American Journal of Epidemiology

Vol. 186, No. 1
DOI: 10.1093/aje/kwx024
Advance Access publication:
May 19, 2017

Original Contribution

Skin Pigmentation and Risk of Hearing Loss in Women

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Initially submitted April 8, 2016; accepted for publication June 14, 2016.

Black individuals have a lower risk of hearing loss than do whites, possibly because of differences in cochlear melanocytes. Previous studies have suggested that darker-skinned individuals tend to have more inner ear melanin, and cochlear melanocytes are important in generating the endocochlear potential. We investigated the relationship between self-reported hearing loss and skin pigmentation by using hair color, skin tanning ability, and skin reaction to prolonged sun exposure as surrogate measures of pigmentation among 49,323 white women in the Nurses' Health Study. Cox proportional hazards regression models were used to adjust for potential confounders. During 1,190,170 person-years of follow-up (1982–2012), there was no association between risk of hearing loss and hair color (for black hair vs. red or blonde hair, multivariable-adjusted relative risk (RR) = 0.99, 95% confidence interval (CI): 0.90, 1.09), skin tanning ability (for dark tan vs. no tan, multivariable-adjusted RR = 0.98, 95% CI: 0.92, 1.05), skin reaction to prolonged sun exposure (for painful burn with blisters vs. practically no reaction, multivariable-adjusted RR = 1.01, 95% CI: 0.93, 1.08), or Fitzpatrick skin phototype (for type IV vs. type I, multivariable-adjusted RR = 0.99, 95% CI: 0.92, 1.05). In our cohort of white women, surrogates for skin pigmentation were not associated with risk of hearing loss.

hearing loss; melanin; skin pigmentation

Abbreviations: CI, confidence interval; RR, relative risk.

Hearing loss is highly prevalent among adults. Among women in the United States, approximately one-third have hearing loss by the age of 50 years, and approximately two-thirds have hearing loss by the age of 60 years (1). Hearing loss adversely affects quality of life; thus, the identification of modifiable risk factors is an important public health issue (2, 3).

Previous studies have shown that blacks have a 40%–70% lower prevalence of hearing loss than do whites (1, 4, 5). In a previous cross-sectional study, Lin et al. demonstrated (6) an association between certain Fitzpatrick skin phototypes and lower odds of hearing loss among Hispanics, which they suggested might be due to differences in melanocytes between darker-skinned and lighter-skinned individuals. Melanocytes are known to be present in the inner ear (7), and results from evolutionary studies have suggested that darker-colored individuals tend to have more internal (nonskin) melanin (8). Furthermore, studies in humans have demonstrated a positive association between numbers of melanocytes in the skin and in the inner ear (9, 10).

Melanocytes have antioxidant functions (11, 12) that might serve to protect against reactive oxygen species that are associated with death of inner ear hair cells in noise-induced hearing loss (13). Furthermore, cochlear melanocytes serve as intermediate cells in the stria vascularis and are important in the generation of the endocochlear potential (14).

Although the difference in risk of hearing loss between whites and blacks has been well established, it is unclear whether it is due to differences in skin pigmentation. Therefore, we sought to explore the relationship between skin pigmentation and the risk of hearing loss in a prospective cohort of 49,323 white women in the Nurses' Health Study by using hair color, skin tanning ability, and skin reaction to prolonged sun exposure as surrogates for skin pigmentation. We restricted our analysis to white participants to reduce the

amount confounding by unknown genetic factors related to race but not skin pigmentation.

METHODS

Study participants

The Nurses' Health Study is a cohort of 121,700 registered female nurses aged 30–55 years at the time of study onset in 1976. Follow-up questionnaires are administered biennially, with an average follow-up rate of greater than 90% of the eligible person-time. In the Conservation of Hearing Study (CHEARS), researchers investigate factors associated with hearing loss in the Nurses' Health Study. The participants were first asked about hearing loss, as well as age at onset (if applicable), on the 2012 long version of the questionnaire. Of the 63,966 women who answered this questionnaire, 47% reported a hearing problem. We limited our analysis to white participants to reduce the amount of confounding by unknown genetic factors related to race but not skin pigmentation. After excluding women who reported a hearing problem before 1982 and those with a history of cancer other than nonmelanoma skin cancer (because of potential exposure to ototoxic chemotherapeutic agents), our study population included 49,323 women. The rate of nonresponse to the question about hearing was low (0.8%), and the 1982 characteristics of women who were excluded from our analysis were similar to those of women who were included in our analysis.

Ascertainment of skin characteristics

On the 1982 questionnaire, participants were asked a series of questions regarding their skin characteristics. These questions inquired about participants' natural hair color at the age of 21 years (red, blonde, light brown, dark brown, or black), childhood or adolescent skin reaction after exposure to 2 or more hours of sunlight on a bright sunny day (no tan, light tan, average tan, or dark tan), and childhood or adolescent skin reaction after repeated sun exposures (practically no reaction, redness only, burn, painful burn, or painful burn with blisters). By assessing skin in this manner, investigators have demonstrated associations of lighter hair color, inability to tan skin, and skin burning after prolonged sun exposure with higher risks of skin cancer (15–18). Genome-wide association studies on self-reported pigmentary traits in the cohort confirmed the presence of previously identified human pigmentation loci (19), which demonstrated that these skin characteristics are associated with skin pigmentation. We utilized participant responses to these questions as surrogate measures for skin pigmentation. We further characterized participants by Fitzpatrick skin phototype, which is a scale from type I to IV. Type I corresponds to skin that does not tan, burns with prolonged sun exposure, and is typically lighter in pigment; type IV corresponds to skin that tans easily, does not burn, and is typically darker in pigment (20–22). Fitzpatrick skin phototypes were derived from participant responses to the questions regarding skin tanning and skin reactions to prolonged sun exposure. Fitzpatrick skin phototypes I–III assessed in this manner have been associated with the risk of melanoma in situ in this cohort (22).

Ascertainment of hearing loss

The outcome was self-reported hearing loss. The 2012 questionnaire included the question, "Do you have a hearing problem?" If participants responded yes, they also answered the question, "At what age did you first notice a change in your hearing?" Participants who reported a hearing problem that they noticed after 1982 were defined as having incident cases of hearing loss.

Although the gold standard for evaluation of hearing loss is pure-tone audiometry, it is logistically and financially challenging to obtain audiograms on a large cohort. In previous studies, researchers who investigated self-reported hearing loss and hearing loss diagnosed using audiograms found that self-reporting is a relatively reliable indicator of hearing loss (23–26). Significant associations between several factors and risk of hearing loss have been described using this method of assessment in our and other similar cohorts (27–30).

Ascertainment of covariates

Covariates were selected based on previously reported associations with hearing loss. Factors considered included age (1), body mass index (27), waist circumference (27), alcohol consumption (31, 32), dietary intakes (folate (33), potassium (34), magnesium (35), β-carotene (36), *trans* fatty acids (28), ω-3 fatty acids (28), β-cryptoxanthin (36), vitamin A, vitamin B_{12}, vitamin C (36), vitamin E (36)), physical activity level (27, 37), smoking status (31), history of diabetes (38), history of hypertension (30), history of tinnitus (39, 40), and analgesic (acetaminophen, aspirin, and ibuprofen) use (29). Body mass index was measured as weight in kilograms divided by height in meters squared and was categorized as <21.0, 21.0–24.9, 25.0–29.9, 30.0–34.9, 35.0–39.9, or ≥40.0; waist circumference was categorized as <71 cm, 71–79 cm, 80–88 cm, or ≥89 cm. We also adjusted for body mass index and waist circumference as continuous variables.

Covariate information was obtained from data from the biennial questionnaires. Validation studies in our and other similar cohorts demonstrated that the correlation for weight was 0.97 and the correlation for physical activity level was 0.79 (41–43). Dietary intakes (alcohol, folate, vitamin B_{12}, vitamin A, vitamin C, vitamin E, potassium, magnesium, *trans* fatty acids, ω-3 fatty acids, β-carotene, and β-cryptoxanthin) were derived from semiquantitative food frequency questionnaires that were filled out by study participants every 4 years. Previous studies have demonstrated the validity and reproducibility of these questionnaires (44, 45).

Statistical analysis

All analyses were performed prospectively by using information on skin characteristics that was collected before the reported onset of hearing loss. The person-time contribution of each participant was assigned based on responses to the questions about skin characteristics in 1982. Women were censored at the time of reported cancer diagnosis. Cox proportional hazards regression models were used to calculate multivariable-adjusted relative risks and the corresponding 95% confidence intervals. We used the Anderson-Gill data structure to efficiently manage left truncation and time-varying covariates (46). To control for

confounding by age, we stratified the analysis by age in years at the start of follow-up and the year of the most recent questionnaire cycle. Covariate status from the 1982 questionnaire was used as baseline and updated on each subsequent questionnaire. Participants with incomplete or missing data were categorized as "missing" in the analysis. Because age is a strong risk factor for hearing loss, we also tested for possible effect modification by age (<60 years vs. ≥60 years) of the associations with hair color, skin tanning ability, skin reaction to prolonged sun exposure, and Fitzpatrick skin phototype. All *P* values are 2-sided. SAS software, version 9.4 (SAS Institute Inc., Cary, North Carolina), was used to perform all statistical analyses.

RESULTS

Participant characteristics at baseline according to skin characteristics are shown in Tables 1–3. Women with black hair color tended to be older, were less physically active and less likely to smoke, consumed less alcohol, and were more likely to have a history of hypertension or diabetes than were women with lighter-colored hair (Table 1). Women who reported dark skin tans in childhood or adolescence tended to have lower body mass indices, were more likely to smoke, consumed more alcohol, and were less likely to have a history of diabetes than were women with skin that did not tan darkly (Table 2). Women with sunburn susceptibility in childhood or adolescence tended to have higher body mass indices and waist circumferences, were less physically active, consumed less alcohol, and were more likely to have a history of hypertension or diabetes than were women with skin that did not tend to burn (Table 3).

During 1,190,170 person-years of follow-up (1982–2012), participants reported 18,461 cases of incident hearing loss. There was no significant association of hearing loss with hair color (for black hair vs. red or blonde hair, multivariable-adjusted relative risk (RR) = 0.99, 95% confidence interval (CI): 0.90, 1.09; *P* for trend = 0.53), skin tanning ability (for dark tan vs. no tan, multivariable-adjusted RR = 0.98, 95% CI: 0.92, 1.05; *P* for trend = 0.19), skin reaction to prolonged sun exposure (for painful burn with blisters vs. practically no reaction, multivariable-adjusted RR = 1.01, 95% CI: 0.93, 1.08; *P* for trend = 0.15), or Fitzpatrick skin phototype (for type IV vs. type I, multivariable-adjusted RR = 0.99, 95% CI: 0.92, 1.05; *P* for trend = 0.22) (Tables 4–7). There was no effect modification by age for hair color ($P = 0.37$), skin tanning ability ($P = 0.20$), skin reaction to prolonged sun exposure ($P = 0.70$), or Fitzpatrick skin phototype ($P = 0.37$).

We performed an analysis in which we did not adjust for history of tinnitus as a covariate, and the results were not materially changed. We also performed a cross-sectional analysis of prevalence of hearing loss by participants' natural hair colors, skin tanning characteristics in childhood or adolescence, skin reactions to prolonged sun exposure in childhood or adolescence, and Fitzpatrick skin phototypes in childhood or adolescence, and we found the results to be the same.

DISCUSSION

In our large prospective study, hair color, skin tanning ability, skin reaction to prolonged sun exposure, and Fitzpatrick skin phototype were not significantly associated with risk of hearing loss in white women. Black individuals are half as likely as whites to develop hearing loss (1, 4, 5), but the reasons are unclear. One proposed explanation relates to differences in the number of cochlear melanocytes (6). Data from animals and humans have suggested that there is a correlation between skin melanocytes and inner ear melanocytes (7–10). Sodium-potassium adenosine triphosphatase pumps and potassium pumps in cochlear melanocytes are important in generating the endocochlear potential (14, 47, 48), and the absence of melanin in the stria vascularis has been associated with marginal cell loss and reduced endocochlear potential (49). Melanocytes have also been found in other sites in the inner ear: the scala vestibuli, Reissner's membrane, modiolus, utricle, and saccule (7). Melanocytes have been demonstrated to possess antioxidative functions (11, 12) that might protect the inner ear against reactive oxygen species shown to play a central role in noise-induced hearing loss (13, 50, 51). Furthermore, mutations in genes resulting in deficient melanocytes also resulted in impaired hearing in rodent models and in humans (47, 52, 53).

We examined the relationship between risk of hearing loss and skin pigmentation as ascertained using surrogate measures (hair color, childhood or adolescent skin tanning ability, and skin reaction after prolonged sun exposure) that have been associated with skin pigmentation (19). We observed no association of hair color, skin tanning ability, or skin reaction with the risk of hearing loss in white women. Results from a previous cross-sectional study showed no association between Fitzpatrick skin phototype—classified by a dermatologist using standardized photographs—and rates of hearing loss among whites and blacks (6). The manner in which Fitzpatrick skin phototype was assessed in our study differed from that in the previous study. We derived participants' Fitzpatrick skin phototypes from participant skin characteristics (skin tanning ability and skin reaction to prolonged exposure to sun), which is a direct method of assessing Fitzpatrick skin phototype (21). We also found no association between participant Fitzpatrick skin phototype and risk of hearing loss. Our data demonstrated that skin pigmentation as assessed by these surrogate skin characteristics was not associated with the risk of hearing loss in whites.

Our study has limitations. We utilized participant self-reported pigmentary traits as surrogates for participant skin pigmentation. However, gene loci linked to these pigmentary traits have been associated with skin pigmentation (19), which supports the validity of our assessment of pigmentary traits. It is possible that the range of variability in skin pigmentation among whites is limited—the darkest-skinned white individuals might possess fewer melanocytes than light-skinned black individuals—and perhaps a greater difference in melanocytes is required to observe differences in the risk of hearing loss. Therefore, the generalizability of our findings to other races/ethnicities is uncertain. The outcome of our study was self-reported hearing loss. Although pure-tone audiometry is considered the gold standard for evaluation of hearing loss, self-reported hearing loss has been shown to be a reasonably reliable indicator of hearing loss (26, 54–56). Furthermore, in a recent study, Chou et al. (57) showed that a single question about hearing loss provided results almost as accurate as those from a more extensive questionnaire or portable audiometric device for

Table 1. Baseline Characteristics of Participants According to Natural Hair Color, Nurses' Health Study, 1982[a]

Characteristic	Natural Hair Color											
	Red or Blonde (n = 7,478)			Light Brown (n = 19,045)			Dark Brown (n = 21,275)			Black (n = 1,340)		
	Mean (SD)	Median (IQR)	%[b]	Mean (SD)	Median (IQR)	%[b]	Mean (SD)	Median (IQR)	%[b]	Mean (SD)	Median (IQR)	%[b]
Age, years	46.7 (6.6)			46.1 (6.6)			45.8 (6.5)			47.7 (6.4)		
Body mass index[c]	24.2 (4.2)			24.2 (4.2)			24.3 (4.3)			24.5 (4.2)		
Waist circumference[d], cm	77.4 (10.2)			77.5 (10.5)			77.3 (10.5)			77.2 (10.1)		
Physical activity level[d], METs		8.3 (3.1–20.2)			8.1 (2.9–19.8)			7.7 (2.9–19.0)			7.5 (2.5–19.6)	
Smoking status												
Never smoker			46.2			47.1			47.3			49.9
Past smoker			31.5			30.8			30.8			29.3
Current smoker			22.0			21.9			21.6			20.6
Alcohol consumption[d], g/day		1.8 (0.0–9.7)			1.8 (0.0–8.5)			1.8 (0.0–7.6)			1.0 (0.0–6.6)	
History of hypertension			15.0			13.6			13.9			13.3
History of diabetes			1.4			1.3			1.4			1.7

Abbreviations: IQR, interquartile range; METs, metabolic equivalents; SD, standard deviation.
[a] A total of 185 women were excluded because of incomplete or missing data on the 1982 questionnaire.
[b] Values of polytomous variables may not sum to 100% because of rounding.
[c] Weight (kg)/height $(m)^2$.
[d] Physical activity level, waist circumference, and alcohol consumption data were from the 1986 questionnaire.

Table 2. Baseline Characteristics of Participants According to Childhood or Adolescent Skin Tanning Characteristics, Nurses' Health Study, 1982[a]

Characteristic	Childhood or Adolescent Skin Tanning Characteristic											
	No Tan (n = 3,736)			Light Tan (n = 11,073)			Average Tan (n = 22,405)			Dark Tan (n = 11,538)		
	Mean (SD)	Median (IQR)	%[b]	Mean (SD)	Median (IQR)	%[b]	Mean (SD)	Median (IQR)	%[b]	Mean (SD)	Median (IQR)	%[b]
Age, years	46.6 (6.5)			45.9 (6.6)			46.2 (6.6)			45.9 (6.5)		
Body mass index[c]	25.0 (4.7)			24.3 (4.3)			24.1 (4.1)			24.0 (4.2)		
Waist circumference[d], cm	79.4 (11.3)			77.9 (10.6)			77.3 (10.2)			76.5 (10.2)		
Physical activity level[d], METs		6.2 (2.3–15.9)			7.4 (2.7–17.4)			8.2 (3.0–19.6)			9.0 (3.1–21.5)	
Smoking status												
Never smoker			49.1			49.2			48.5			41.7
Past smoker			28.3			30.1			30.8			32.8
Current smoker			22.2			20.5			20.5			25.3
Alcohol consumption[d], g/day		1.5 (0.0–6.7)			1.7 (0.0–7.2)			1.8 (0.0–8.0)			2.0 (0.0–10.2)	
History of hypertension			18.1			14.0			13.6			13.6
History of diabetes			2.2			1.4			1.3			1.1

Abbreviations: IQR, interquartile range; METs, metabolic equivalents; SD, standard deviation.

[a] A total of 571 women were excluded from the table because of incomplete or missing data on the 1982 questionnaire.

[b] Values of polytomous variables may not sum to 100% because of rounding.

[c] Weight (kg)/height $(m)^2$.

[d] Physical activity level, waist circumference, and alcohol consumption data were from the 1986 questionnaire.

Table 3. Baseline Characteristics of Participants According to Childhood or Adolescent Skin Reaction to Prolonged Sun Exposure, Nurses' Health Study, 1982[a]

Characteristic	Childhood or Adolescent Skin Reaction to Prolonged Sun Exposure														
	Practically No Reaction (n = 9,668)			Redness Only (n = 21,713)			Burn (n = 10,895)			Painful Burn (n = 4,619)			Painful Burn With Blisters (n = 2,279)		
	Mean (SD)	Median (IQR)	%[b]	Mean (SD)	Median (IQR)	%[b]	Mean (SD)	Median (IQR)	%[b]	Mean (SD)	Median (IQR)	%[b]	Mean (SD)	Median (IQR)	%[b]
Age, years	45.9 (6.6)			46.2 (6.6)			46.2 (6.5)			45.8 (6.5)			46.6 (6.5)		
Body mass index[c]	24.1 (4.1)			24.0 (4.0)			24.3 (4.3)			24.8 (4.6			25.3 (5.1)		
Waist circumference[d], cm	76.6 (10.1)			77.0 (10.1)			78.0 (10.6)			78.7 (10.9)			80.0 (12.1)		
Physical activity level[d], METs		8.4 (2.9–20.8)			8.3 (3.1–19.9)			7.7 (2.9–18.3)			6.5 (2.5–16.5)			6.8 (2.4–16.6)	
Smoking status															
Never smoker			46.5			47.4			47.1			48.5			45.1
Past smoker			30.1			30.9			31.2			31.1			32.0
Current smoker			23.2			21.4			21.5			20.1			22.5
Alcohol consumption[d], g/day		1.8 (0.0–8.2)			1.8 (0.0–8.8)			1.8 (0.0–7.6)			1.7 (0.0–6.8)			1.5 (0.0–7.6)	
History of hypertension			13.2			13.3			14.6			16.2			19.2
History of diabetes			1.2			1.3			1.3			1.8			2.4

Abbreviations: IQR, interquartile range; METs, metabolic equivalents; SD, standard deviations.

[a] A total of 149 women were excluded from the table because of incomplete or missing data on the 1982 questionnaire.

[b] Values of polytomous variables may not sum to 100% because of rounding.

[c] Weight (kg)/height $(m)^2$.

[d] Physical activity level, waist circumference, and alcohol consumption data were from the 1986 questionnaire.

Table 4. Age- and Multivariable-Adjusted Relative Risks of Incident Hearing Loss Among White Women by Natural Hair Color, Nurses' Health Study, 1982–2012[a]

Hair Color	No. of Cases	No. of Person-Years	Age Adjusted		Multivariable Adjusted[b]	
			RR	95% CI	RR	95% CI
Red or blonde	2,803	178,701	1.00	Referent	1.00	Referent
Light brown	7,166	459,799	1.04	1.00, 1.09	1.02	0.98, 1.07
Dark brown	7,915	515,861	1.05	1.00, 1.09	1.03	0.98, 1.07
Black	513	31,658	0.95	0.86, 1.04	0.99	0.90, 1.09
P for trend					0.53	

Abbreviations: CI, confidence interval; RR, relative risk.
[a] A total of 64 cases of hearing loss were excluded from analysis because of missing or incomplete data.
[b] Adjusted for age, body mass index, waist circumference, alcohol consumption, physical activity level, nutrient intake, smoking status, history of hypertension, history of diabetes, history of tinnitus, and analgesic (acetaminophen, aspirin, and ibuprofen) use.

Table 5. Age- and Multivariable-Adjusted Relative Risks of Incident Hearing Loss Among White Women by Childhood or Adolescent Skin Tanning Characteristics, Nurses' Health Study, 1982–2012[a]

Tanning Characteristic	No. of Cases	No. of Person-Years	Age Adjusted		Multivariable Adjusted[b]	
			RR	95% CI	RR	95% CI
No Tan	1,424	89,203	1.00	Referent	1.00	Referent
Light Tan	4,216	266,265	1.06	1.00, 1.13	1.01	0.95, 1.07
Average Tan	8,370	541,212	1.01	0.95, 1.06	0.98	0.92, 1.04
Dark Tan	4,233	280,025	1.01	0.95, 1.07	0.98	0.92, 1.05
P for trend					0.19	

Abbreviations: CI, confidence interval; RR, relative risk.
[a] A total of 218 cases of hearing loss were excluded from analysis because of missing or incomplete data.
[b] Adjusted for age, body mass index, waist circumference, alcohol consumption, physical activity level, nutrient intake, smoking status, history of hypertension, history of diabetes, history of tinnitus, and analgesic (acetaminophen, aspirin, and ibuprofen) use.

Table 6. Age- and Multivariable-Adjusted Relative Risks of Incident Hearing Loss Among White Women by Childhood or Adolescent Skin Reaction to Prolonged Sun Exposure, Nurses' Health Study, 1982–2012[a]

Skin Reaction	No. of Cases	No. of Person-Years	Age Adjusted		Multivariable Adjusted[b]	
			RR	95% CI	RR	95% CI
Practically none	3,521	235,078	1.00	Referent	1.00	Referent
Redness only	8,143	524,247	1.02	0.98, 1.06	1.02	0.98, 1.06
Burn	4,109	262,828	1.02	0.97, 1.07	1.02	0.97, 1.07
Painful burn	1,794	110,798	1.12	1.06, 1.18	1.07	1.01, 1.14
Painful burn with blisters	838	53,618	1.02	0.94, 1.10	1.01	0.93, 1.08
P for trend					0.15	

Abbreviations: CI, confidence interval; RR, relative risk.
[a] A total of 56 cases of hearing loss were excluded from analysis because of missing or incomplete data.
[b] Adjusted for age, body mass index, waist circumference, alcohol consumption, physical activity level, nutrient intake, smoking status, history of hypertension, history of diabetes, history of tinnitus, and analgesic (acetaminophen, aspirin, and ibuprofen) use.

Table 7. Age- and Multivariable-Adjusted Relative Risks of Incident Hearing Loss Among White Women by Childhood or Adolescent Fitzpatrick Skin Phototype, Nurses' Health Study, 1982–2012[a]

Fitzpatrick Skin Phototype	No. of Cases	No. of Person-Years	Age Adjusted		Multivariable Adjusted[b]	
			RR	95% CI	RR	95% CI
Type I[c]	1,233	76,780	1.00	Referent	1.00	Referent
Type II[d]	6,184	392,739	1.03	0.97, 1.10	1.01	0.95, 1.07
Type III[e]	6,337	410,846	0.99	0.93, 1.05	0.98	0.92, 1.04
Type IV[f]	3,843	255,455	1.00	0.94, 1.06	0.99	0.92, 1.05
P for trend					0.22	

Abbreviations: CI, confidence interval; RR, relative risk.

[a] A total of 864 cases of hearing loss were excluded from analysis because of missing or incomplete data.

[b] Adjusted for age, body mass index, waist circumference, alcohol consumption, physical activity level, nutrient intake, smoking status, history of hypertension, history of diabetes, history of tinnitus, and analgesic (acetaminophen, aspirin, and ibuprofen) use.

[c] Type I was defined as skin that does not tan and has blistering burns, does not tan and has painful burns, or does not tan and burns.

[d] Type II was defined as skin that lightly tans and has painful burns, lightly tans and has blistering burns, lightly tans and burns, lightly tans and has some redness, average tans and has painful burns, or average tans and burns.

[e] Type III was defined as skin that average tans and has some redness, average tans and does not burn, or tans deeply and burns.

[f] Type IV was defined as skin that tans well and does not burn or tans deeply and has some redness.

detecting hearing loss. In conclusion, characteristics associated with skin pigmentation (natural hair color, childhood or adolescent tanning ability and burning tendency, and Fitzpatrick skin phototype) were not associated with risk of hearing loss in white women, which suggests that differences in melanocytes may not be associated with risk of hearing loss in whites.

ACKNOWLEDGMENTS

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This work was supported by grants U01 DC010811 and UM1 CA176726 from the National Institutes of Health.

The sponsors of this study had no role in study design, data collection, data analysis, data interpretation, or writing of the manuscript.

Conflict of interest: none declared.

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