	few	1.19 *** [1.17-1.2]	1.17 *** [1.16-1.19]	1.17 *** [1.15-1.19]
	lots	1.54 *** [1.53-1.54]	1.55 *** [1.55-1.55]	1.46 *** [1.46-1.46]
	many	2.05 *** [1.97-2.13]	1.97 *** [1.88-2.06]	1.66 *** [1.57-1.74]
Sunbathing frequency before age of 30		0.9%	0.79%	0.3%
	never			
	rarely	1.03 [0.99-1.07]	1.02 [0.97-1.07]	0.91 [0.86-0.96]
	sometimes	1.34 *** [1.28-1.41]	1.24 *** [1.16-1.31]	1.02 [0.94-1.09]
	frequently	1.67 *** [1.6-1.75]	1.61 *** [1.52-1.71]	1.23 * [1.15-1.32]
	very frequently	2.04 [1.97-2.1]	1.92 [1.84-2]	1.39 [1.33-1.45]
Actinic keratosis before age of 40		0.52%	0.7%	0.04%
	no			
	yes	3.38 *** [3.09-3.7]	3.64 *** [3.34-3.97]	1.38 ** [1.21-1.59]
Adulthood latitude		0.29%	0.33%	0.03%
	25			
	35	0.77 [0.74-0.8]	0.76 [0.73-0.8]	0.95 [0.9-1.01]
	45	0.6 [0.58-0.61]	0.59 [0.57-0.61]	0.91 [0.86-0.95]
BMI		0.33%	0.19%	0.01%
	20			
	25	0.47 [0.42-0.53]	0.52 [0.45-0.61]	0.76 [0.62-0.92]
	30	0.35 [0.31-0.39]	0.41 [0.35-0.47]	0.67 [0.55-0.8]
	35	0.26 [0.24-0.28]	0.33 [0.3-0.36]	0.59 [0.51-0.67]
Blisters caused by sunburns		0.28%	0.23%	0.13%
	0			
	1-2	1.13 *** [1.13-1.14]	1.23 *** [1.21-1.24]	1.01 [1-1.02]
	3-4	1.26 *** [1.26-1.27]	1.37 *** [1.36-1.39]	1.12 [1.11-1.13]
	5+	1.44 *** [1.43-1.45]	1.44 *** [1.42-1.45]	1.22 *** [1.21-1.24]
Skin response to 3-4 hours of sun exposure		0.19%	0.18%	0.16%
	always burns			
	usually burns	0.93 [0.91-0.94]	0.91 [0.89-0.94]	0.87 [0.85-0.9]
	sometimes burns tans	0.74 [0.72-0.76]	0.72 [0.7-0.75]	0.72 [0.69-0.75]
	rarely burns	0.59 [0.59-0.59]	0.58 [0.58-0.59]	0.59 [0.59-0.59]
	never burns	0.54 [0.47-0.63]	0.57 [0.47-0.69]	0.74 [0.58-0.94]
Physical activity		0.06%	0.02%	0%
	no			
	highly active	1.12 *** [1.11-1.13]	1.06 * [1.05-1.07]	1.01 [1-1.02]
Typical sun exposure per week		0.11%	0.1%	0.07%
	0			
	320	1.16 [1.16-1.17]	1.18 [1.17-1.2]	1.14 [1.12-1.15]
	640	1.31 [1.31-1.32]	1.33 [1.32-1.34]	1.26 [1.25-1.28]
	960	1.44 [1.41-1.48]	1.41 [1.37-1.46]	1.37 [1.32-1.43]
	1280	1.53 [1.44-1.63]	1.42 [1.31-1.54]	1.46 [1.33-1.61]
	1600	1.58 [1.4-1.79]	1.35 [1.14-1.61]	1.52 [1.25-1.86]
	1920	1.58 [1.27-1.98]	1.22 [0.9-1.66]	1.56 [1.09-2.22]
Alcohol consumption		0.04%	0.03%	0.01%
	no or (low) consumption			
	intermediate consumption	1.15 *** [1.15-1.16]	1.12 *** [1.12-1.13]	1.05 [1.04-1.06]
	abuser	1.11 *** [1.11-1.11]	1.11 *** [1.11-1.11]	1 [0.99-1]
Weight		0.07%	0.03%	0.03%
	100			
	201	1.84 [1.68-2.02]	1.56 [1.38-1.76]	1.51 [1.29-1.76]
	299	2.99 [2.93-3.05]	2.22 [2.16-2.28]	2.08 [2.01-2.16]
Hair color		0.07%	0.03%	0.16%
	light blond			
	dark blond	0.93 [0.9-0.96]	0.94 [0.9-0.97]	0.8 [0.77-0.84]
	red	1.02 [1.02-1.03]	1.05 [1.05-1.05]	1.14 [1.14-1.14]
	light brown	0.84 [0.81-0.88]	0.91 [0.86-0.95]	0.74 [0.69-0.78]
	dark brown	0.82 [0.79-0.86]	0.9 [0.85-0.95]	0.68 [0.64-0.72]
	black	0.74 *** [0.72-0.77]	0.81 * [0.77-0.84]	0.71 ** [0.66-0.76]
Eye color		0.04%	0.07%	0.02%
	blue			
	blue gray	0.89 [0.88-0.9]	0.87 [0.85-0.89]	0.94 [0.92-0.96]
	gray	0.72 * [0.6-0.87]	0.78 [0.62-0.99]	1.01 [0.76-1.34]
	gray green	0.91 [0.9-0.93]	0.86 [0.84-0.88]	1.01 [0.98-1.04]
	green	0.96 [0.95-0.97]	0.95 [0.94-0.96]	1 [0.98-1.01]
	light brown	0.87 [0.84-0.91]	0.89 [0.85-0.93]	0.91 [0.85-0.97]
	medium brown	0.87 [0.86-0.88]	0.83 [0.82-0.84]	0.93 [0.91-0.94]
	dark brown black	0.86 [0.83-0.89]	0.8 [0.77-0.84]	0.86 [0.81-0.92]
Presence of large moles		0.04%	0.01%	0.3%
	no			
	yes	1.15 *** [1.14-1.16]	1.1 *** [1.09-1.11]	1.33 *** [1.32-1.34]
Moles in your right arm		0.03%	0.07%	0.36%
	less than 3			
	3 to 6	0.92 [0.9-0.94]	0.89 [0.87-0.92]	1.15 [1.12-1.18]
	7 to 11	0.91 [0.88-0.95]	0.86 [0.82-0.91]	1.38 [1.32-1.45]
	12 to 18	0.85 [0.8-0.89]	0.77 [0.71-0.83]	1.52 [1.44-1.62]
	19 to 28	0.99 [0.92-1.06]	0.83 [0.75-0.92]	1.57 [1.45-1.71]
	29 to 39	0.85 [0.76-0.95]	0.77 [0.66-0.9]	1.67 [1.48-1.88]
	more than 39	1 [0.9-1.1]	0.8 [0.69-0.93]	2.15 [1.94-2.38]
Childhood latitude		0.02%	0.03%	0.02%
	25			
	35	0.9 [0.86-0.93]	0.87 [0.83-0.91]	0.89 [0.83-0.95]
	45	0.81 [0.78-0.84]	0.76 [0.73-0.79]	0.79 [0.75-0.84]
Sun hair lightening		0.02%	0.02%	0.02%
	very much			
	somewhat	0.96 [0.92-1]	0.91 [0.87-0.96]	0.88 [0.83-0.94]
	a little bit	0.97 [0.93-1.02]	0.95 [0.89-1.01]	0.96 [0.89-1.03]
	unchanged	1.06 [1.01-1.11]	1.04 [0.98-1.1]	1 [0.94-1.07]
Skin response to sun exposure without sun protection		0.02%	0.02%	0.01%
	painful blister			
	blister	1.02 [1.01-1.02]	0.99 [0.99-0.99]	1.08 [1.07-1.08]
	burns sometimes	1.1 [1.07-1.13]	1.1 [1.06-1.14]	1.05 [1.01-1.1]
	rarely burns	1.03 [1.02-1.05]	1.04 [1.02-1.05]	1.05 [1.02-1.08]
	never burns	0.83 [0.67-1.03]	0.78 [0.59-1.05]	1.09 [0.76-1.55]
Tanning bed		0.02%	0.04%	0.04%
	never			
	1-4times	1.04 [1.02-1.06]	1.04 [1.02-1.07]	1.05 [1.02-1.08]
	5-10times	1.12 ** [1.09-1.16]	1.08 [1.03-1.13]	1 [0.94-1.07]
	11-20times	1.17 *** [1.12-1.23]	1.15 * [1.07-1.22]	1.12 [1.03-1.21]
	21-30times	1.08 [1.01-1.16]	1.1 [1-1.21]	1 [0.89-1.12]
	30+times	1.12 ** [1.08-1.16]	1.28 *** [1.23-1.34]	1.25 *** [1.18-1.31]
Outdoor job		0.01%	0.01%	0.01%
	no			
	yes	1.09 *** [1.08-1.11]	1.09 ** [1.07-1.11]	1.1 * [1.08-1.12]
Smoking		0.02%	0%	0.01%
	no			
	yes	0.93 *** [0.92-0.93]	0.97 [0.97-0.98]	0.95 [0.94-0.96]
Adulthood elevation		0.01%	0%	0%
	18			
	1004	1.06 [1.05-1.07]	1.03 [1.02-1.04]	0.98 [0.96-1]
	2029	1.12 [1.07-1.18]	1.06 [0.99-1.13]	0.96 [0.88-1.05]
Morning person		0.02%	0.04%	0.03%
	night			
	morning	1.07 *** [1.07-1.08]	1.11 *** [1.11-1.12]	1.09 * [1.09-1.1]
Desk clean		0.03%	0.02%	0.02%
	very clen			
	fairly clean	0.99 [0.97-1.01]	0.97 [0.94-0.99]	0.91 [0.89-0.94]
	fairly messy	0.92 [0.91-0.94]	0.91 [0.89-0.93]	0.9 [0.87-0.92]
	very messy	0.87 [0.87-0.87]	0.86 [0.86-0.86]	0.86 [0.86-0.86]
Seasonal allergies		0.02%	0%	0.07%
	no allergy			
	has seasonal allergy	0.93 *** [0.93-0.93]	1.02 [1.02-1.02]	0.84 *** [0.84-0.84]
Total deviance explained:		19.99%	19.46%	18.96%
Numbers of cases - controls:		14898/88110	7479/95529	3998/99010

Supplementary Table 9: General linear model (GLM with binomial response) results for 32-risk factor models. See Supplementary Table 4 for a detailed description and Figure 2.

Variable	Level	BCC	SCC	Melanoma
Age		9.87%	10.69%	3.28%
	30	1	1	1
	40	3.5 [2.97-4.13]	2.56 [1.97-3.32]	1.53 [1.31-1.78]
	50	9.14 [7.56-11.06]	6.69 [4.94-9.07]	2.4 [1.99-2.88]
	60	19.76 [16.13-24.22]	17.04 [12.25-23.71]	3.85 [3.16-4.71]
	70	42.1 [34.26-51.75]	43.75 [31.23-61.3]	6.59 [5.37-8.01]
Sex	M	0.05%	0.09%	0.21%
	F	1	1	1
Polygenic risk score (PRS)		0.78 *** [0.78-0.79]	0.73 *** [0.72-0.73]	0.67 *** [0.66-0.67]
	-1.71	3.05%	1.54%	1.86%
	-0.57	0.88 [0.34-2.28]	2.49 [1.73-3.6]	5.38 [2.97-9.73]
	0.57	3.33 [1.29-8.85]	5.38 [3.65-7.85]	16.28 [8.65-30.83]
	1.71	7.68 [5.62-10.5]	9.98 [8.77-11.34]	27.77 [22.66-34.02]
Dysplastic moles	no	2.95%	2.06%	11.51%
	yes	1	1	1
Family history of skin cancer		2.58 *** [2.55-2.61]	2.2 *** [2.17-2.23]	6.7 *** [6.68-6.71]
	Risk 0	1.07%	0.97%	0.17%
	Risk 1	1.51 [1.48-1.53]	1.43 [1.4-1.46]	1.17 [1.14-1.2]
	Risk 2	2.29 [2.17-2.4]	2.14 [2.02-2.26]	1.25 [1.14-1.36]
	Risk 3	3.52 [3.01-4.12]	3.13 [2.67-3.67]	1.46 [1.16-1.84]
Skin color	extremely fair	0.29%	0.38%	0.27%
	light	1	1	1
	medium	0.95 [0.93-0.98]	0.92 * [0.89-0.94]	0.98 [0.95-1.02]
	olive	0.84 *** [0.83-0.85]	0.78 *** [0.77-0.79]	0.82 ** [0.81-0.84]
Freckling tendency	none	0.68 *** [0.66-0.71]	0.7 *** [0.67-0.74]	0.89 [0.83-0.95]
	few	0.37%	0.38%	0.37%
	lots	1.11 *** [1.1-1.12]	1.12 *** [1.11-1.13]	1.15 ** [1.13-1.17]
	many	1.32 *** [1.32-1.32]	1.37 *** [1.37-1.37]	1.4 *** [1.39-1.4]
Sunbathing frequency before age of 30	never	1.62 *** [1.56-1.69]	1.66 *** [1.58-1.73]	1.56 *** [1.48-1.64]
	rarely	1%	0.87%	0.33%
	sometimes	1.06 [1.02-1.1]	1.04 [0.99-1.09]	0.92 [0.87-0.97]
	frequently	1.4 *** [1.33-1.47]	1.27 *** [1.2-1.35]	1.03 [0.96-1.11]
	very frequently	1.76 *** [1.68-1.84]	1.67 *** [1.58-1.77]	1.26 ** [1.18-1.35]
Actinic keratosis before age of 40	no	2.18 [2.11-2.25]	2 [1.92-2.09]	1.43 [1.37-1.5]
	yes	0.45%	0.64%	0.03%
Adulthood latitude	25	3.15 *** [2.88-3.45]	3.45 *** [3.17-3.77]	1.35 ** [1.18-1.55]
	35	0.31%	0.34%	0.03%
	45	0.76 [0.4-0.79]	0.76 [0.73-0.8]	0.95 [0.59-1.01]
BMI	20	0.59 [0.57-0.6]	0.59 [0.57-0.6]	0.9 [0.86-0.94]
	25	0.33%	0.19%	0.01%
	30	0.47 [0.42-0.52]	0.52 [0.45-0.6]	0.76 [0.63-0.92]
	35	0.34 [0.3-0.38]	0.4 [0.35-0.47]	0.67 [0.55-0.8]
Blisters caused by sunburns	0	0.25 [0.23-0.27]	0.32 [0.29-0.36]	0.59 [0.51-0.67]
	1-2	0.2%	0.18%	0.1%
	3-4	1.12 *** [1.11-1.13]	1.21 *** [1.2-1.23]	1 [0.99-1.01]
	5+	1.23 *** [1.23-1.24]	1.35 *** [1.33-1.36]	1.1 [1.09-1.11]
Skin response to 3-4 hours of sun exposure	never burns	1.39 *** [1.38-1.4]	1.4 *** [1.38-1.41]	1.2 ** [1.19-1.22]
	usually burns	0.11%	0.11%	0.11%
	sometimes burns tans	0.96 [0.94-0.98]	0.94 [0.91-0.96]	0.88 [0.85-0.9]
	rarely burns	0.8 [0.78-0.83]	0.77 [0.74-0.79]	0.74 [0.71-0.77]
	never burns	0.67 [0.66-0.67]	0.64 [0.64-0.64]	0.63 [0.62-0.63]
Physical activity	no	0.63 [0.55-0.73]	0.63 [0.52-0.76]	0.78 [0.61-0.99]
	highly active	0.05%	0.02%	0%
Typical sun exposure per week	0	1.11 *** [1.11-1.12]	1.06 [1.05-1.07]	1 [0.99-1.01]
	320	0.1%	0.09%	0.08%
	640	1.15 [1.15-1.16]	1.18 [1.17-1.19]	1.14 [1.12-1.15]
	960	1.3 [1.29-1.31]	1.27 [1.25-1.28]	1.25 [1.23-1.28]
	1280	1.42 [1.39-1.46]	1.41 [1.37-1.45]	1.39 [1.34-1.44]
	1600	1.52 [1.43-1.61]	1.42 [1.31-1.54]	1.49 [1.36-1.64]
	1920	1.58 [1.39-1.79]	1.36 [1.14-1.61]	1.58 [1.29-1.92]
Alcohol consumption	no or (low) consumption	1.6 [1.28-2]	1.23 [0.9-1.67]	1.64 [1.15-2.33]
	intermediate consumption	0.04%	0.03%	0.01%
	abuser	1.14 *** [1.13-1.14]	1.12 *** [1.11-1.12]	1.05 [1.04-1.06]
Weight	100	1.1 *** [1.1-1.11]	1.11 ** [1.11-1.11]	0.99 [0.99-1]
	201	0.07%	0.03%	0.04%
	299	1.89 [1.72-2.07]	1.59 [1.41-1.8]	1.55 [1.32-1.81]
Hair color	dark blond	3.11 [3.05-3.18]	2.3 [2.24-2.36]	2.18 [2.11-2.26]
	red	0.09%	0.06%	0.08%
	light brown	0.91 [0.88-0.94]	0.92 [0.89-0.96]	0.81 [0.78-0.85]
	dark brown	0.92 [0.91-0.92]	0.95 [0.95-0.95]	0.99 [0.99-1]
	black	0.79 [0.76-0.83]	0.86 [0.82-0.9]	0.76 [0.71-0.8]
Eye color	blue	0.74 [0.72-0.78]	0.82 [0.78-0.87]	0.73 [0.68-0.77]
	gray	0.64 *** [0.62-0.66]	0.7 *** [0.67-0.74]	0.81 [0.75-0.86]
	green	0.02%	0.05%	0.01%
	light brown	0.92 [0.91-0.94]	0.89 [0.87-0.91]	0.95 [0.92-0.97]
	medium brown	0.78 * [0.64-0.94]	0.81 [0.64-1.02]	1.04 [0.79-1.38]
	dark brown black	0.99 [0.97-1]	0.88 [0.86-0.9]	1.03 [1-1.06]
Presence of large moles	no	1.05 [1.04-1.06]	0.99 [0.98-1]	1.02 [1.01-1.03]
	yes	1.01 [0.97-1.04]	0.92 [0.88-0.96]	0.94 [0.88-1]
	blister	1.02 [1.02-1.03]	0.86 [0.85-0.87]	0.96 [0.94-0.97]
	burns sometimes	1.04 [1-1.07]	0.85 [0.81-0.89]	0.9 [0.85-0.96]
	rarely burns	0.06%	0.02%	0.3%
	never burns	1.19 *** [1.18-1.2]	1.13 *** [1.12-1.14]	1.33 *** [1.32-1.35]
Moles in your right arm	less than 3	0.02%	0.05%	0.36%
	3 to 6	0.93 [0.91-0.95]	0.9 [0.88-0.93]	1.14 [1.11-1.17]
	7 to 11	0.94 [0.91-0.97]	0.88 [0.84-0.93]	1.37 [1.31-1.44]
	12 to 18	0.89 [0.85-0.94]	0.79 [0.74-0.86]	1.55 [1.46-1.64]
	19 to 28	1.02 [0.95-1.1]	0.86 [0.78-0.95]	1.57 [1.45-1.71]
	29 to 39	0.9 [0.81-1]	0.81 [0.69-0.94]	1.66 [1.48-1.87]
	more than 39	1.06 [0.95-1.17]	0.84 [0.72-0.98]	2.16 [1.96-2.39]
Childhood latitude	25	0.02%	0.03%	0.02%
	35	0.89 [0.86-0.93]	0.87 [0.83-0.91]	0.89 [0.83-0.94]
	45	0.8 [0.78-0.83]	0.76 [0.73-0.79]	0.79 [0.74-0.83]
Sun hair lightening	very much	0.01%	0.02%	0.02%
	somewhat	0.95 [0.91-0.99]	0.91 [0.86-0.96]	0.89 [0.84-0.94]
	a little bit	0.96 [0.91-1]	0.94 [0.89-1]	0.96 [0.89-1.03]
	unchanged	1.02 [0.98-1.07]	1.01 [0.96-1.07]	1 [0.94-1.07]
Skin response to sun exposure without sun protection	painful blister	0.02%	0.02%	0.01%
	blister	1.01 [1.01-1.02]	0.99 [0.98-0.99]	1.08 [1.07-1.08]
	burns sometimes	1.11 [1.08-1.14]	1.1 [1.07-1.14]	1.06 [1.02-1.11]
	rarely burns	1.05 [1.04-1.06]	1.05 [1.03-1.06]	1.06 [1.03-1.1]
	never burns	0.84 [0.68-1.04]	0.81 [0.61-1.08]	1.13 [0.79-1.6]
Tanning bed	never	0.02%	0.04%	0.03%
	1-4times	1.05 [1.03-1.06]	1.04 [1.02-1.08]	1.05 [1.02-1.08]
	5-10times	1.12 ** [1.08-1.16]	1.08 [1.03-1.13]	1.01 [0.95-1.07]
	11-20times	1.16 ** [1.1-1.21]	1.13 [1.06-1.21]	1.11 [1.02-1.2]
	21-30times	1.07 [1-1.14]	1.09 [0.99-1.2]	1 [0.89-1.12]
	30+times	1.1 * [1.06-1.14]	1.26 *** [1.21-1.31]	1.23 ** [1.17-1.29]
Outdoor job	no	0.01%	0.01%	0.01%
	yes	1.09 *** [1.08-1.1]	1.08 * [1.06-1.1]	1.09 * [1.07-1.11]
Smoking	no	0.02%	0%	0.01%
	yes	0.92 *** [0.92-0.93]	0.97 [0.96-0.97]	0.94 [0.93-0.95]
Adulthood elevation	18	0.01%	0%	0%
	1004	1.06 [1.05-1.07]	1.03 [1.01-1.04]	0.98 [0.97-1]
	2029	1.13 [1.07-1.18]	1.05 [0.99-1.12]	0.97 [0.89-1.06]
Morning person	night	0.03%	0.03%	0.01%
	morning	1.1 *** [1.1-1.1]	1.1 *** [1.1-1.1]	1.04 [1.04-1.05]
Desk clean	very clean	0.02%	0.02%	0.04%
	fairly clean	1.01 [1-1.03]	0.97 [0.95-0.99]	0.86 [0.84-0.89]
	fairly messy	0.96 [0.94-0.97]	0.92 [0.9-0.94]	0.85 [0.83-0.87]
	very messy	0.92 [0.92-0.92]	0.88 [0.88-0.88]	0.81 [0.81-0.81]
Seasonal allergies	no allergy	0.02%	0%	0.07%
	has seasonal allergy	0.92 *** [0.92-0.93]	1.02 [1.02-1.02]	0.84 *** [0.84-0.84]
Total deviance explained:		21.65%	19.95%	19.81%
Numbers of cases - controls:		14874/88026	7472/95428	3994/98906

Supplementary Table 10: Variants identified by GWAS performed on the training set, and used in the PRS for each three skin cancer.

Variant genomic positions from hg19 build.

Basal cell carcinoma						
Variant ID	Chr	Pos	Non-risk allele	Risk allele	Genes	Coefficient
rs2476601	1	114377568	A	G	PTPN22	0.0873
rs74520550	1	155006450	A	C	DCST1	-0.0754
rs60960598	1	17744532	-	T	RCC2	0.1308
rs61824911	1	228979737	A	G	RHOA,TMEM78	0.0843
rs12568757	1	150729793	A	G	CTSS	-0.0587
rs2349073	2	202186986	A	C	ALS2CR12	0.1199
rs6707137	2	88554351	A	G	THNSL2,FOXI3	0.1529
rs16982253	2	16498408	C	T	MYCN,FAM49A	0.1244
rs831544	2	74125261	A	C	ACTG2	0.0321
rs10932028	2	204793063	A	C	CTLA4,ICOS	-0.0519
rs143325404	2	38308857	C	G	CYP1B1,ATL2	0.0584
rs11720317	3	20619752	C	T	SGO1,ZNF385D	0.0381
rs13076312	3	188089254	C	T	LPP	-0.0759
rs57929572	3	71563561	C	T	FOXP1	0.1015
rs401681	5	1322087	C	T	CLPTM1L	-0.1018
rs727685	5	115968619	C	G	SEMA6A	-0.0402
rs16891982	5	33951693	C	G	SLC45A2	0.5672
rs115293868	6	32649308	A	G	HLA-DQB1,HLA-DQA2	-0.101
rs12203592	6	396321	C	T	IRF4	0.4187
rs56353819	6	91012867	C	T	BACH2,MAP3K7	-0.0794
rs2016246	7	129431529	C	T	NRF1,UBE2H	0.0254
rs73183650	7	101421000	A	T	MYL10,CUX1	-0.0988
rs62445146	7	17088083	C	G	AGR3,AHR	0.0922
rs17431544	8	77467488	G	T	HNF4G,ZFXH4	0.1676
rs3901080	8	81410116	G	T	ZBTB10	0.0764
rs28792460	8	101007669	A	G	RGS22	-0.1629
rs55987622	8	126481470	C	T	TRIB1	0.0874
rs13300853	9	16901228	C	T	BNC2,CNTLN	-0.1069
rs2518723	9	21995882	C	T	RP11-145E5.5	0.0944
rs57288860	9	106973791	-	T	SMC2,OR13F1	-0.0619
rs7067933	10	90615570	C	G	ANKRD22,STAMBPL1	0.0452
rs77097907	10	8946470	A	C	GATA3	0.1933
rs2193	11	3870799	A	G	RHOA,STIM1	0.0761
rs12575636	11	95311260	G	T	SESN3,FAM76B	0.0762
rs1126809	11	89017961	A	G	TYR	-0.171
rs11023815	11	16007239	C	G	SOX6	0.0596
rs200633324	12	52898782	-	TTC	KRT6A,KRT5	0.0951
rs75273011	12	47030440	A	T	SLC38A2,SLC38A4	-0.057
rs1577900	13	100766817	A	G	PCCA	-0.0616
rs2526887	14	71355048	A	G	MAP3K9,PCNX1	0.0307
rs1129038	15	28356859	C	T	HERC2	0.1253
rs1805007	16	89986117	C	T	MC1R	0.3374
rs6059655	20	32665748	A	A	ASIP	-0.2945
rs75653149	20	34726973	A	C	CNBD2,EPB41L1	-0.0145
rs214803	20	2290333	A	C	TGM3	0.157
rs2849699	21	43089086	C	G	TMPRSS2,RIPK4	-0.0761
rs5932909	23	130553877	A	T	IGSF1,OR13H1	0.0594
Squamous cell carcinoma						
Variant ID	Chr	Pos	Non-risk allele	Risk allele	Genes	Coefficient
rs2352551	2	204794757	C	T	CTLA4,ICOS	-0.1
rs3773031	3	29535317	A	G	RP11-9J18.1,RBMS3	-0.037
rs16891982	5	33951693	C	G	SLC45A2	0.5177
rs116687190	6	32652865	C	T	HLA-DQB1,HLA-DQA2	-0.0862
rs12203592	6	396321	C	T	IRF4	0.4163
rs16939289	8	77437038	A	T	HNF4G,ZFXH4	-0.136
rs868764	9	129281648	A	G	MVB12B,LMX1B	0.0572
rs7025549	9	16881256	G	T	BNC2,CNTLN	-0.1028
rs1126809	11	89017961	A	G	TYR	-0.1575
rs896513	12	130240775	C	T	TMEM132D	-0.0072
rs201156703	16	90052186	-	TA	MC1R	-0.4271
rs12456267	18	49148119	A	T	MEX3C,DCC	-0.0717
rs75653149	20	34726973	A	C	CNBD2,EPB41L1	-0.0402
rs6059655	20	32665748	A	G	ASIP	-0.2663
Melanoma						
Variant ID	Chr	Pos	Non-risk allele	Risk allele	Genes	Coefficient
rs2791368	1	245918151	C	T	SMYD3	0.0914
rs907188	1	226612826	G	T	PARP1,STUM	-0.126
rs4235327	4	25026034	G	T	LGI2	-0.0549
rs16891982	5	33951693	C	G	SLC45A2	0.4679
rs7712562	5	1296072	A	G	TERT,CLPTM1L	-0.1498
rs201414626	7	28209954	-	AT	JAZF1	-0.0635
chr9:21808605	9	21808606	-	C	MTAP,RP11-145E5.5	0.1402
rs75387125	10	89931260	C	T	PTEN,RNLS	-0.3006
rs4432037	11	57103797	C	T	SSRP1,P2RX3	0.0359
rs1126809	11	89017961	A	A	TYR	-0.139
rs4899263	14	69285264	A	G	ZFP36L1,ACTN1	-0.0431
rs35083644	14	29547008	C	T	FOXG1,PRKD1	-0.0404
rs200180665	15	94068177	-	G	AC112693.2,MCTP2	0.1404
rs4778138	15	28335820	A	G	HERC2	-0.1732
rs1805007	16	89986117	C	T	MC1R	0.4361
rs56238684	20	33236696	C	G	ASIP	-0.2889
rs75653149	20	34726973	A	C	CNBD2,EPB41L1	-0.0263
rs2824133	21	18292297	A	G	CXADR	-0.0849

Supplementary Table 12: General linear model (GLM with binomial response) results for pairwise interaction analysis between risk scores.

Only interactions with P-value < 0.1 are reported.

Basal cell carcinoma					
	Estimate	Std. Error	z value	P value	Deviance explained
(Intercept)	-24.482	0.893	-27.41	2.0e-165	
Age	0.138	0.009	16.04	6.9e-58	9.52%
Sex	0.516	0.214	2.41	1.6e-02	0.04%
Ancestry	3.849	0.475	8.09	5.7e-16	0.58%
PRS	1.854	0.194	9.58	1.0e-21	3.41%
Family history of skin cancer	1.421	0.211	6.73	1.7e-11	1.4%
Mole	10.417	1.058	9.84	7.3e-23	3.42%
Susceptibility	9.077	0.871	10.43	1.9e-25	1.03%
Exposure	8.425	0.94	8.96	3.2e-19	1.6%
Age:Sex	-0.009	0.002	-5.04	4.6e-07	0.03%
Age:PRS	-0.007	0.002	-3.58	3.4e-04	0.01%
Age:Family history of skin cancer	-0.003	0.002	-2.11	3.5e-02	0%
Age:Mole	-0.045	0.008	-5.7	1.2e-08	0.03%
Age:Exposure	-0.032	0.011	-3.07	2.2e-03	0.01%
Sex:Family history of skin cancer	-0.112	0.035	-3.24	1.2e-03	0.02%
Sex:Mole	0.366	0.186	1.97	4.9e-02	0%
Sex:Susceptibility	-0.861	0.246	-3.5	4.6e-04	0.02%
PRS:Family history of skin cancer	-0.079	0.035	-2.27	2.3e-02	0.01%
PRS:Susceptibility	-1.043	0.243	-4.29	1.8e-05	0.02%
Family history of skin cancer:Susceptibility	-0.359	0.209	-1.72	8.5e-02	0%
Family history of skin cancer:Exposure	-0.599	0.193	-3.1	1.9e-03	0.01%
Mole:Susceptibility	-3.371	1.085	-3.11	1.9e-03	0.01%
Mole:Exposure	-3.377	1.077	-3.14	1.7e-03	0.01%

Squamous cell carcinoma					
	Estimate	Std. Error	z value	P value	Deviance explained
(Intercept)	-22.98	1.522	-15.1	1.6e-51	
Age	0.124	0.006	19.41	6.4e-84	10.39%
Sex	0.222	0.226	0.98	3.3e-01	0.07%
Ancestry	12.822	2.876	4.46	8.3e-06	0.89%
PRS	0.3	0.21	1.43	1.5e-01	1.61%
Family history of skin cancer	0.516	0.032	15.88	9.1e-57	1.25%
Mole	8.511	0.79	10.77	4.8e-27	2.77%
Susceptibility	12.62	2.719	4.64	3.5e-06	1.08%
Exposure	4.703	0.312	15.09	1.8e-51	1.39%
Age:Sex	-0.011	0.002	-4.37	1.3e-05	0.04%
Age:Mole	-0.067	0.012	-5.79	6.9e-09	0.07%
Sex:Family history of skin cancer	-0.209	0.041	-5.07	3.9e-07	0.05%
Sex:Mole	0.326	0.262	1.24	2.1e-01	0%
Ancestry:Susceptibility	-16.969	5.367	-3.16	1.6e-03	0.02%
PRS:Exposure	0.66	0.402	1.64	1.0e-01	0.01%

Melanoma					
	Estimate	Std. Error	z value	P value	Deviance explained
(Intercept)	-19.447	0.731	-26.62	4.4e-156	
Age	0.099	0.005	20.97	1.2e-97	3.27%
Sex	0.511	0.331	1.54	1.2e-01	0.2%
Ancestry	3.946	0.738	5.35	8.9e-08	0.2%
PRS	0.207	1.116	0.19	8.5e-01	2.03%
Family history of skin cancer	0.42	0.093	4.52	6.1e-06	0.47%
Mole	11.142	0.864	12.9	4.4e-38	11.8%
Susceptibility	4.656	0.311	14.96	1.3e-50	0.9%
Exposure	6.83	0.996	6.86	6.9e-12	0.51%
Age:Sex	-0.014	0.003	-4.98	6.3e-07	0.14%
Age:Mole	-0.07	0.007	-10.55	5.0e-26	0.38%
Sex:PRS	0.167	0.106	1.58	1.1e-01	0%
Sex:Family history of skin cancer	-0.143	0.056	-2.56	1.0e-02	0.03%
Sex:Mole	0.948	0.166	5.7	1.2e-08	0.08%
Sex:Susceptibility	-1.345	0.434	-3.1	1.9e-03	0.03%
Ancestry:PRS	3.919	2.171	1.81	7.1e-02	0.01%
PRS:Susceptibility	-2.555	0.583	-4.38	1.2e-05	0.06%
Family history of skin cancer:Mole	-0.292	0.129	-2.26	2.4e-02	0.02%
Mole:Exposure	-4.407	1.423	-3.1	2.0e-03	0.03%

Supplementary Table 13: General linear model (GLM with binomial response) results for pairwise interaction analysis using the factor with larger effect in each risk score.

Only interactions with P-value < 0.1 are reported.

Basal cell carcinoma						
	Estimate	Std. Error	z value	P value	Deviance explained	
(Intercept)	-17.172	0.674	-25.47	3.8e-143		
Age	0.117	0.006	18.24	2.4e-74	9.52%	
Sex	0.239	0.19	1.26	2.1e-01	0.04%	
Ancestry	4.878	0.465	10.48	1.0e-25	0.58%	
PRS	1.871	0.186	10.06	8.4e-24	3.41%	
Family history of skin cancer	1.223	0.16	7.64	2.2e-14	1.4%	
Dysplastic moles	2.2	0.224	9.82	9.4e-23	2.73%	
Skin color	-0.6	0.083	-7.22	5.3e-13	0.28%	
Sunbathing frequency before age 30	0.725	0.081	8.92	4.5e-19	1.12%	
BMI	0.017	0.012	1.39	1.7e-01	0.31%	
Age:Sex	-0.009	0.002	-4.69	2.7e-06	0.04%	
Age:PRS	-0.007	0.002	-3.9	9.8e-05	0.01%	
Age:Family history of skin cancer	-0.003	0.002	-2.19	2.8e-02	0%	
Age:Dysplastic moles	-0.009	0.002	-4.71	2.5e-06	0.02%	
Age:Sunbathing frequency before age 30	-0.003	0.001	-3.47	5.2e-04	0.01%	
Sex:Family history of skin cancer	-0.108	0.034	-3.17	1.5e-03	0.02%	
Sex:Dysplastic moles	0.179	0.047	3.78	1.6e-04	0.01%	
Sex:Skin color	0.081	0.027	3	2.7e-03	0.01%	
Sex:BMI	-0.012	0.004	-3.06	2.2e-03	0.02%	
PRS:Family history of skin cancer	-0.091	0.033	-2.75	6.0e-03	0.01%	
PRS:Dysplastic moles	-0.183	0.049	-3.76	1.7e-04	0.02%	
PRS:Skin color	0.062	0.027	2.33	2.0e-02	0.01%	
PRS:BMI	-0.009	0.004	-2.25	2.4e-02	0%	
Family history of skin cancer:Dysplastic moles	-0.087	0.035	-2.49	1.3e-02	0.01%	
Family history of skin cancer:Sunbathing frequency before age 30	-0.032	0.015	-2.13	3.3e-02	0.01%	
Dysplastic moles:Skin color	0.083	0.031	2.66	7.9e-03	0%	
Dysplastic moles:Sunbathing frequency before age 30	-0.08	0.022	-3.64	2.7e-04	0.02%	
Sunbathing frequency before age 30:BMI	-0.004	0.002	-2.52	1.2e-02	0.01%	

Squamous cell carcinoma						
	Estimate	Std. Error	z value	P value	Deviance explained	
(Intercept)	-10.476	0.875	-11.97	5.4e-33		
Age	0.111	0.005	21.51	1.2e-102	10.39%	
Sex	0.525	0.198	2.66	7.9e-03	0.07%	
Ancestry	1.522	1.465	1.04	3.0e-01	0.89%	
PRS	1.164	0.105	11.1	1.3e-28	1.61%	
Family history of skin cancer	0.922	0.119	7.74	9.9e-15	1.25%	
Dysplastic moles	1.284	0.261	4.92	8.8e-07	1.85%	
Skin color	-1.015	0.351	-2.89	3.8e-03	0.38%	
Sunbathing frequency before age 30	0.266	0.013	21.2	1.0e-99	0.94%	
BMI	-0.025	0.009	-2.86	4.2e-03	0.17%	
Age:Sex	-0.013	0.002	-5.21	1.9e-07	0.05%	
Age:Dysplastic moles	-0.014	0.003	-5.39	7.1e-08	0.05%	
Age:Skin color	-0.004	0.002	-2.62	8.8e-03	0.01%	
Sex:Family history of skin cancer	-0.194	0.041	-4.77	1.8e-06	0.04%	
Sex:Dysplastic moles	0.135	0.059	2.3	2.1e-02	0.01%	
Ancestry:Skin color	1.751	0.654	2.68	7.4e-03	0.01%	
PRS:Dysplastic moles	-0.248	0.077	-3.21	1.3e-03	0.03%	
Family history of skin cancer:Dysplastic moles	-0.107	0.042	-2.57	1.0e-02	0.01%	
Family history of skin cancer:BMI	-0.008	0.004	-2.12	3.4e-02	0.01%	
Dysplastic moles:Skin color	0.069	0.04	1.75	8.1e-02	0.01%	
Dysplastic moles:BMI	0.01	0.005	1.88	6.0e-02	0.01%	

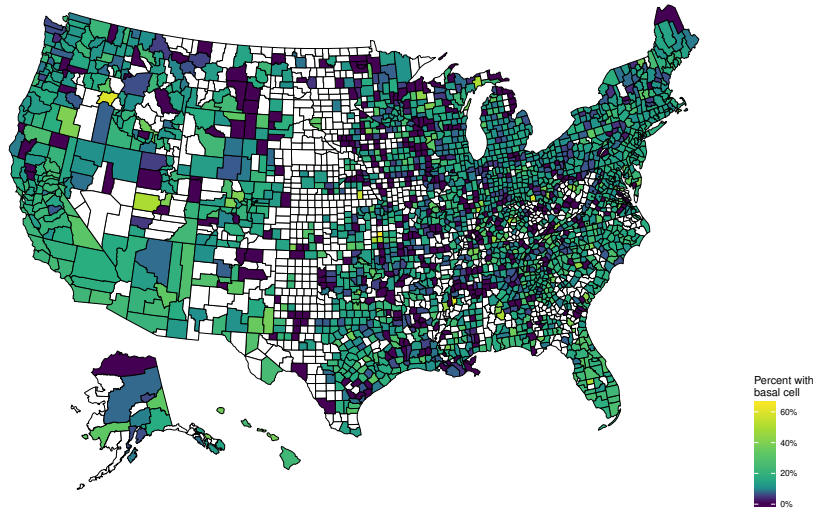
Melanoma						
	Estimate	Std. Error	z value	P value	Deviance explained	
(Intercept)	-13.774	0.536	-25.67	2.2e-145		
Age	0.093	0.005	19.65	6.4e-86	3.27%	
Sex	-0.204	0.255	-0.8	4.2e-01	0.2%	
Ancestry	4.055	0.72	5.63	1.8e-08	0.2%	
PRS	0.74	0.144	5.12	3.0e-07	2.03%	
Family history of skin cancer	0.489	0.093	5.25	1.6e-07	0.47%	
Dysplastic moles	3.933	0.208	18.9	1.1e-79	11.26%	
Skin color	-0.226	0.073	-3.1	1.9e-03	0.27%	
Sunbathing frequency before age 30	0.224	0.047	4.71	2.5e-06	0.31%	
BMI	-0.002	0.003	-0.57	5.7e-01	0%	
Age:Sex	-0.016	0.003	-5.77	8.1e-09	0.17%	
Age:Dysplastic moles	-0.029	0.003	-10.31	6.6e-25	0.38%	
Sex:Family history of skin cancer	-0.139	0.055	-2.52	1.2e-02	0.02%	
Sex:Dysplastic moles	0.395	0.071	5.58	2.4e-08	0.09%	
Sex:Skin color	0.145	0.048	3.04	2.4e-03	0.02%	
PRS:Skin color	0.142	0.065	2.17	3.0e-02	0.02%	
Family history of skin cancer:Dysplastic moles	-0.134	0.055	-2.43	1.5e-02	0.02%	
Skin color:Sunbathing frequency before age 30	-0.03	0.021	-1.42	1.6e-01	0.01%	

Supplementary Table 14: Risk factor weights for DRS and DRSA computation

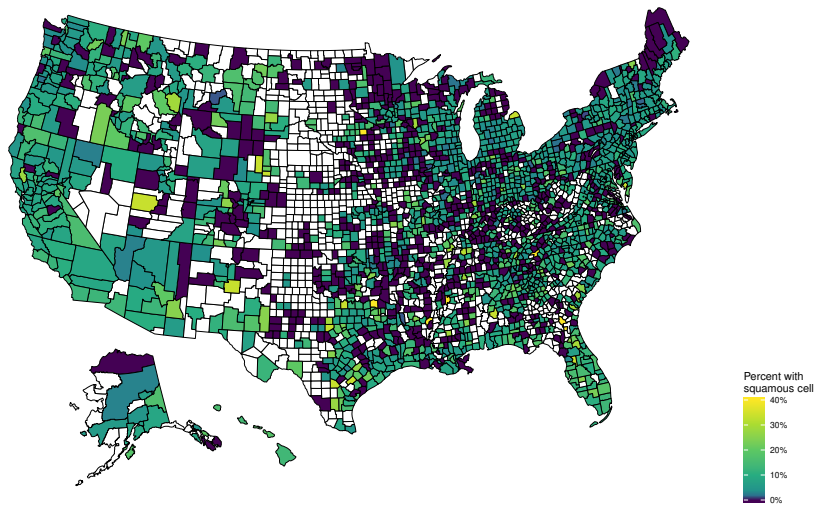
Risk factor	BCC	SCC	Melanoma
Age	0.0761	0.0823	0.0461
Sex (M)	0.1526	-0.4404	0.0333
Sex (F)	-0.0909	-0.7604	-0.3717
PC1	-0.5256	0.0642	-0.9599
PC2	3.4687	4.24	2.2686
PC3	-2.2573	-2.8384	-1.2158
PC4	-2.628	-4.4661	-5.2706
PC5	0.3858	0.1474	1.2237
PRS	0.5998	0.6454	0.96
Dysplastic moles (no)	-0.1356	-0.7474	-0.4968
Dysplastic moles (yes)	0.8127	0.0403	1.4048
Family history of skin cancer (Risk 0)	-0.0756	-0.7025	-0.2294
Family history of skin cancer (Risk 1)	0.3348	-0.3458	-0.074
Family history of skin cancer (Risk 2)	0.7509	0.0578	-0.0068
Family history of skin cancer (Risk 3)	1.183	0.4386	0.1498
Skin color (extremely fair)	0.1119	-0.4854	-0.1298
Skin color (light)	0.0651	-0.5723	-0.1491
Skin color (medium)	-0.0623	-0.7397	-0.323
Skin color (olive)	-0.2665	-0.8405	-0.2489
Freckling tendency (none)	-0.1111	-0.7609	-0.3509
Freckling tendency (few)	-0.0079	-0.6488	-0.2099
Freckling tendency (lots)	0.1656	-0.4448	-0.0163
Freckling tendency (many)	0.3713	-0.257	0.0923
Sunbathing frequency before age of 30 (never)	-0.3284	-0.908	-0.2803
Sunbathing frequency before age of 30 (rarely)	-0.273	-0.8701	-0.3669
Sunbathing frequency before age of 30 (sometimes)	0.0081	-0.6658	-0.2461
Sunbathing frequency before age of 30 (frequently)	0.2344	-0.3942	-0.0475
Sunbathing frequency before age of 30 (very frequently)	0.4506	-0.2147	0.0767
Actinic keratosis before age of 40 (no)	-0.0024	-0.6406	-0.2031
Actinic keratosis before age of 40 (yes)	1.1447	0.5988	0.0996
Adulthood latitude	-0.0268	-0.0268	-0.0054
BMI	-0.0482	-0.032	-0.0256
Blisters caused by sunburns (0)	-0.1421	-0.8226	-0.2621
Blisters caused by sunburns (1-2)	-0.0302	-0.6286	-0.263
Blisters caused by sunburns (3-4)	0.0688	-0.5259	-0.1644
Blisters caused by sunburns (5+)	0.1883	-0.4889	-0.0774
Skin response to 3-4 hours of sun exposure (always burns)	0.2101	-0.3918	0.0647
Skin response to 3-4 hours of sun exposure (usually burns)	0.1688	-0.4576	-0.0673
Skin response to 3-4 hours of sun exposure (sometimes burns tans)	-0.0076	-0.6564	-0.2345
Skin response to 3-4 hours of sun exposure (rarely burns)	-0.1939	-0.8387	-0.4035
Skin response to 3-4 hours of sun exposure (never burns)	-0.2509	-0.8533	-0.1847
Physical activity (no)	-0.0563	-0.66	-0.2003
Physical activity (highly active)	0.051	-0.6043	-0.1984
Typical sun exposure per week (in min.)	1.209e-04	-1.418e-04	1.709e-04
Alcohol consumption (no or (low) consumption)	-0.0678	-0.6978	-0.2185
Alcohol consumption (intermediate consumption)	0.0619	-0.5868	-0.1698
Alcohol consumption (abuser)	0.0312	-0.5951	-0.2238
Weight	0.0051	0.0038	0.0035
Hair color (light blond)	0.2351	-0.4749	0.0574
Hair color (dark blond)	0.1371	-0.5559	-0.1532
Hair color (red)	0.1474	-0.5258	0.0489
Hair color (light brown)	0.0031	-0.6248	-0.2223
Hair color (dark brown)	-0.0594	-0.6678	-0.2616
Hair color (black)	-0.212	-0.826	-0.1578
Eye color (blue)	0.01	-0.5477	-0.178
Eye color (blue gray)	-0.069	-0.6653	-0.2334
Eye color (gray)	-0.2449	-0.7631	-0.1373
Eye color (gray green)	-0.0043	-0.6758	-0.1471
Eye color (green)	0.0577	-0.5569	-0.1599
Eye color (light brown)	0.016	-0.6324	-0.2403
Eye color (medium brown)	0.0337	-0.6953	-0.2208
Eye color (dark brown black)	0.0459	-0.7094	-0.2809
Presence of large moles (no)	-0.0426	-0.6627	-0.2921
Presence of large moles (yes)	0.1298	-0.5428	-0.0032
Moles in your right arm (less than 3)	0.0356	-0.5682	-0.3243
Moles in your right arm (3 to 6)	-0.0349	-0.6706	-0.1917
Moles in your right arm (7 to 11)	-0.0273	-0.6933	-0.0075
Moles in your right arm (12 to 18)	-0.0798	-0.7987	0.1114
Moles in your right arm (19 to 28)	0.0586	-0.7178	0.1289
Moles in your right arm (29 to 39)	-0.0735	-0.7839	0.1842
Moles in your right arm (more than 39)	0.0894	-0.743	0.4471
Childhood latitude	-0.011	-0.0138	-0.0121
Sun hair lightening (very much)	0.0345	-0.5842	-0.1591
Sun hair lightening (somewhat)	-0.0168	-0.6795	-0.2777
Sun hair lightening (a little bit)	-0.01	-0.6428	-0.1978
Sun hair lightening (unchanged)	0.0553	-0.5722	-0.155
Skin response to sun exposure without sun protection (painful blister)	-0.0592	-0.6879	-0.2536
Skin response to sun exposure without sun protection (blister)	-0.0455	-0.7017	-0.1809
Skin response to sun exposure without sun protection (burns sometimes)	0.0457	-0.5899	-0.1929
Skin response to sun exposure without sun protection (rarely burns)	-0.01	-0.6435	-0.1917
Skin response to sun exposure without sun protection (never burns)	-0.2322	-0.8985	-0.1358
Tanning bed (never)	-0.0222	-0.667	-0.2315
Tanning bed (1-4times)	0.0231	-0.6267	-0.181
Tanning bed (5-10times)	0.0933	-0.5919	-0.2249
Tanning bed (11-20times)	0.1239	-0.542	-0.1294
Tanning bed (21-30times)	0.0438	-0.5803	-0.2345
Tanning bed (30+times)	0.0713	-0.4373	-0.0243
Outdoor job (no)	-0.0058	-0.641	-0.2187
Outdoor job (yes)	0.0788	-0.5643	-0.1298
Smoking (no)	0.0468	-0.6108	-0.1744
Smoking (yes)	-0.0363	-0.6433	-0.2349
Adulthood elevation	5.775e-05	2.366e-05	-1.586e-05
Morning person (night)	-0.0362	-0.673	-0.2205
Morning person (morning)	0.0579	-0.5791	-0.1794
Desk clean (very clean)	0.035	-0.5659	-0.0581
Desk clean (fairly clean)	0.0482	-0.5996	-0.2033
Desk clean (fairly messy)	-0.0085	-0.6453	-0.2214
Desk clean (very messy)	-0.0514	-0.6953	-0.2704
Seasonal allergies (no allergy)	0.0543	-0.6346	-0.1064
Seasonal allergies (has seasonal allergy)	-0.024	-0.6147	-0.2817

Supplementary Figure 1: Maps of BCC, SCC, and melanoma distributions in USA. The maps combined all data (training and validation sets) from 23andMe skin cancer cohorts. a) map for BCC, b) map for SCC, and c) map for melanoma

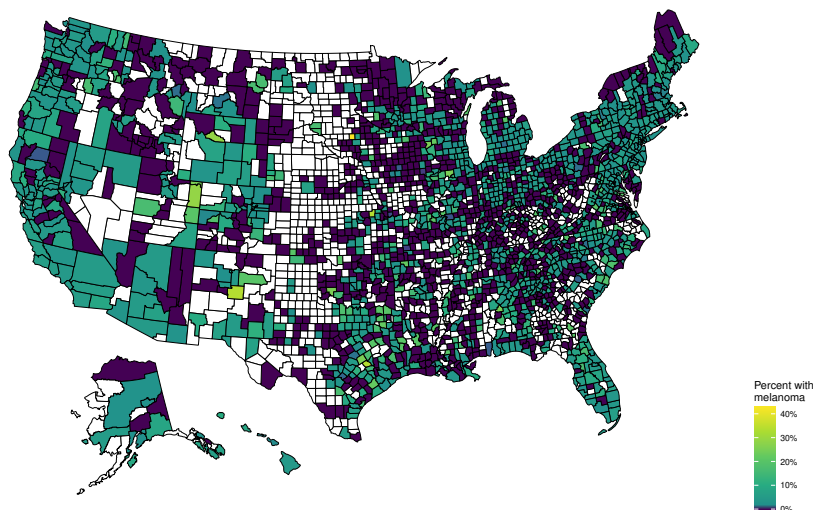
a) BCC



b) SCC

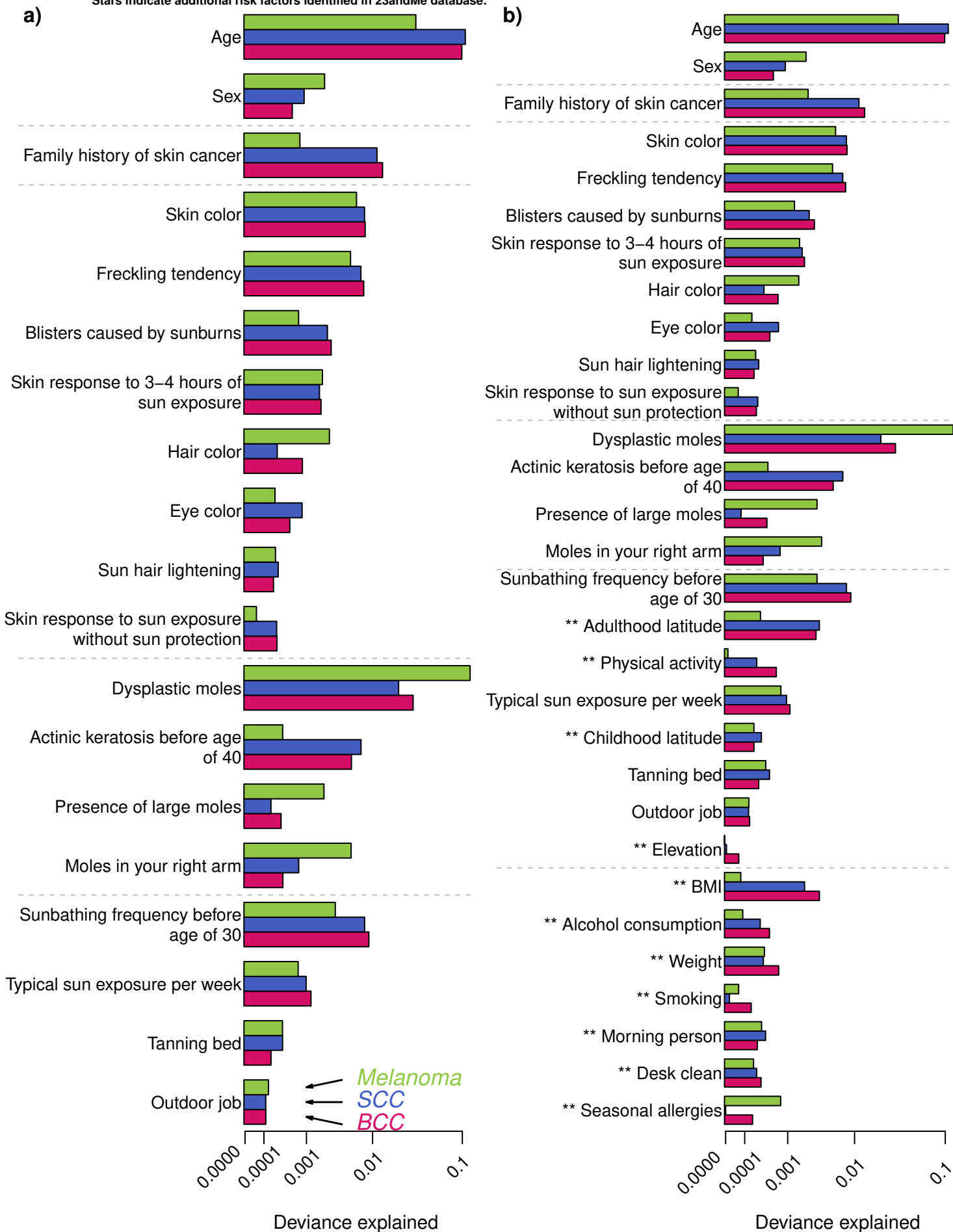


c) Melanoma

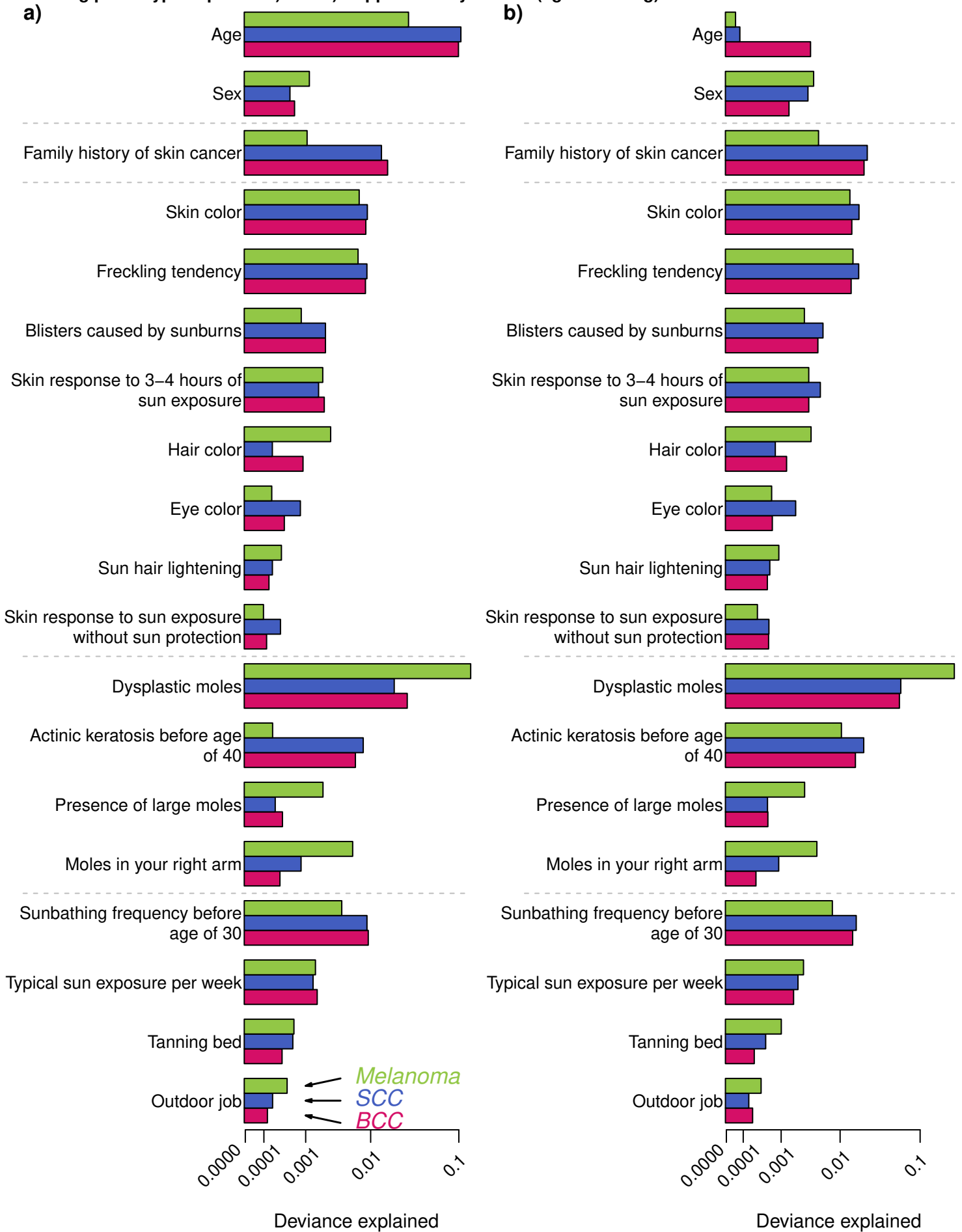


Supplementary Figure 2: Deviance explained from GLMs described in a) Supplementary Table 4 and b) Supplementary Table 8.

Stars indicate additional risk factors identified in 23andMe database.

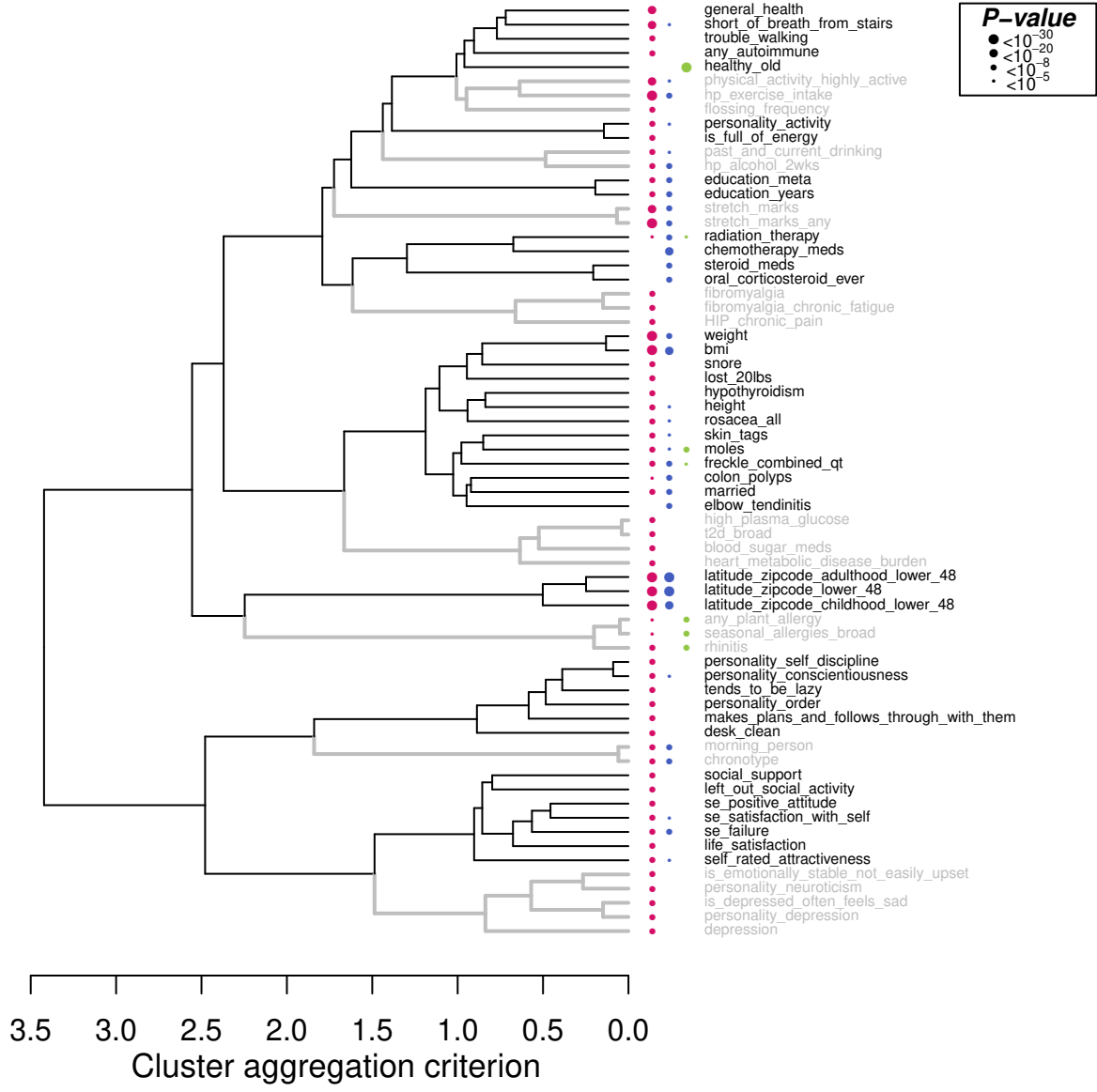


Supplementary Figure 3: Deviance explained from GLMs described in a) Supplementary Table 5 (no missing phenotype imputation) and b) Supplementary Table 6 (age matching)



Supplementary Figure 4: Cluster analysis of additional risk factors identified in 23andMe database.

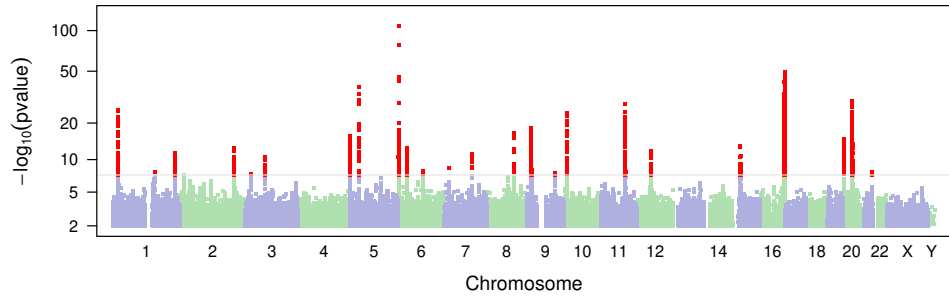
A total 608 phenotypes from 23andMe database were tested. We selected additional risk factors with P-value < 1e-8 criteria and clustered them using ClustOfVar library in R. The aggregation criterion is the decrease in homogeneity for the cluster being merged. The homogeneity of a cluster is the sum of the correlation ratio (for qualitative variables) and the squared correlation (for quantitative variables) between the variables and the center of the cluster which is the first principal component of PCAmix. PCAmix is defined for a mixture of qualitative and quantitative variables and includes ordinary principal component analysis (PCA) and multiple correspondence analysis (MCA) as special cases.



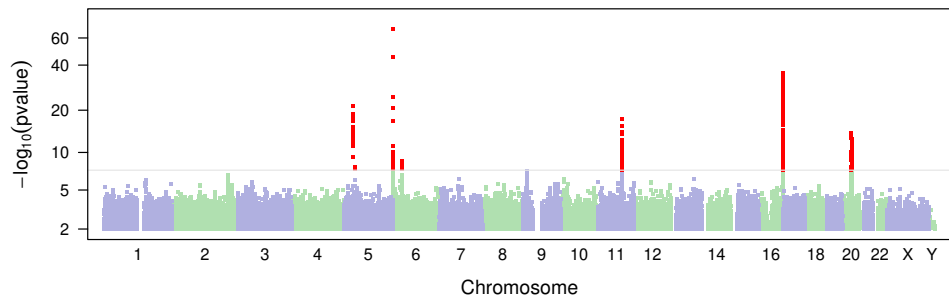
Supplementary Figure 5: Manhattan plots of each skin cancer GWAS (performed on the training set).

a) BCC GWAS, b) SCC GWAS, and c) melanoma GWAS.

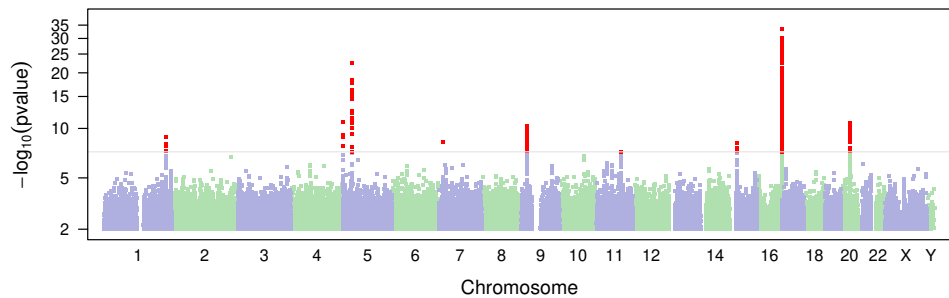
a) BCC



b) SCC

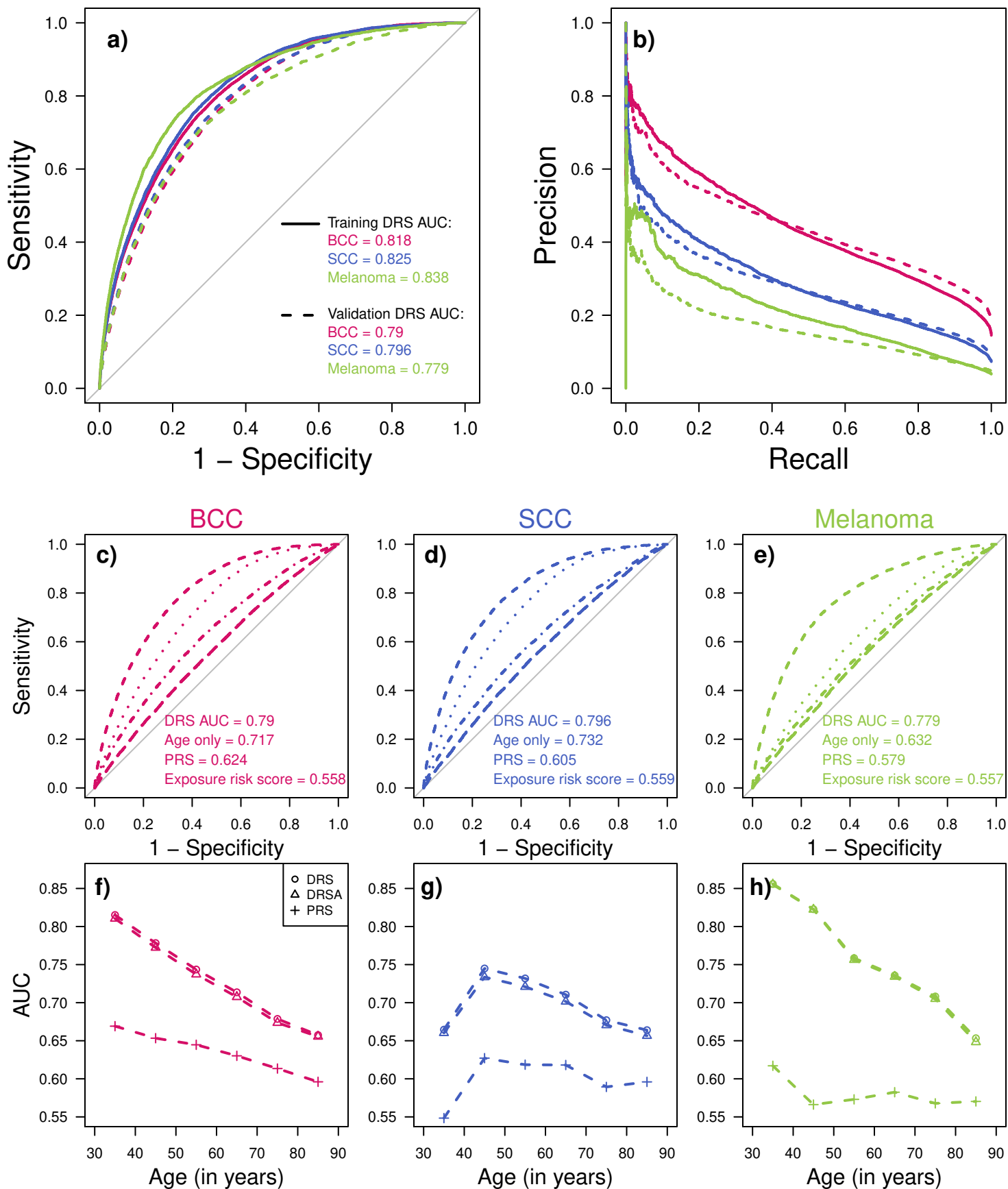


c) Melanoma

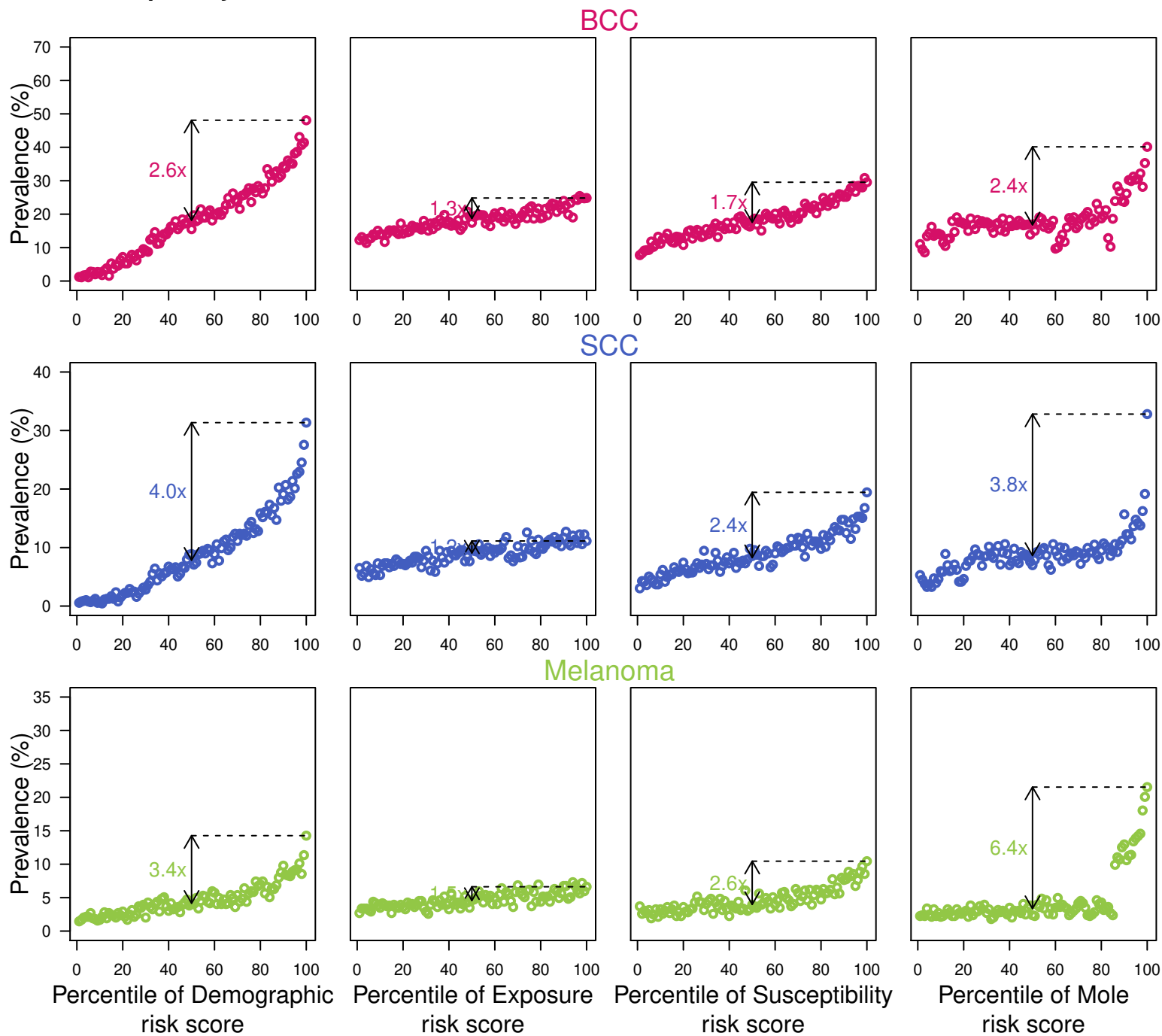


Supplementary Figure 6: Risk score performances in training and validation sets

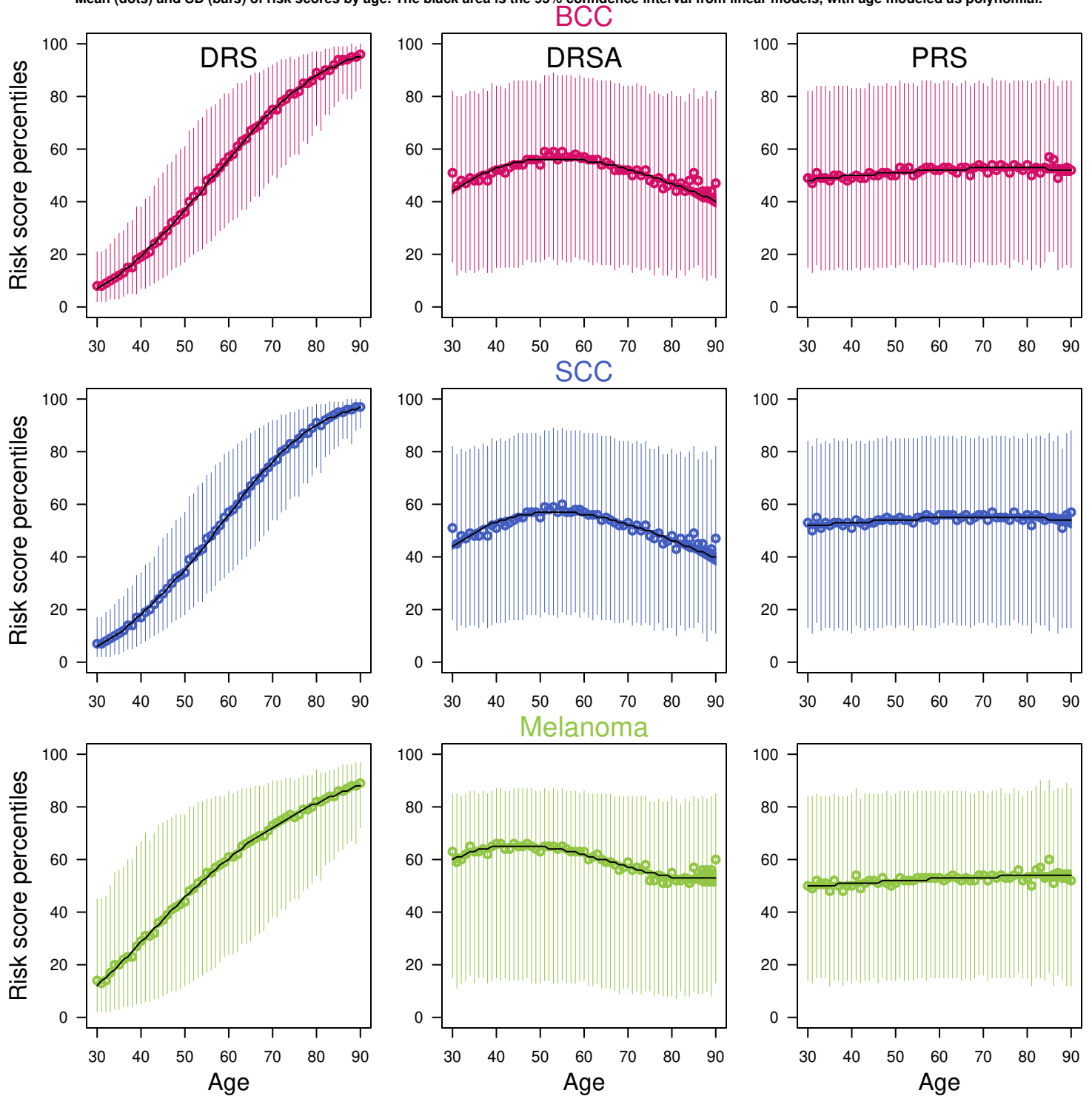
a) and b) ROC (+ AUC) and precision–recall curves for the Disease Risk Score (DRS) in the training and validation sets. c), d) and e) are AUCs in the validation set for BCC, SCC, and melanoma, respectively. AUC for DRS, age, PRS, and Exposure risk score are shown. f), g) and h) are AUCs in the validation set across the participants age.



Supplementary Figure 7: Prevalence of skin cancer cases across the Demographic, Exposure, Susceptibility, and Mole risk score distributions in the validation set.



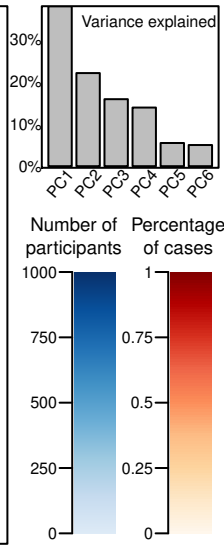
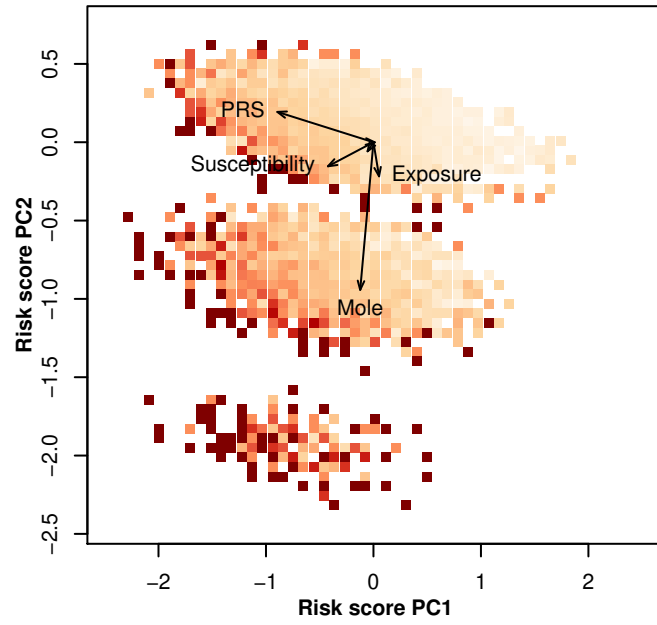
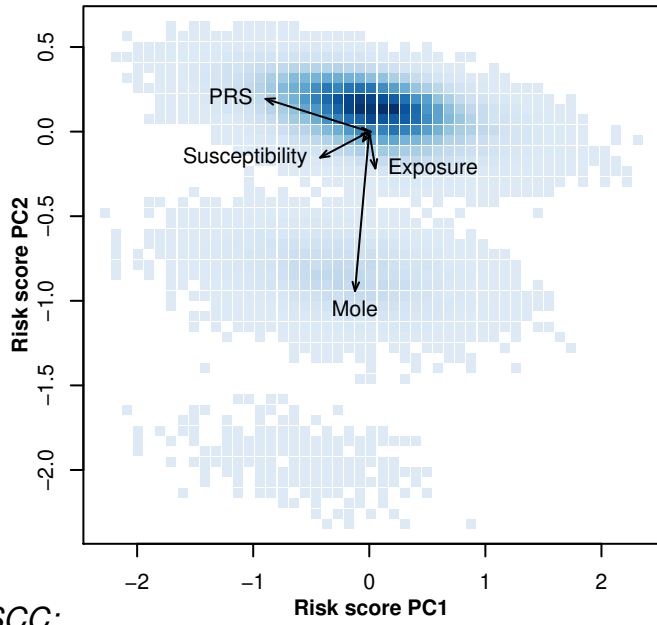
Supplementary Figure 8: DRS, DRSA and PRS distributions across the participant age at baseline in the validation set (103,008 participants, including 14,898 BCC, 7,479 SCC, and 3,998 melanoma cases). Mean (dots) and SD (bars) of risk scores by age. The black area is the 95% confidence interval from linear models, with age modeled as polynomial.



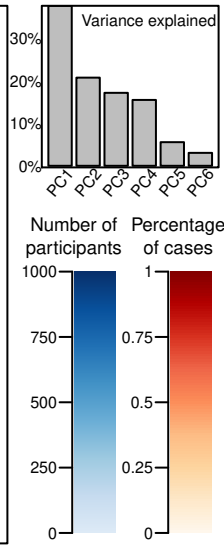
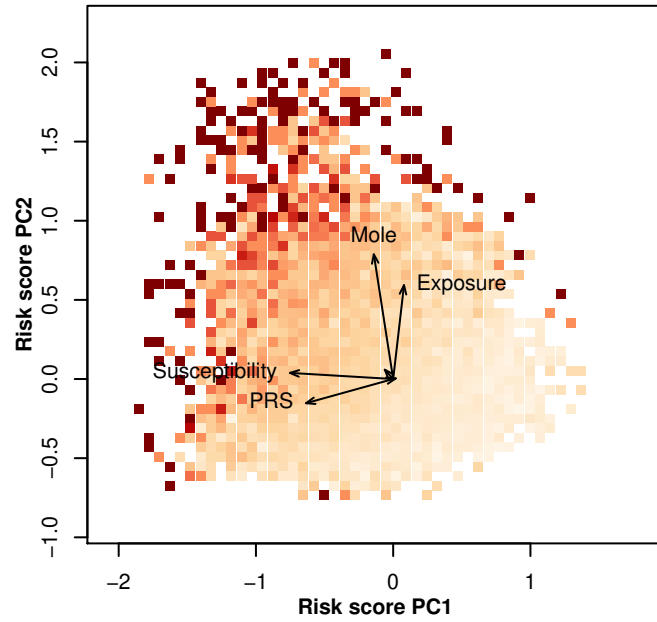
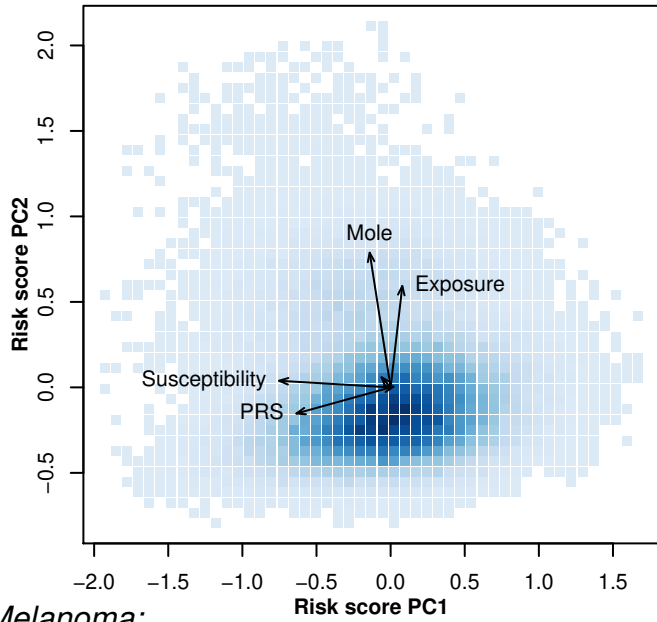
Supplementary Figure 9: Principal component analysis on PRS, Exposure, Susceptibility, Mole, Family, and Miscellaneous risk scores.

Right panel: all participants; Middle panel: skin cancer cases; Left panels: variance explained and legends of right and middle panels.

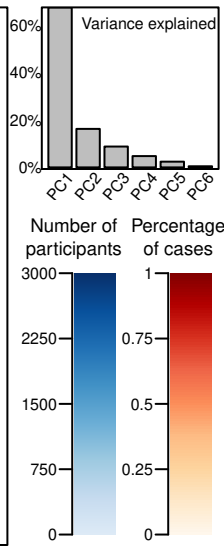
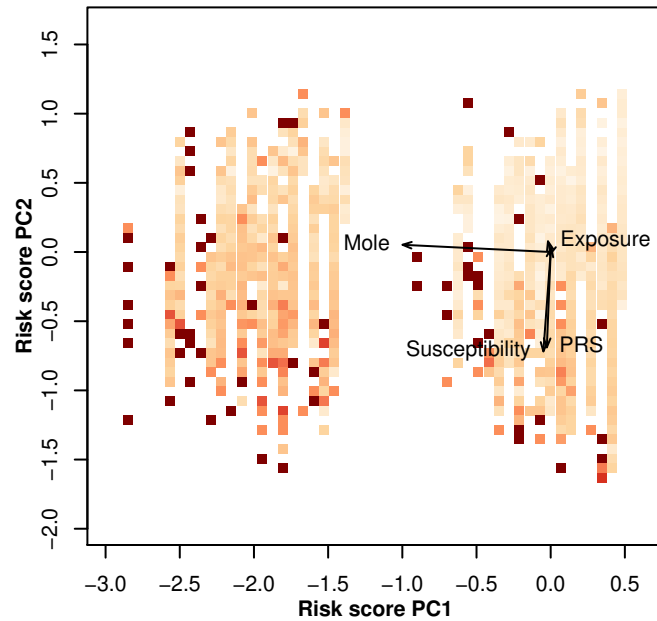
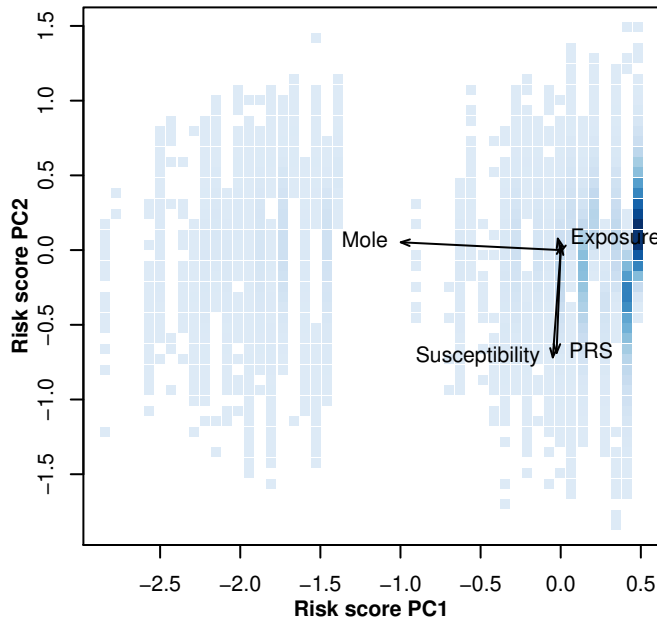
BCC:



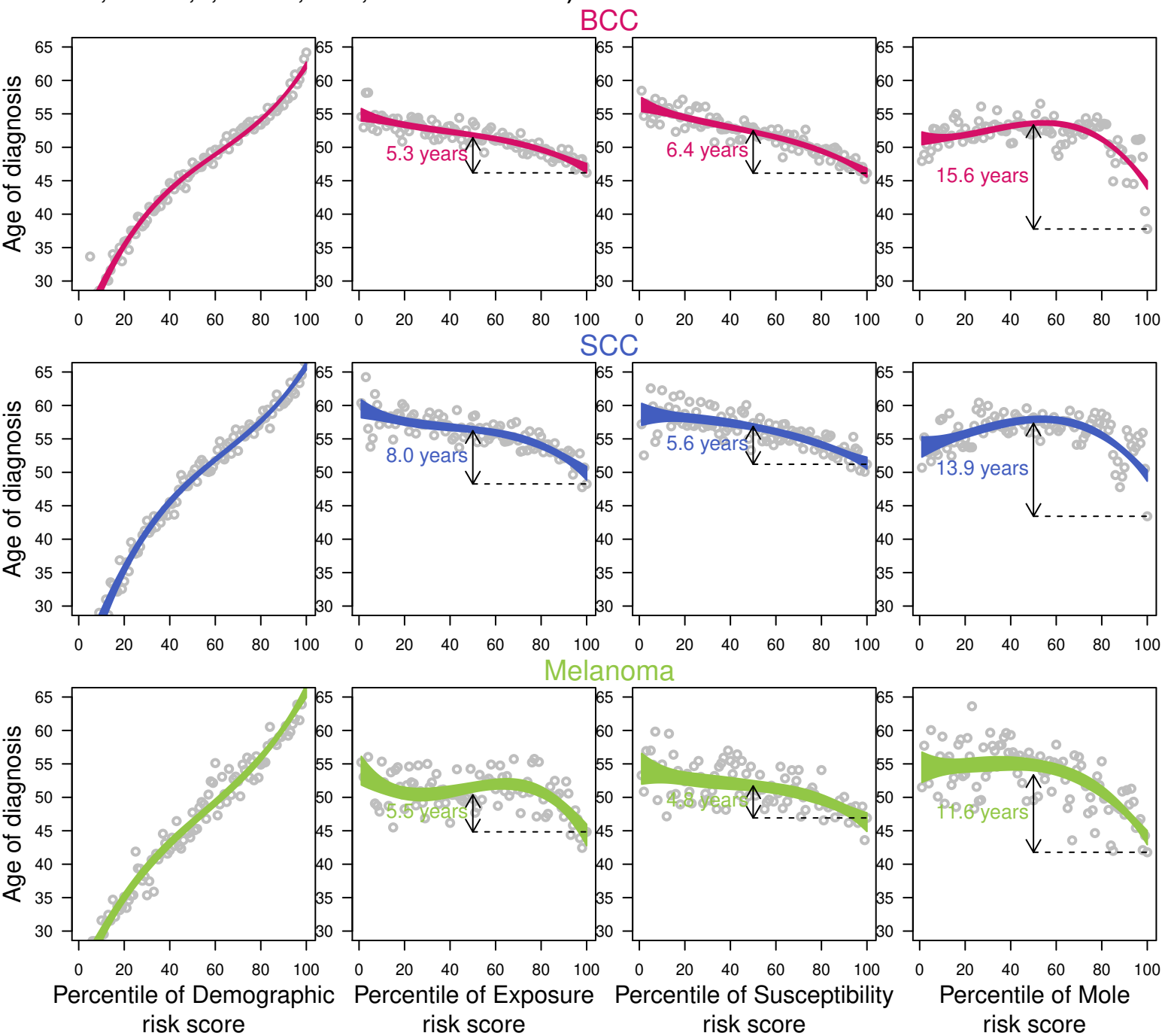
SCC:



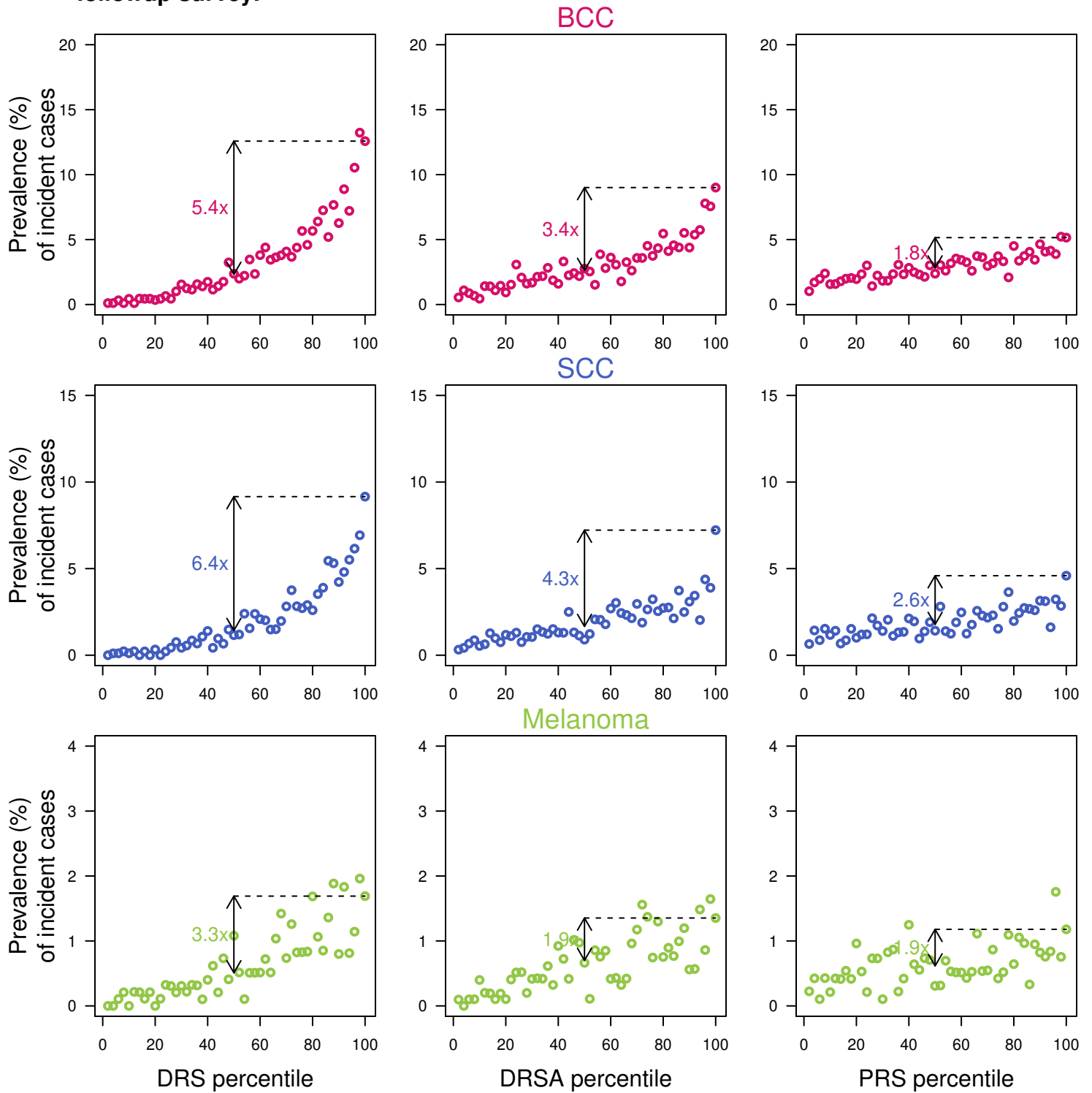
Melanoma:



Supplementary Figure 10: Mean age (and 95% CI) of skin cancer diagnosis across the Demographic, Exposure, Susceptibility, and Mole risk score distributions in the validation set (103,008 participants, including 14,898 BCC, 7,479 SCC, and 3,998 melanoma cases).

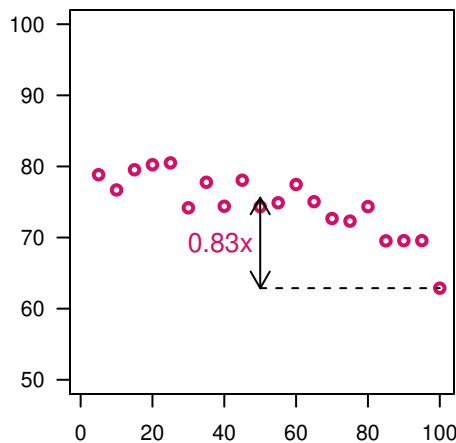
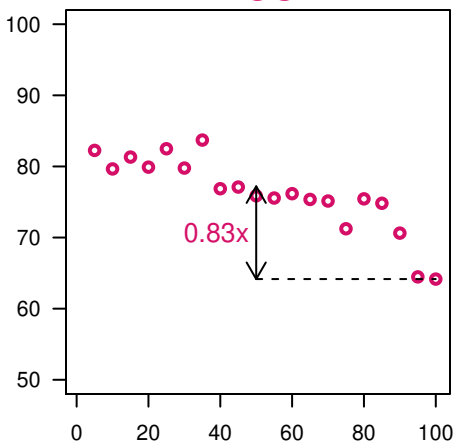
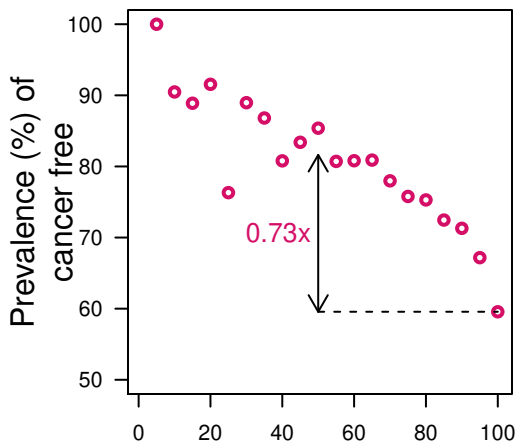


Supplementary Figure 11: Incident skin cancer cases in the validation set, from 2018 and 2019 followup survey.

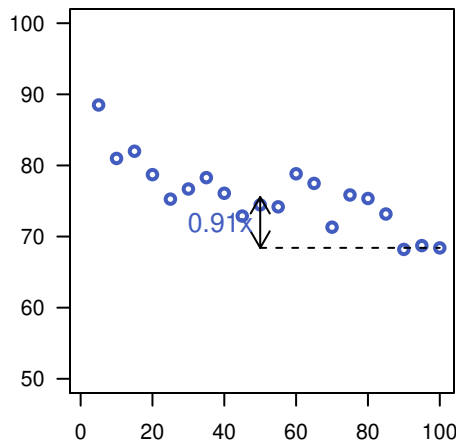
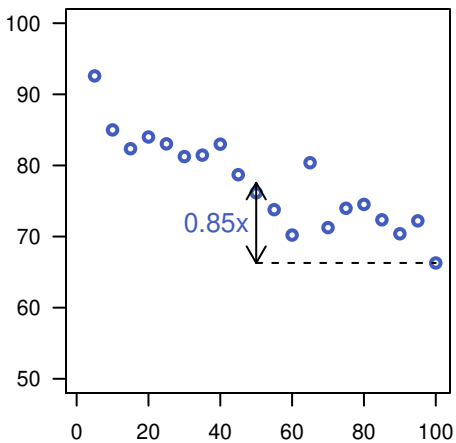
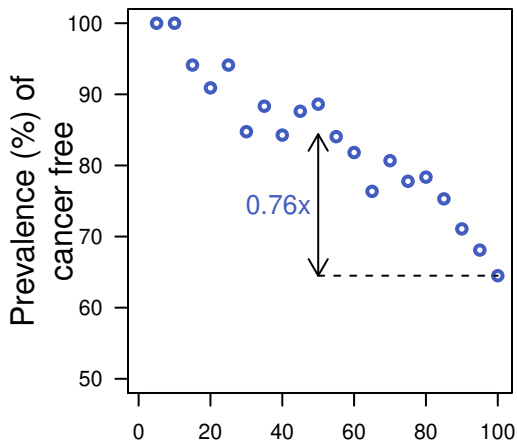


Supplementary Figure 12: Cancer free in the validation set, from 2018 and 2019 followup survey.

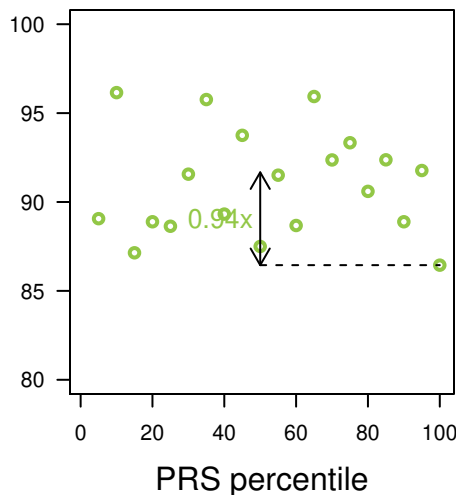
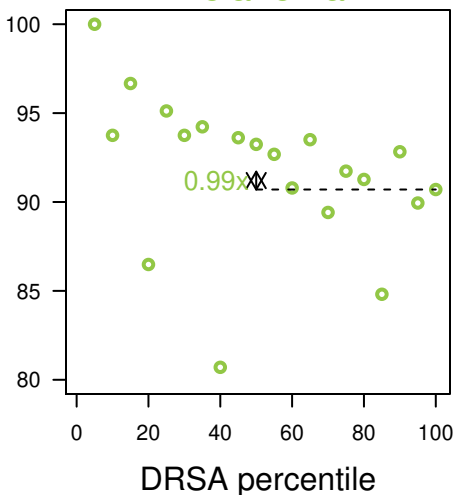
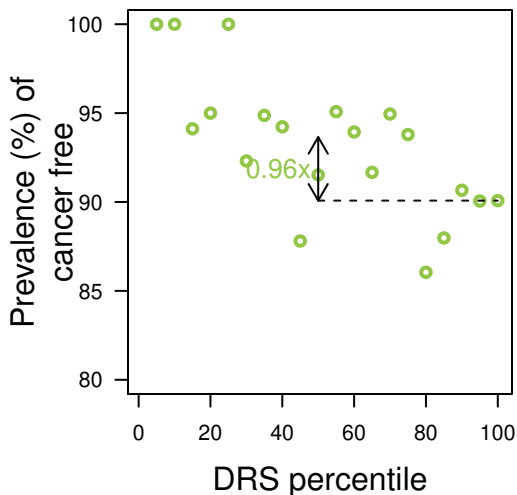
BCC



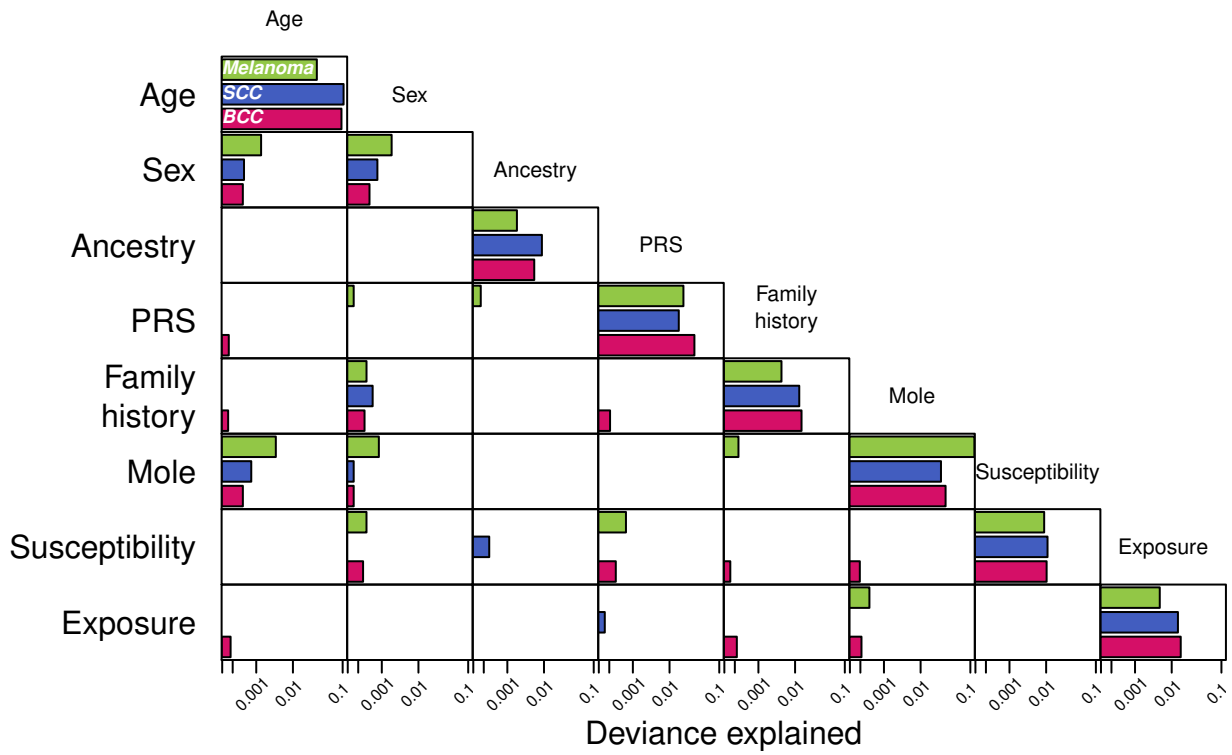
SCC



Melanoma

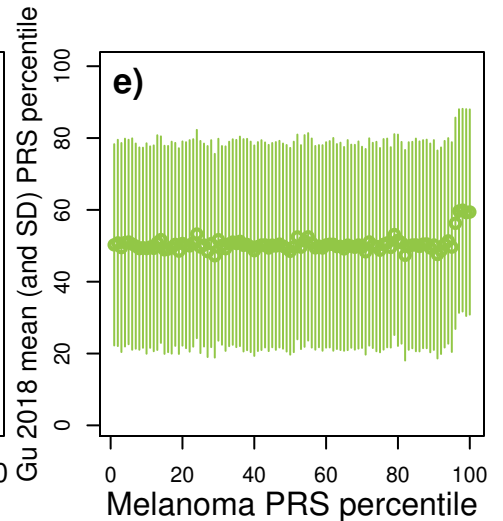
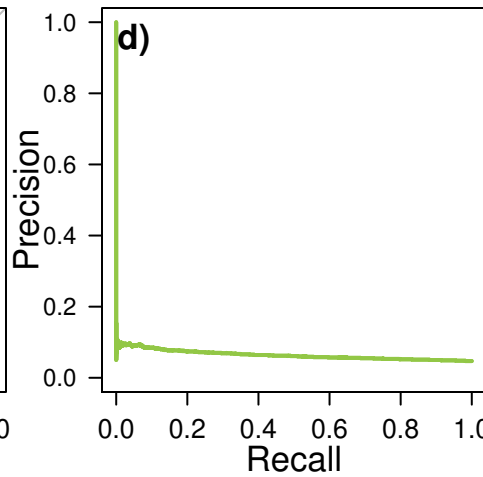
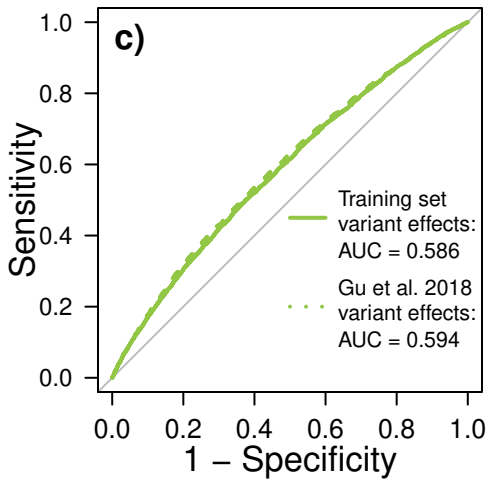
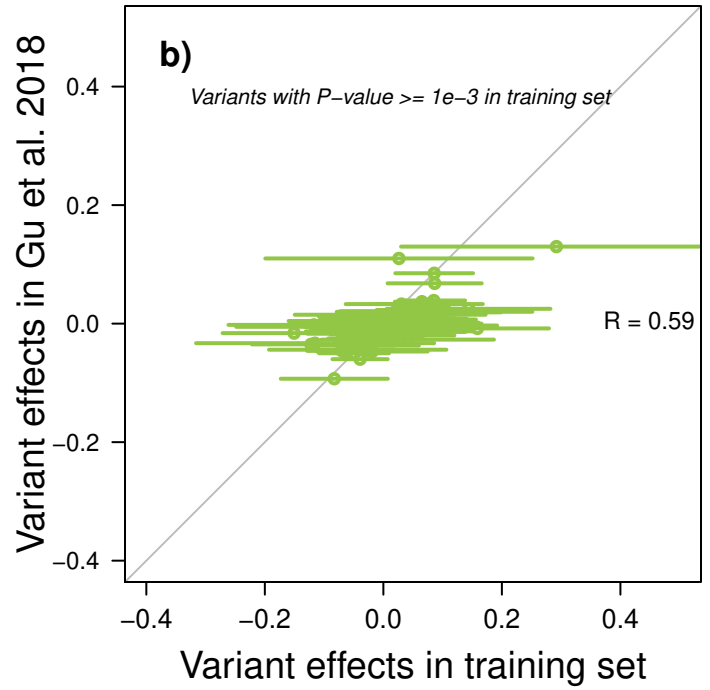
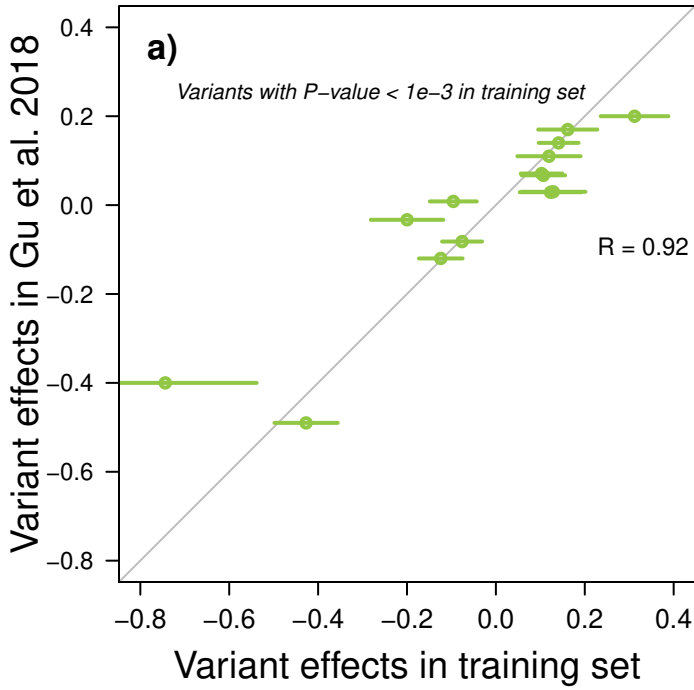


Supplementary Figure 13: Deviance explained in prediction models with pairwise interaction.



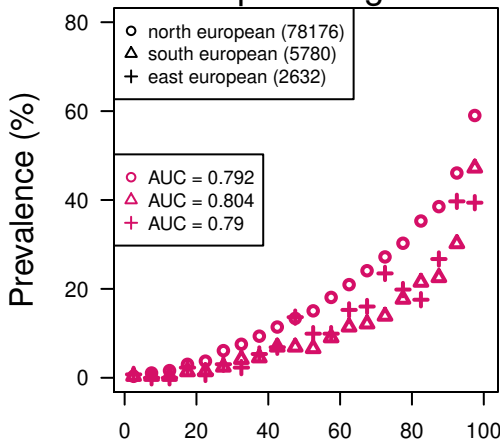
Supplementary Figure 14: Comparison between a published melanoma PRS (Gu et al. 2018) and the melanoma PRS from this study

Gu et al. (2018) developed a melanoma PRS using 12,874 melanoma cases and 23,203 controls from the Melanoma Meta-Analysis Consortium as a training set, and 3102 cases and 2301 controls from the MelaNostrum consortium for validation. The Melanoma Meta-Analysis Consortium combined multiple cohorts from Europe, Australia and the United States. Cases were identified through clinicians, pathology or cancer registers, and cases were generally diagnosed with pathology or histopathology confirmed invasive, cutaneous melanoma. The MelaNostrum Consortium included cases with histologically confirmed primary cutaneous melanoma from Italy, Spain, Greece and Cyprus. The PRS included 204 SNPs and achieved an AUC = 0.644 (95% CI = 0.630–0.658). All 204 variants were present in 23andMe database and passed our quality control (QC) requirements. a) and b) are a comparison of the estimated effects (and 95% CI) of the 204 PRS variants in 23andMe training set and in Gu et al. (2018)'s publication. The two figures present the variants with a P-value < 1e-3 or > 1e-3, respectively, in 23andMe training set. c) and d) are the performance of Gu et al.'s PRS in 23andMe validation set. The dashed line used directly Gu et al.'s PRS weights from the publication. The solid line used effect estimates from the 23andMe training set. e) Comparison between melanoma PRS from this study (grouped by percentile bins) and Gu et al. (2018) melanoma PRS (mean and SD of percentiles) in the validation set.

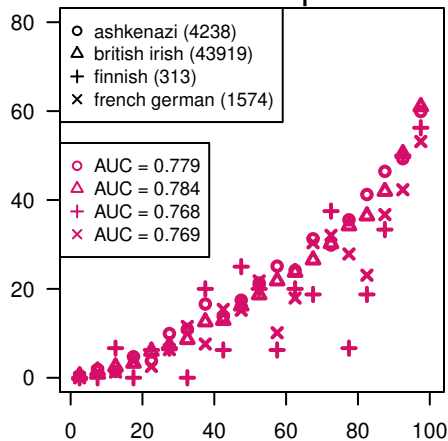


Supplementary Figure 15: Prevalence of skin cancer per 5% DRS bins and AUC in the validation set, split by European ancestries.

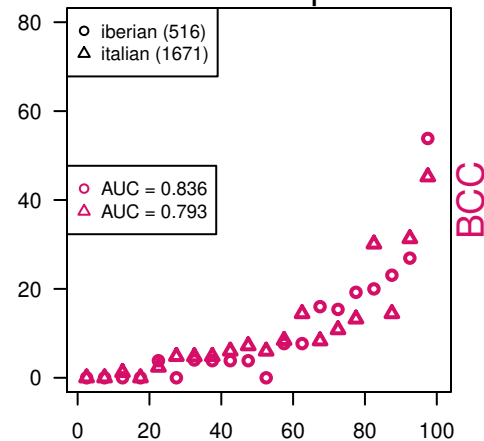
European regions



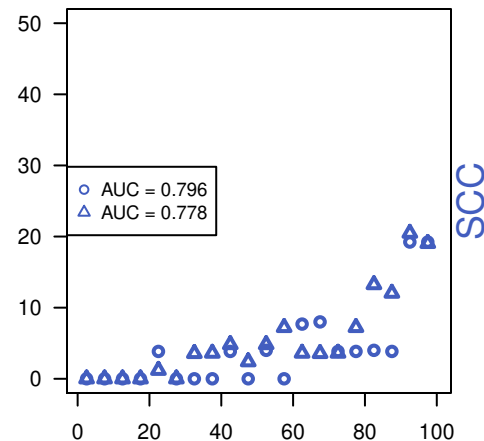
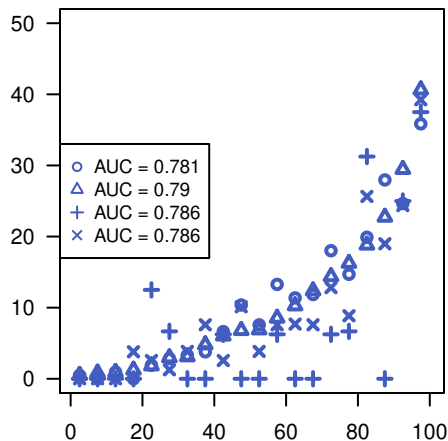
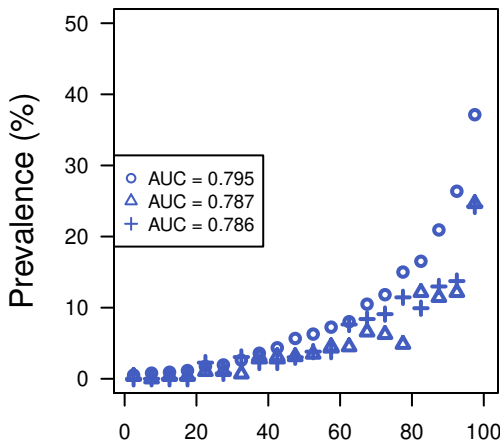
North European



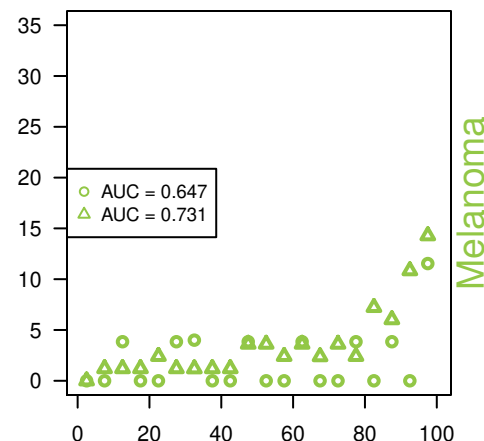
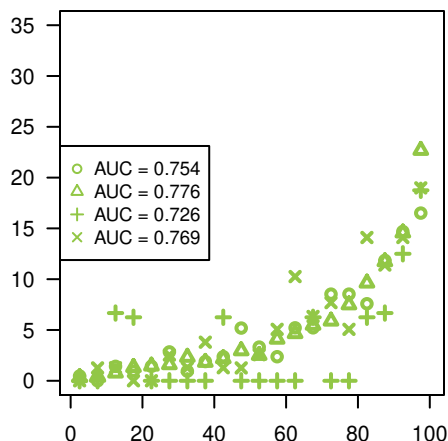
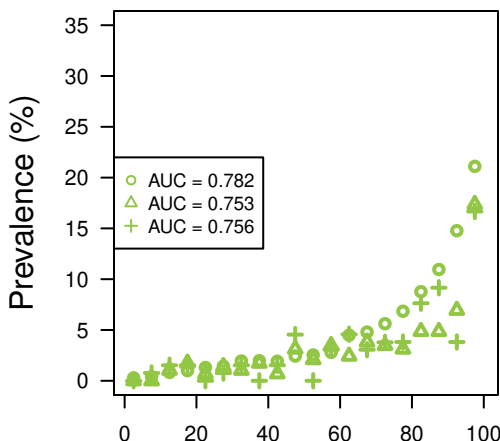
South European



BCC



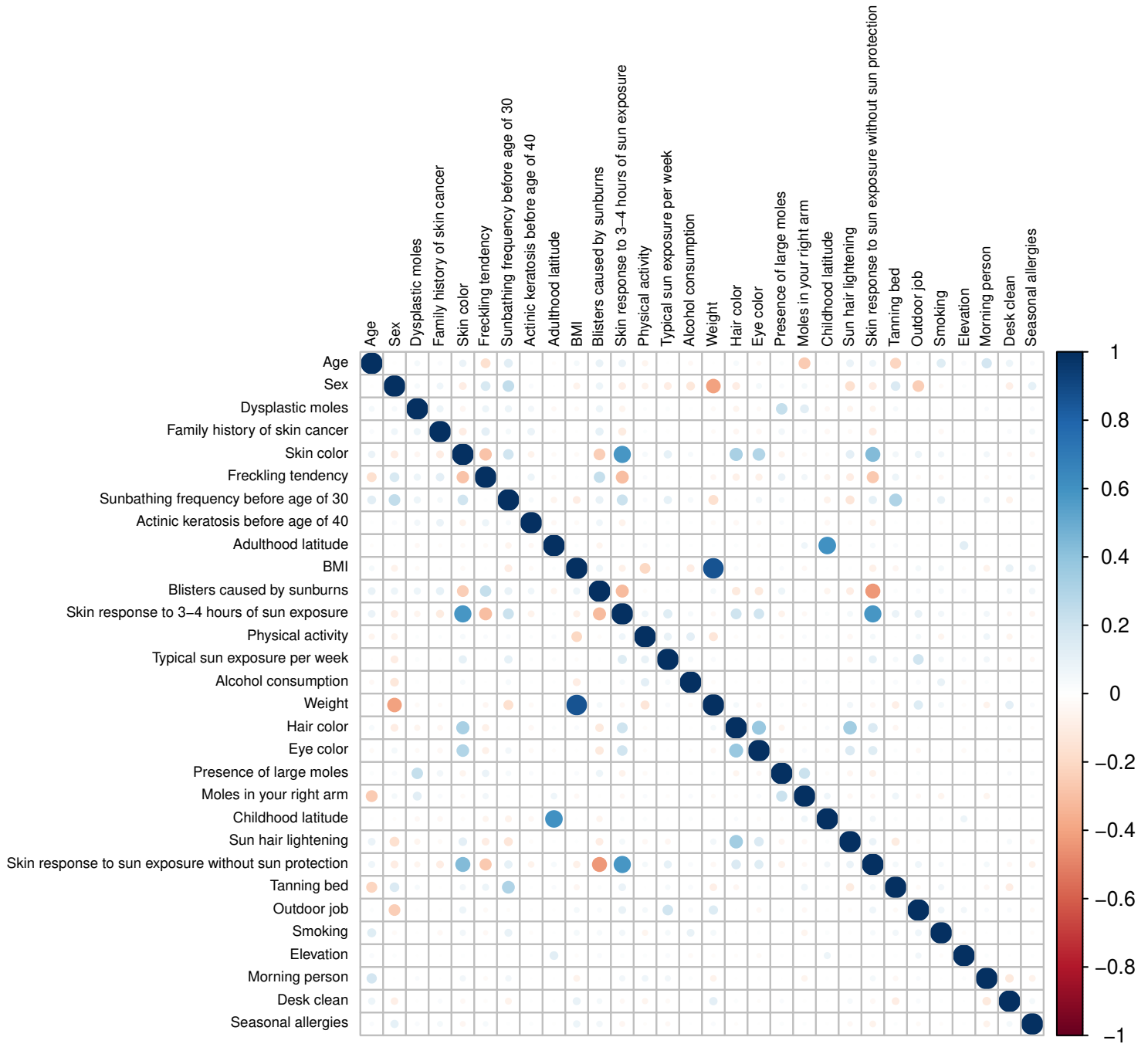
SCC



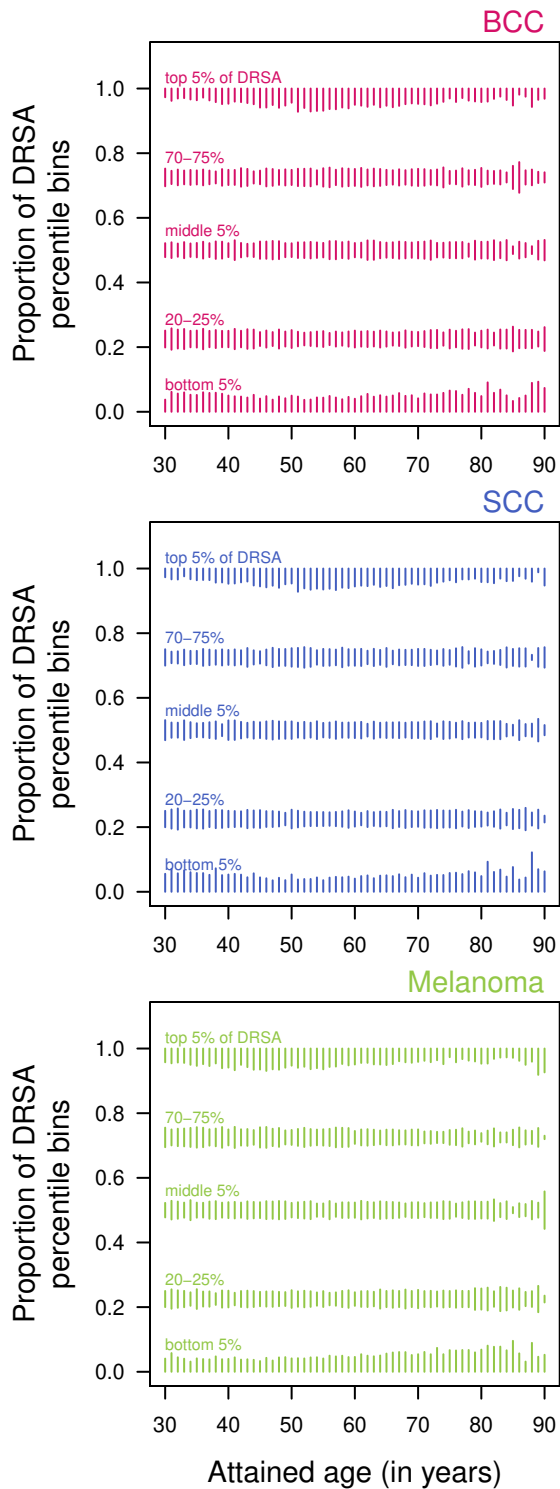
Melanoma

DRS percentile

Supplementary Figure 16: Correlation matrix, in the training set, for the 32 factors included in the final models.

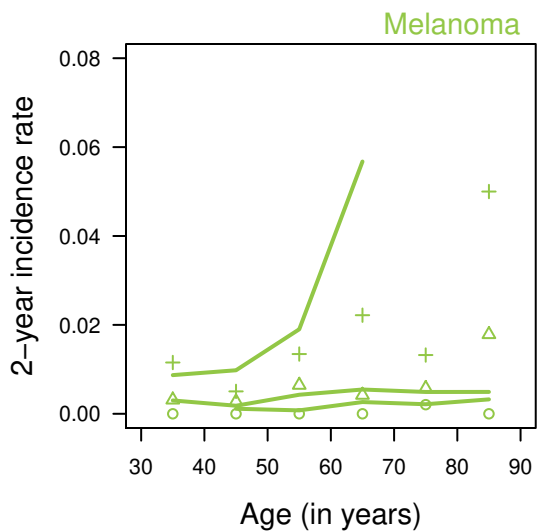
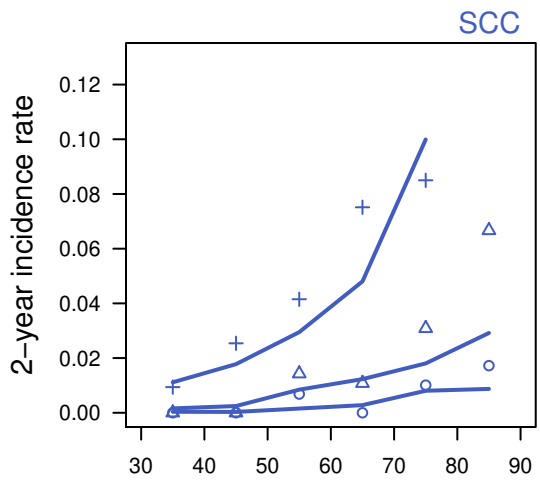
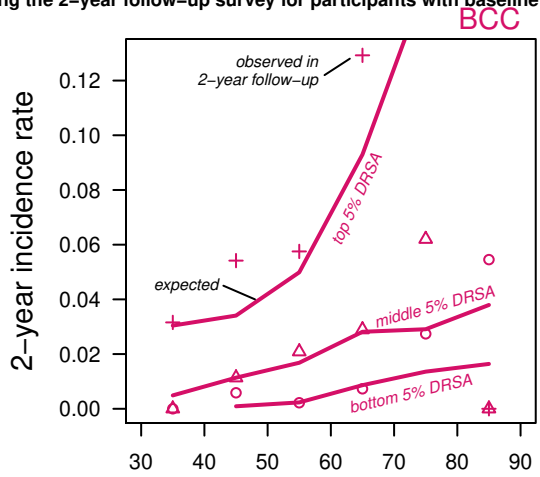


Supplementary Figure 17: Proportion of DRSA percentile bins in each age class.



Supplementary Figure 18: Expected and observed incidence rate in the 2-year follow-up for the bottom, middle, and top 5% DRSA.

The expected incidence rates were computed from the prevalences from the validation set (see Methods). The observed incidence rates were calculated using the 2-year follow-up survey for participants with baseline bottom, middle, and top 5% DRSA (circle, triangle, and cross, respectively).



Supplementary Figure 19: Mean risk score contribution to DRSA scores across ages, for the bottom, middle, and top 5% DRSA.

