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Behavioral Counseling to Prevent Skin Cancer: A Systematic Review for the U.S. Preventive Services Task Force

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Background: More than 2 million cases of skin cancer are diagnosed annually in the United States, and melanoma incidence is increasing.

Purpose: To assist the U.S. Preventive Services Task Force in updating its 2003 recommendation on behavioral counseling to prevent skin cancer.

Data Sources: Existing systematic reviews, database searches through February 2010, and outside experts.

Study Selection: English-language, primary care–relevant counseling trials to promote sun-protective behaviors and studies examining the association between sun-protective behaviors and skin cancer outcomes or potential adverse effects were included.

Data Extraction: Each study was appraised by using design-specific quality criteria. Important study details were abstracted into evidence tables.

Data Synthesis: 11 fair- or good-quality, randomized, controlled trials examined the counseling interventions' effect on sun-protective behaviors. In young women, appearance-focused behavioral interventions decrease indoor tanning and ultraviolet exposure. In young adolescents, computer support can decrease midday sun exposure and increase sunscreen use. Thirty-five mainly fair-quality observational studies examined the relationship between ultraviolet exposure or sunscreen use and skin cancer. Increasing intermittent sun exposure in childhood is associated with an increased risk for squamous cell carcinoma, basal cell carcinoma, and melanoma. Evidence suggests that regular or early use of indoor tanning may increase melanoma risk. On the basis of 1 fair-quality trial, regular sunscreen use can prevent squamous cell carcinoma, but it is yet unclear if it can prevent basal cell carcinoma or melanoma.

Limitations: There are limited rigorous counseling trials. Observational studies are limited by the complexity of measuring ultraviolet exposure and sunscreen use, and inadequate adjustment for important confounders.

Conclusion: Randomized, controlled trials suggest that primary care–relevant counseling can increase sun-protective behaviors and decrease indoor tanning.

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Editor's Note: *As part of the U.S. Preventive Services Task Force's (USPSTF) ongoing commitment to clarity about its work and methods, the USPSTF is inviting public comment on all draft recommendation statements. The USPSTF's draft recommendation statement on behavioral counseling to prevent skin cancer will soon be available for public comment at* www.uspreventiveservicestaskforce.org/tfcomment.htm. *As a result, the recommendation on behavioral counseling to prevent skin cancer does not appear with this accompanying background review. Once finalized, the recommendation statement will reflect any changes made based on the public comments received. A summary of these changes will be included in a new section of the final recommendation statement.*

In the United States, more than 2 million cases of nonmelanoma skin cancer are diagnosed each year. Of these cases, about two thirds are basal cell carcinoma and one quarter are squamous cell carcinoma (1). Although melanoma is considerably less common than basal cell or squamous cell carcinoma, it now accounts for about 75% of skin cancer deaths (1). Age-adjusted incidence rates for melanoma among white Americans have increased from approximately 8.7 per 100 000 in 1975 to 25.3 per 100 000 in 2007 (2). Several factors may contribute to this increase in incidence, including increased ultraviolet exposure, increased public awareness of the warning signs of melanoma, and increased screening by clinicians (3–5).

Skin cancer has well-known host and environmental risk factors. Several phenotypic characteristics are associated with skin cancer risk, including hair and eye color, freckles, and tendency to sunburn (6, 7). Exposure to solar ultraviolet radiation is the most important environmental risk factor for all types of skin cancer (8). Therefore, the primary strategies for preventing skin cancer include limiting ultraviolet exposure by avoiding midday sun, wearing protective clothing and broad-brimmed hats, applying sunscreen, and avoiding indoor tanning (7). However, sun-protective counseling in primary care varies in frequency and content (9–11), despite data suggesting that these behaviors need to be improved (12). Among adolescents in the United States, for example, about 83% reported at least 1 sunburn during the previous summer, only 34% reported sunscreen use, and nearly 10% of adolescents and 20% of young adults reported indoor tanning during the previous year (13, 14).

See also:

Web-Only
Appendix Tables
Appendix Figures
Conversion of graphics into slides

In 2003, the U.S. Preventive Services Task Force (USPSTF) concluded that evidence was insufficient to recommend for or against routine counseling by primary care clinicians to prevent skin cancer because of the uncertainty surrounding whether clinician counseling is effective in changing patient behaviors to reduce skin cancer, the uncertainty about potential harms of sun-protective behaviors, and availability of only fair-quality evidence linking sunscreen use or indoor tanning to skin cancer outcomes (15). Therefore, using the USPSTF methods (16), we developed an analytic framework with 5 key questions focusing on the evidence gaps identified in 2003 (**Appendix Figure 1**, available at www.annals.org).

Key question 1: Is there direct evidence that counseling patients on sun-protective behaviors reduces sunburns, nevi, actinic keratoses, or skin cancer?

Key question 2: Do primary care–relevant counseling interventions change sun-protective behaviors?

Key question 3: Do primary care–relevant counseling interventions have adverse effects?

Key question 4: Are certain behaviors (for example, changes in sun exposure, indoor tanning, or sunscreen use) associated with skin cancer outcomes?

Key question 5: Are sun-protective behaviors associated with adverse effects?

METHODS

Data Sources and Searches

We initially searched for existing systematic reviews from 2001 to March 2008 and evaluated 15 relevant systematic reviews, in addition to the previous evidence report, for quality and their potential in answering questions or identifying primary research for each question (15, 17–31). We used 10 reviews to identify primary evidence and subsequently searched from the end dates of existing systematic reviews through February 2010 (**Table 1**) (15, 17, 18, 21, 23, 32–36). Details of the existing systematic reviews search are included in the full report (37). We identified 6132 abstracts through MEDLINE and the Cochrane Central Register of Controlled Trials and 165 articles from outside experts and reviewing bibliographies of other relevant articles and existing systematic reviews (**Appendix Figure 2**, available at www.annals.org).

Study Selection

We reviewed all abstracts and articles for potential inclusion on the basis of a priori–determined inclusion criteria (**Appendix Table 1**, available at www.annals.org). For key questions 1 to 3, we included randomized or controlled clinical trials evaluating behavioral interventions that were conducted in primary care settings, judged to be feasible for delivery in primary care (for example, mailed or electronic interventions) or widely available for referral from primary care. Outcomes for key question 2 included self-reported or directly observed measures of sun-protective behaviors (for example, limitation or avoidance of midday sun, use of sun-protective clothing, use of sunscreen, or limitation or avoidance of indoor tanning) at 3 months of follow-up or longer. For key questions 4 and 5, we included trials, cohort studies, and population-based case–control studies. We excluded cross-sectional studies that were ecological analyses and hospital-based case–control studies because hospital-based control participants are not generally representative of the community, and hospital-based cases can introduce considerable selection bias (38, 39). Outcomes for key question 5 included potentially clinically important harms (for example, paradoxical increase in sun exposure, reduced physical activity, dysphoric mood, vitamin D deficiency, and increased incidence of nonskin cancer).

Two investigators independently screened 6132 abstracts, 73 articles for key questions 1 to 3, and 309 articles for key questions 4 and 5.

Data Extraction and Quality Assessment

Two investigators independently assessed study quality using the USPSTF's study design–specific quality criteria and the Newcastle–Ottawa Scale for assessing cohort and case–control studies (16, 40). All poor-quality studies were

Table 1. **Search Strategies for Each Question Based on Existing Systematic Reviews**

Key Question	Skin Cancer	Systematic Review Used to Locate Primary Research	Search Date*
1–3: Counseling	Any	Primary: Helfand and Krages, 2003 (15) Others: Saraiya et al, 2004 (32)	2001 to February 2010
4: Sun exposure	Melanoma	Primary: Helfand and Krages, 2003 (15) Others: Gandini et al, 2005 (23); Saraiya et al, 2004 (32)	2001 to February 2010
	SCC, BCC	No systematic review found	1966 to February 2010
4: Indoor tanning	Any	Primary: IARC, 2007 (17) Others: Gallagher et al, 2005 (21)	2005 to February 2010
4: Sunscreen	Melanoma	Primary: Dennis et al, 2003 (18) Others: Huncharek and Kupelnick, 2002 (33); Gefeller and Pfahlberg, 2002 (34)	2002 to February 2010
	SCC, BCC	No systematic review found	1966 to February 2010
5: Harms	Any	Primary: No systematic review found Others: Helfand and Krages, 2003 (15); Grant, 2007 (35); Autier et al, 2007 (36)	1966 to February 2010

BCC = basal cell carcinoma; IARC = International Agency for Research on Cancer; SCC = squamous cell carcinoma.
* Start date for searches is 1 y before the end search date used in the primary existing systematic review.

excluded. Listings of all excluded articles are included in the full evidence report (37).

We found no trials for key question 1, 13 articles (11 unique trials) for key questions 2 and 3, 60 articles (35 unique studies) for key question 4, and 19 articles (17 unique studies) for key question 5. One primary reviewer abstracted relevant information into standardized evidence tables for each included article. A second reviewer checked the abstracted data for accuracy and completeness.

Data Synthesis and Analysis

We were unable to conduct quantitative synthesis primarily because of the heterogeneity of the populations addressed and counseling intervention methods and measurement of exposures and outcomes. Instead, we qualitatively synthesized our results, stratified by population counseled (adults, young adults with a mean age of 18 to 21 years, and children) or type of exposure.

Role of the Funding Source

The Agency for Healthcare Research and Quality funded this research under a contract to support the USPSTF, provided project oversight, reviewed the draft evidence synthesis, and assisted in external review of the draft evidence synthesis. The Agency for Healthcare Research and Quality had no role in the study selection, quality assessment, or evidence synthesis.

Results

Key Questions 1 and 2: Effectiveness of Counseling to Promote Sun-Protective Behaviors

We found no trials meeting our inclusion criteria that directly examined whether behavioral counseling interventions can reduce skin cancer. We included 11 fair-quality, randomized, controlled trials (RCTs) examining counseling interventions that included sun-protective behavior outcomes (**Table 2**). Quality considerations for these trials are summarized in **Table 2**.

In adults, 1 trial was conducted in the United Kingdom (41) and 4 trials were conducted in the United States (42–45). All of the trials used tailored risk feedback to promote sun-protective behaviors. Three of the counseling interventions conducted in the United States were coupled with in-office computer support on the basis of the transtheoretical model to generate printed stage-based tailored feedback (43–45). The trial conducted in the United Kingdom used a self-directed computer station in primary care practice to deliver the counseling intervention (41). Populations studied included predominantly middle-aged white men and women. Interventions ranged from a single 15-minute self-directed session to several sessions with in-person counseling, phone counseling, or written assessments followed by tailored written feedback. Overall, 4 of 5 trials (6949 participants) showed that primary care–relevant counseling with tailored feedback (with or without computer support) can modestly affect self-reported sun-protective behaviors, as measured by composite behavior scores (**Table 2**) (42–44). The differences in these scores, although statistically significant, were small, and it is unclear whether these differences translate into clinically meaningful behavior change. In the 1 trial (724 participants) that also reported individual types of behavior change, only the change in use of sunglasses was statistically significant (**Table 2**) (42). One trial conducted among siblings of patients with melanoma, which evaluated a similar counseling intervention, did not show any statistically significant changes in sun-protective behaviors (**Table 2**) (45). This trial, however, used different outcome measures than the other trials and had only 64% follow-up at 12 months.

Four trials in young adults were conducted in university settings and used "appearance-based" behavioral interventions that emphasized the effects of photoaging effects of ultraviolet exposure and norms about tanning and appearing tan instead of a primarily "health-based" message about skin cancer prevention (46–49). Interventions ranged from a written self-guided booklet to a brief video and to a 30-minute 1:1 peer-counseling session. In 3 trials (897 participants), the appearance-focused counseling intervention successfully reduced indoor tanning among women who had the intention to tan indoors (**Table 2**) (46, 48, 49). Although the interventions decreased indoor tanning behavior by up to 35% (46), follow-up for these trials was only 3 to 6 months. In another RCT (133 participants), a brief video intervention with or without an ultraviolet facial photograph produced a moderate decrease in objectively measured skin pigmentation (using skin reflectance spectrophotometry) at 12 months (**Table 2**) (47). The change in pigmentation was judged "moderate" on the basis of the Cohen *d* statistic.

In children, we found only 2 trials (50, 51). Participants in both trials were predominantly white. In 1 trial (819 participants), young adolescents randomly assigned to brief counseling by their primary care providers, coupled with in-office computer support to generate printed tailored feedback, reported both higher composite sun-protection scores and a greater likelihood of avoiding or limiting midday sun exposure or using sunscreen on the face or sun-exposed areas at 24 months than the attention control group (**Table 2**). The other cluster RCT, conducted in a large managed care organization, integrated counseling into 4 sequential well-child visits at the discretion of the primary care provider (51). Parents of newborns (728 participants) in practices randomly assigned to receive the intervention reported higher composite sun-protection scores at 36-month follow-up than those in control practices (**Table 2**). The clinical significance of these higher scores, however, is unclear, given the very small numerical differences and the lack of statistically significant differ-

Table 2. **Effectiveness of Behavioral Counseling Interventions to Promote Sun-Protective Behaviors**

Study, Year (Reference); Study Design	Setting and Population	Intervention	Outcomes	Validity Concerns
Adults				
Glanz et al, 2010 (42); RCT	Home (primary care); $n = 724$; mean age, 42 y; high risk	3 mailed packages with tailored risk feedback and recommendations	Sun-protection score (6-item, higher is safer), adjusted mean (±SE) Group: Baseline: 3 mo: *P* value IG: 2.34 ± 0.03: 2.57 ± 0.03: 0.001 CG: 2.34 ± 0.0: 2.46 ± 0.03	Fair quality: 82% follow-up; short follow-up; for individual behavior results, only sunglasses use was significant
Glazebrook et al, 2006 (41); cluster RCT	Primary care; $n = 589$; mean age, 38 y; high risk	~15-min self-directed computer session, "Skin Safe program"	Sun-protection score (8-item, higher is safer), mean (SD) Group: Baseline: 6 mo: *P* value IG: 4.60 (1.82): 5.36 (1.72): 0.004 CG: 4.66 (1.55): 5.06 (1.59) Mean difference, 0.30 (95% CI, 0.10–0.51)	Fair quality: 78% follow-up, higher follow-up in intervention group, composite score only
Prochaska et al, 2005 (43); RCT	Home (primary care); $n = 3834$; mean age, 45 y; stage of change	4 phone sessions (unknown duration), written survey assessments with computer-generated tailored materials	Sun-avoidance score (4-item, higher is safer), mean (SD) Group: Baseline: 12 mo: 24 mo: *P* value IG: 12.7 (3.6): 13.5 (3.5): 13.7 (3.5): <0.005 CG: 12.4 (3.7): 12.9 (3.6): 12.9 (3.6) Sunscreen-use score (3-item, higher is safer), mean (SD) IG: 8.6 (3.9): 9.8 (3.8): 10.0 (3.9): <0.001 CG: 8.5 (3.9): 8.9 (3.9): 9.2 (3.9)	Fair quality: <80% follow-up, higher follow-up in control group, some gaps in reporting, composite scores only
Prochaska et al, 2004 (44); RCT	Home (school); $n = 1802$; mean age, 42 y; stage of change	4 phone sessions (unknown duration), written survey assessments with computer-generated tailored materials	Sun-avoidance score (4-item, higher is safer), mean (SD) Group: Baseline: 12 mo: 24 mo: *P* value IG: 12.65 (3.9): 13.71 (3.5): 13.99 (3.4): >0.05 CG: 12.60 (3.9): 13.22 (3.6): 13.35 (3.7) Sunscreen-use score (3-item, higher is safer), mean (SD) IG: 8.32 (4.0): 9.96 (3.9): 10.21 (3.9): <0.05 CG: 8.16 (4.0): 9.29 (4.0): 9.18 (3.8)	Fair quality: <80% follow-up, higher follow-up in control group, some gaps in reporting, composite scores only
Geller et al, 2006 (45); cluster RCT	Home (dermatology); $n = 494$; mean age, 58 y; family history	4 (~15-min) phone sessions with computer-generated tailored materials	Tanned by the end of previous summer Group: 6 mo: 12 mo IG: 36.8%: 25.7% CG: 38.0%: 35.6% Adjusted OR, 0.72 (CI, 0.47–1.09) Routinely use sunscreen with SPF ≥15 IG: 66.7%: 67.4% CG: 64.4%: 66.1% Adjusted OR, 0.96 (CI, 0.67–1.38)	Fair quality: only 64% follow-up at 12 mo, different behavioral outcomes reported
Young adults				
Hillhouse et al, 2008 (46); RCT	University; $n = 430$; mean age, 19 y; women who use indoor tanning	Professionally produced booklet, appearance-focused	Indoor tanning sessions for previous 3 mo, mean (±SE) Group: Baseline: 6 mo: *P* value IG: 4.67 ± 0.60: 6.80 ± 0.93: <0.001 CG: 4.48 ± 0.55: 10.90 ± 0.93	Fair quality: good (96%) follow-up but some gaps in reporting
Mahler et al, 2007 (47); RCT	University; $n = 133$; mean age, 20 y; 80% women	11-min appearance-focused video on photoaging (plus or minus UV facial photo)	Skin color using skin-reflectance spectrophotometry, change in L* scale (measure of lightness or black versus white) at 12 mo (higher is lighter; exact numbers NR) Exposure site: Video: No video: *P* value Higher: ~1.6: ~−0.6: Significant Lower: ~2.3: ~0.9: Significant Sun-protection score (8-item, higher is safer), *Z* scores adjusted for baseline (±SE) at 12 mo : Video: No video: *P* value Index: −0.02 ± 0.10: −0.07 ± 0.09: NS	Fair quality: only 63% follow-up, results not presented vs. control group
Stapleton et al, 2010 (48); RCT	University; $n = 362$; mean age, 19 y; women who use indoor tanning	Professionally produced booklet, appearance-focused	Indoor tanning sessions in previous 3 mo, mean (SD) (results presented by subgroups only) Group: Baseline: 3 mo: *P* value: Cohen *d* statistic Knowledgeable, appearance tanner ($n = 175$) IG: NR: 7.61 (10.01): NS: 0.20 CG: NR: 9.68 (10.85) Low-knowledge tanner ($n = 114$) IG: NR: 5.59 (7.59): <0.05: 0.46 CG: NR: 9.71 (10.06) Low-knowledge, relaxation tanner ($n = 26$) IG: NR: 7.15 (9.17): NS: 0.30 CG: NR: 10.46 (12.28) Knowledgeable, low-appearance, relaxation tanner ($n = 35$) IG: NR: 2.25 (5.79): NS: 0.27 CG: NR: 1.04 (2.62)	Fair quality: <80% follow-up, only 3-mo follow-up, some gaps in reporting, results by subgroup only

Continued on following page

Table 2—Continued

Study, Year (Reference); Study Design	Setting and Population	Intervention	Outcomes	Validity Concerns
Turrisi et al, 2008 (49); RCT	University; n = 105; mean age, NR; women who frequently indoor tan	IG1: 30-min appearance-focused peer-counseling session with graphic feedback IG2: mailed graphic feedback only	Indoor tanning sessions in previous 3 mo, mean difference (SD) Group — 3 mo — P value IG1 — 4.40 (7.74) — <0.006 IG2 — 9.03 (11.92) — NS CG — 11.78 (13.03)	Fair quality: follow-up NR, only 3-mo follow-up
Children				
Norman et al, 2007 (50); RCT	Primary care; n = 819; mean age, 13 y; not selected for risk	Two 20-min computer sessions with tailored materials, 4 phone sessions, brief primary care physician counseling	Adjusted mean sun-protection scale (7-item, higher is safer) Exact numbers NR At 6, 12, and 24 mo for IG, a statistically significant increase in sun-protection scores compared with CG, with trajectory of scores flattening (but still statistically significant) from 12–24 mo	Fair quality: 80% follow-up; some gaps in reporting; for individual behavior results, only avoid or limit midday sun exposure were significant
Crane et al, 2006 (51); cluster RCT	Primary care; n = 728; new parents; not selected for risk	Counseling and written materials given by primary care physician at 4 well-child visits	Mean sun-protection score (7-item, higher is safer) Group — 12 mo — 24 mo — 36 mo — P value IG — 18.55 — 18.52 — 18.18 — 0.04 CG — 18.40 — 18.05 — 17.71	Fair quality: >75% follow-up, none of the individual behavior results was statistically significant

CG = control group; IG = intervention group; NR = not reported; NS = not significant; OR = odds ratio; RCT = randomized, controlled trial; SPF = sun protection factor; UV = ultraviolet.

ences in 6 of 7 sun-protection questions that contribute to the composite score.

Key Question 4: Association Between Sun Exposure, Sunscreen Use, and Indoor Tanning and Skin Cancer

Sixty articles representing 35 unique fair- or good-quality studies evaluated the epidemiologic association between sun exposure, indoor tanning, or sunscreen use and skin cancer (**Table 3** and **Appendix Table 2**, available at www.annals.org). We found only 1 good-quality trial, the Nambour Skin Cancer and Actinic Eye Disease Prevention Trial (The Nambour Trial) (53, 85, 87–89); 6 fair- or good-quality cohort studies (52, 54–56, 64, 86); and 28 fair- or good-quality, population-based, case–control studies (31, 57–63, 65–84), 3 of which were nested case–control studies (57, 73, 75). Odds ratios (ORs) and risk ratios provide a general estimate of the magnitude of the association between the highest- and lowest-risk groups. The ORs and risk ratios, however, should not be compared between studies because the studies used very different measures of exposures and choice of reference groups. Although measures of sun exposure varied greatly among studies, they can be generally categorized as intermittent, which includes measures of recreational sun exposure; chronic, which includes occupational measures of sun exposure; or total, which are cumulative estimates of sun exposure. This section for key question 4 includes a higher-level synthesis of results (**Table 3**) and a summary of the major limitations of these results; interested readers may refer to **Appendix Table 2** for individual study details with outcome data.

Sun Exposure

On the basis of 5 fair- or good-quality cohort studies and 7 fair- or good-quality case–control studies, increasing intermittent sun exposure in childhood and during one's lifetime is associated with an increased risk for both squamous cell carcinoma and basal cell carcinoma (range of ORs, 1.27 to 3.86) (**Appendix Table 2**) (52–63). The evidence is more consistent for intermittent sun exposure in childhood leading to an increased risk for squamous cell carcinoma and basal cell carcinoma than in adulthood (52, 58, 60, 62). Although few studies examined the association between total (or cumulative) and chronic (or occupational) sun exposure, most existing studies did not suggest a strong association between total or chronic sun exposure and squamous cell carcinoma or basal cell carcinoma (**Appendix Table 2**) (53, 54, 58, 59, 61, 62).

On the basis of 1 fair-quality cohort study and 13 fair-quality case–control studies, it seems that increasing intermittent sun exposure is generally associated with an increased risk for melanoma (**Appendix Table 2**). A large, fair-quality cohort study from Norway and Sweden showed a statistically significant trend between frequency of sunbathing vacations (childhood and adulthood) and the risk for melanoma (64). Of the 8 case–control studies that examined lifetime recreational sun exposure (31, 57, 65, 66, 69, 70, 72, 76), 5 studies showed that increasing total recreational sun exposure was associated with melanoma risk (range of ORs, 1.3 to 5.0) (57, 65, 66, 69, 70). Three of 4 case–control studies that examined recreational sun exposure during childhood suggest that increasing sun-

bathing behavior in childhood is associated with an increased risk for melanoma (range of ORs, 1.7 to 3.5) (70, 71, 73, 75). On the basis of fair-quality case–control studies, it seems that both total and chronic sun exposure are not as strongly associated with melanoma. Six case–control studies included some measure of total sun exposure, either during childhood, during the recent past, or over the lifetime (**Appendix Table 2**) (65, 67, 69, 79–81). These studies showed mixed results: Two studies found a statistically significant association between total lifetime sun exposure and melanoma (65, 81) and 4 did not (67, 69, 79, 80). All 3 studies that examined total sun exposure during childhood, however, showed a statistically significant association between increasing sun exposure and melanoma (range of ORs, 1.81 to 4.4) (67, 79, 81). Nine case–control studies included some measure of chronic or occupational sun exposure (**Appendix Table 2**) (65, 66, 68, 69, 71, 77–80). Three of these studies suggest that occupational sun exposure is associated with an increased risk for melanoma. These studies, however, used crude measures of occupational sun exposure (66, 77, 78), and 1 study showed an increased risk only with the highest level of occupational exposure (>20 years' exposure) (78). In contrast, 5 of the remaining 6 studies suggest that occupational sun exposure is inversely associated with melanoma risk (65, 68, 69, 79, 80).

Indoor Tanning

Five fair-quality case–control studies examined the association between indoor tanning and the risk for squamous cell carcinoma or basal cell carcinoma (**Appendix Table 2**) (57, 59, 61, 62, 82). Four of 5 studies used only a crude dichotomous measure of indoor tanning, and none of these studies found a statistically significant association between ever and never use (57, 59, 61, 62). Three studies adjusted for both skin phenotype and sun exposure (57, 61, 62). One fair-quality case–control study that was larger and had a slightly higher proportion of exposed persons showed a statistically significant association between indoor tanning and risk for squamous cell carcinoma and basal cell carcinoma, with greater risk for persons who reported early first use (before age 20 years). This study, however, did not adjust for sun exposure (82).

We found 1 fair-quality cohort study and 11 fair-quality case–control studies that examined the association between indoor tanning and melanoma (**Appendix Table 2**) (31, 57, 64, 66, 68, 72–74, 76, 83, 84, 90). Most studies used crude measures of indoor tanning exposure. The Norwegian–Swedish Women's Lifestyle and Health Cohort Study found that women who reported regular solarium use (≥1 time per month over 2 or 3 decades) from age 10 to 39 years had an increased risk for melanoma (risk ratio, 2.37 [95% CI, 1.37 to 4.08]) after adjustment for important confounders, including skin phenotype and intermittent sun exposure (64). Six of 11 case–control studies did not find a statistically significant association between ever or never use of indoor tanning and melanoma (**Appendix Table 2**) (66, 68, 72, 73, 84, 90). Only 1 of 6 negative studies adjusted for both skin phenotype and some measure of sun exposure (90). Of the 4 studies that found a statistically significant association between indoor tanning exposure and melanoma, 2 adjusted for both skin phenotype and some measure of sun exposure (57, 76) and 1 adjusted only for skin phenotype (74). These studies suggest that regular or higher frequency of indoor tanning or use at a younger age may increase risk for melanoma. Only 1 study examined sun lamp (older technology) and tanning bed (newer technology) exposure separately. Al-

Table 3. **Association Between Sun Exposure, Indoor Tanning, or Sunscreen Use and Skin Cancer***

Exposure	Skin Cancer	Total in Study Type (Reference)	Total, *n*	Findings
Intermittent or recreational sun exposure	SCC or BCC	5 cohort (52–56) 7 case–control (57–63)	234 214	Increased risk (OR, 1.3–5.0); more consistent in studies with timing of sun exposure in childhood
	Melanoma	1 cohort (64) 14 case–control (31, 57, 65–76)	119 953	
Chronic or occupational sun exposure	SCC or BCC	2 cohort (53, 54) 4 case–control (58, 59, 61, 62)	6337	No significant association
	Melanoma	9 case–control (65, 66, 68, 69, 71, 77–80)	6527	Mixed findings; 5 of 9 studies show inverse association
Total or cumulative sun exposure	SCC or BCC	4 case–control (58–61)	2541	No significant association
	Melanoma	6 case–control (65, 67, 69, 79–81)	4890	Increased risk (OR, 1.8–4.4) in studies with sun exposure in childhood
Indoor tanning	SCC or BCC	5 case–control (57, 59, 61, 62, 82)	4306	Very limited evidence available
	Melanoma	1 cohort (64) 11 case–control (31, 57, 65, 66, 68, 72–74, 76, 83, 84)	119 027	Increased risk (OR, 1.6–2.3) with regular use or use at a younger age
Sunscreen use	SCC or BCC	1 RCT (85) 2 cohort (55, 56) 2 case–control (58, 59)	184 424	Regular use can prevent SCC (RR, 0.65); no significant association for BCC
	Melanoma	1 cohort (86) 4 case–control (31, 66, 68, 76)	182 326	Mixed findings; no clear protective or harmful association

BCC = basal cell carcinoma; OR = odds ratio; RR = relative risk; SCC = squamous cell carcinoma.
* See **Appendix Table 2** (available at www.annals.org) for study details.

though only frequent sun lamp use was associated with increased melanoma risk, study investigators caution that sufficient lag time may not have elapsed to assess a potential effect, given the more recent use of tanning beds (83).

Sunscreen Use

We found 1 RCT (1621 participants) examining whether regular sunscreen use can prevent squamous cell carcinoma or basal cell carcinoma (85, 87, 88). After 8 years of follow-up, persons randomly assigned to regular sunscreen use had a decreased risk for squamous cell carcinoma (risk ratio, 0.65 [CI, 0.45 to 0.94]) but not basal cell carcinoma (risk ratio, 1.02 [CI 0.78 to 1.35]). Two fair-quality cohort studies from the Nurses' Health Study did not show a decrease in squamous cell carcinoma or basal cell carcinoma risk with sunscreen use after adjusting for skin phenotype and sun exposure (**Appendix Table 2**) (55, 56). Both of these studies, however, used only a crude dichotomous measure of sunscreen use. Although 2 fair-quality case–control studies suggest a protective effect of sunscreen for basal cell carcinoma, both used crude measures of sunscreen use and neither adjusted for sun exposure (**Appendix Table 2**) (58, 59).

On the basis of 1 fair-quality cohort and 4 fair-quality case–control studies, sunscreen use has no clear protective or harmful effect on the risk for melanoma (**Appendix Table 2**) (31, 66, 68, 76, 86). One cohort and 1 case–control study found no significant association between a crude dichotomous measure of sunscreen use and risk for melanoma (66, 86). One study found a protective effect for women who reported always using sunscreen compared with those who reported sometimes or never using sunscreen. This study adjusted for skin phenotype and sunburn, but not sun exposure (68). Two studies conducted in Sweden found a statistically significant harmful effect of sunscreen, such that persons who reported always or almost always using sunscreen were at increased risk for melanoma, after adjustment for both skin phenotype and sun exposure (31, 76).

Study Heterogeneity and Methodological Limitations

This body of epidemiologic evidence examining sun exposure, indoor tanning, and sunscreen use has several important limitations. There was great heterogeneity in the actual measurement of sun exposure among studies, the categorization of levels of exposure, and in choice of reference groups. Sun-exposure measurements used different definitions and assessment methods and often covered different periods of a person's life. Measurement of sunscreen rarely included important details, such as sun protection factor, amount, frequency and duration, and years because sunscreens have changed over time. Likewise, measurement of indoor tanning rarely included important details, such as rationale or motivation of use, frequency and duration, and years because indoor tanning devices have also changed over time. Adjustment for important confounders and stratification to examine effect modification also varied across studies. Studies examining sun exposure generally adjusted for age, sex, and some measure of skin phenotype or sun sensitivity. Several studies examining indoor tanning and sunscreen use did not adjust for sun exposure. Some studies also may have overadjusted for confounding, such as adjustment for nevi, freckling, or sunburn history, because these are probably intermediate steps in carcinogenesis or surrogates for sun exposure. Finally, only 4 studies presented results stratified by skin phenotype; these studies suggest an interaction between skin phenotype and skin cancer (25, 57, 75, 91). Therefore, simply adjusting for skin type as a confounder in logistic regression may be insufficient to illuminate the effect of sun exposure in at-risk populations (for example, poor tanners). Lack of adequate adjustment and lack of stratification for skin phenotype may explain the lack of association seen in some studies or inverse association reported with occupational sun exposure.

Key Questions 3 and 5: Potential Harms of Sun-Protective Behaviors

On the basis of the trials included in key questions 1 and 2, we found no evidence for harms of counseling to prevent skin cancer. In addition, we found 17 fair- or good-quality studies that directly examined the potential harms of sun-protective behaviors (**Table 4**) (92–107). Overall validity concerns are summarized in **Table 4**. One fair-quality trial that examined whether adherence to sun-protective behaviors in children reduces physical activity found no difference in body mass index or self-reported time spent outdoors at long-term follow-up between children receiving sun-protection curricula versus standard health-education curricula in schools (92). This finding is consistent with 1 of the included counseling trials that found no difference in self-reported measures of physical activity (50, 106, 107). Six fair- or good-quality trials examined whether sunscreen use leads to increased sun exposure (93–95, 108–110). These RCTs suggest that sunscreen with a higher sun protection factor may increase intentional sun exposure in healthy student volunteers on vacation. Sunscreen use in general, however, does not promote increased sun exposure. Three fair-quality studies examined the effect of sun exposure or sunscreen use on vitamin D levels (96, 97, 111). One small, fair-quality trial showed that sunscreen use during the summer did not significantly decrease vitamin D levels or cause vitamin D deficiency (96). Two fair-quality cohort studies demonstrated that vitamin D levels were influenced by sun exposure, such that post- or perimenopausal women living at high altitudes were at risk for transient vitamin D deficiency during winter months (97, 111).

It is hypothesized that sun exposure may be protective against some types of cancer through vitamin D production. Seven fair- or good-quality studies examined the re-

Table 4. **Summary of Evidence**

Key Question	Studies	Findings	Validity Concerns
1	No trials identified		
2: Adults	5 RCTs (n = 7443)	Counseling with tailored risk feedback (with or without computer support) can make small increases in sun-protective behavior composite scores	No good-quality trials; samples selected for skin-cancer risk factors or suboptimal sun-protective behaviors; trials used composite scores
2: Young adults	4 RCTs (n = 1030)	Appearance-focused counseling in college-aged women who indoor tan can decrease self-reported tanning and objectively measured sun exposure	No good-quality trials; samples selected for women who indoor tan; none conducted in primary care; trials had short-term follow-up
2: Adolescents	1 RCT (n = 819)	Counseling with computer support for adolescents can decrease self-reported sun exposure	Only 1 fair-quality trial
2: Children	1 RCT (n = 728)	Counseling integrated into well-child visits for infants can make small increases in sun-protective behavior composite scores	Only 1 fair-quality trial; none of the individual sun-protective behavior changes was significant
4: Sun exposure	6 cohort (n = 335 835) 25 case–control (n = 20 425)	Intermittent sun exposure, especially sun exposure in childhood, can increase the risk for all types of skin cancer	Overall fair-quality evidence with large variation in measurement of exposure and inconsistent adjustment of confounders; cohort studies not primarily designed to measure sun exposure
4: Indoor tanning	1 cohort (n = 106 366) 15 case–control (n = 15 079)	Limited evidence to suggest that regular or early use of indoor tanning may increase the risk for melanoma	Overall fair- to poor-quality evidence using crude measures of indoor tanning and sunscreen use and inconsistent (sometimes inadequate) adjustment for confounders; concerns about applicability owing to change in indoor tanning and sunscreen technology over past 20–30 y
4: Sunscreen	1 RCT (n = 1621) 3 cohort (n = 369 421) 6 case–control (n = 5708)	Regular sunscreen use can prevent SCC, but benefit is unclear for BCC or melanoma	
3 or 5: Activity	2 RCTs (n = 2434)	No evidence for decrease in physical activity in youth; potential harms include increased sun exposure with higher SPF sunscreen (but not sunburns) in young adults who are intentionally sunbathing; evidence for an inverse association of cancer risk due to sun exposure (through vitamin D) is very limited at this point	Overall, fair-quality evidence; evidence was sparse for lack of harms for vitamin D deficiency owing to inclusion criteria; evidence was sparse with methodological limitations for increased cancer risk; probable publication bias
3 or 5: Sun exposure	6 RCTs (n = 4482) plus the 8 RCTs from key question 2		
5: Vitamin D	1 RCT 2 cohort (n = 2116)		
5: Cancer	1 cohort 8 case–control (n = 26 037)		

BCC = basal cell carcinoma; RCT = randomized, controlled trial; SCC = squamous cell carcinoma; SPF = sun protection factor; UV = ultraviolet.

lationship between sun exposure and risk for nonskin cancer (98, 99, 101–105). On the basis of a sparse body of fair- or good-quality cohort and case–control studies, it seems that sun exposure in lighter pigmented persons may be inversely related to risk for advanced breast and prostate cancer after adjustment for well-established risk factors and that intermittent sun exposure may be inversely related to risk for non-Hodgkin lymphoma (98, 100–103, 105). None of these studies, however, directly measured vitamin D status.

Discussion

New evidence since the 2003 USPSTF recommendation suggests that counseling relevant to primary care can change sun-protective behaviors (**Table 4**). In young women, appearance-focused behavioral interventions can decrease indoor tanning behaviors and ultraviolet exposure in the short term. In young adolescents, primary care counseling with computer support can decrease midday sun exposure and increase sunscreen use. Evidence in adults and parents of newborns suggests that behavioral interventions can minimally increase composite scores measuring sun-protective behaviors. It is unclear, however, whether the small differences in composite scores of self-reported sun-protective behaviors translate into clinically meaningful behavior change to prevent skin cancer or sunburns.

Most of the counseling interventions that were effective in promoting sun-protective behaviors in adults incorporated computerized support providing tailored patient education. This type of computerized support is not widely available, although it is unclear whether it is essential to the effectiveness of the interventions. All trials conducted in young adults used "appearance-focused" behavioral interventions primarily aimed at women. It is possible that different counseling messages will be effective for populations of different age or sex. More primary care–relevant counseling trials to promote sun-protective behaviors are needed, especially in younger persons. On the basis of the epidemiologic evidence, childhood seems to be the ideal time to intervene in terms of sun-protective behaviors. Tri-

als of successful interventions need to be replicated in other populations, however, and trials should incorporate more consistent and robust measures of ultraviolet exposure, sun-protective behaviors, and indoor tanning (112, 113).

Overall, we found little evidence that sun-protective counseling or practicing sun-protective behaviors cause important harms, including decreasing physical activity, paradoxically increasing sun exposure, or causing clinically significant vitamin D deficiency. A recent report from the World Health Organization International Agency for Research on Cancer addresses the complex relationship between serum vitamin D levels and sun exposure (114). Although cutaneous vitamin D synthesis varies among persons, it generally happens relatively quickly, such that maximum vitamin D synthesis occurs at suberythemogenic ultraviolet doses (114). In addition, this report recognizes the importance of dietary vitamin D during the winter when skin synthesis of vitamin D is insufficient (114). Finally, it has been hypothesized that vitamin D production may be protective against certain types of cancer. The few case–control studies published on this topic suggest that intermittent sun exposure in lighter-pigmented persons may be inversely related to risk for advanced breast cancer, prostate cancer, and non-Hodgkin lymphoma. However, this literature is sparse, and the available population-based case–control studies lack adjustment for vitamin D intake and direct measurement of vitamin D levels. Furthermore, given the limited number of published studies, it is likely that this body of literature is affected by publication bias (114).

Fair-quality cohort and case–control studies examining the relationship between sun exposure and skin cancer suggests that increasing intermittent (or recreational) sun exposure is associated with an increased risk for all types of skin cancer (**Table 4**). Fewer studies examined the association of total and chronic (or occupational) sun exposure. These studies do not suggest a strong association between total or chronic sun exposure and skin cancer. Our findings are generally consistent with other existing reviews examining the association between ultraviolet exposure and skin cancer (23, 115). A limited number of studies using crude measures of indoor tanning exposure examined the risk for squamous cell carcinoma and basal cell carcinoma, after adjusting for all important confounders. However, a slightly larger body of higher-quality evidence suggests that regular or early use of indoor tanning may increase the risk for melanoma. Again, this finding is consistent with an existing review by the International Agency for Research on Cancer Working Group on artificial ultraviolet light and skin cancer that found evidence to suggest that first use of indoor tanning equipment before age 35 years increases risk for melanoma (17). Regular sunscreen use can prevent squamous cell carcinoma, but it is unclear whether it can prevent basal cell carcinoma or melanoma. This finding is consistent with a fair-quality systematic review and meta-analysis by Dennis and colleagues (18) that found no significant association between melanoma and sunscreen use. Therefore, behavioral counseling to promote skin cancer prevention should focus on improving several behaviors to reduce ultraviolet exposure and not on increasing sunscreen use alone.

Despite the number of relevant cohort and population-based case–control studies, the available literature is limited because of the complex and variable nature of measuring sun exposure and sunscreen use; inconsistent and inadequate evaluation of important confounders and effect modifiers; and problems with recall bias, retest reliability, and other errors in determining true exposure (116). However, 1 included study found little evidence of important recall bias of ultraviolet exposure (73). In addition, the associations observed in these studies may not apply to current use of indoor tanning or sunscreen because these technologies have changed in the recent past. Indoor tanning devices produced before 1980 had higher ultraviolet B (UVB) content, and those produced after 1980 had higher ultraviolet A (UVA) content (83). Furthermore, modern tanning beds have undergone technologic advances to enrich UVB that allow shorter duration of exposure. In practice, however, the proportion of UVB output of indoor tanning devices varies (17). Likewise, sunscreens have also changed over time. Sun protection factor was introduced in 1978, and protection for UVA was not added until 1989. Ultraviolet sun exposure is approximately 5% UVB and 95% UVA (17). In addition, current sunscreens offer higher-level sun protection factor and water resistance.

More and better-designed studies are needed to examine the potential harms of sunscreen use and decreased sun exposure on vitamin D and other diseases hypothesized to be affected by vitamin D, including nonskin cancer. Currently, no evidence suggests that sun-protective behavior messages aimed at reducing prolonged or intense sun exposure and sunburns cause important harms, such as vitamin D deficiency or increasing risk for cancer. Additional studies with more detailed assessment of sunscreen and indoor tanning are needed. It is important that these studies consistently adjust for both important host and environmental factors. Survey instruments to assess for these types of exposure must be reliable and validated. This body of evidence would be strengthened if studies used the same or similar measurements to facilitate comparisons across studies. It will probably take decades to see a potential protective effect of regular use of sunscreens on melanoma risk or potential harms of current tanning beds on melanoma risk. Therefore, studies evaluating current sunscreens and indoor tanning will continue to be necessary well into the future.

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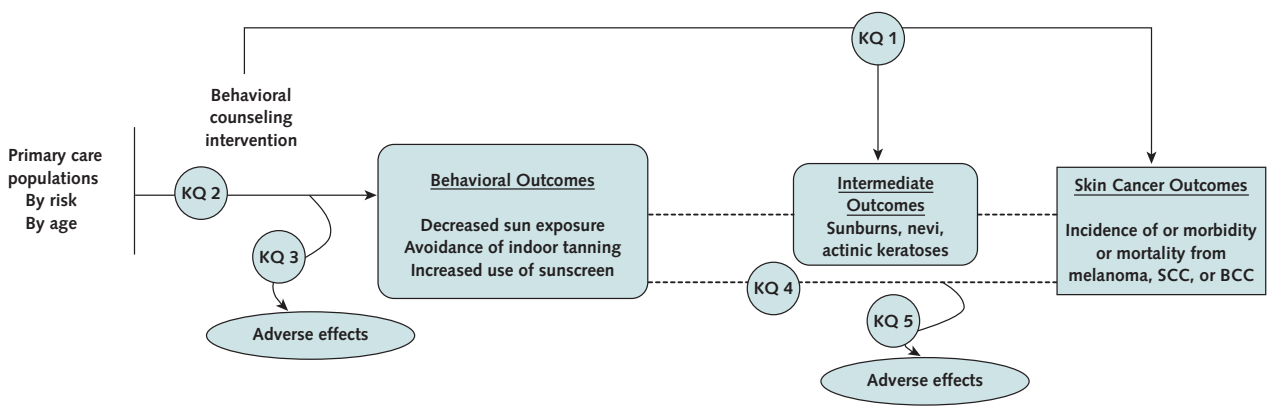
Appendix Figure 1. **Analytic framework and key questions.**

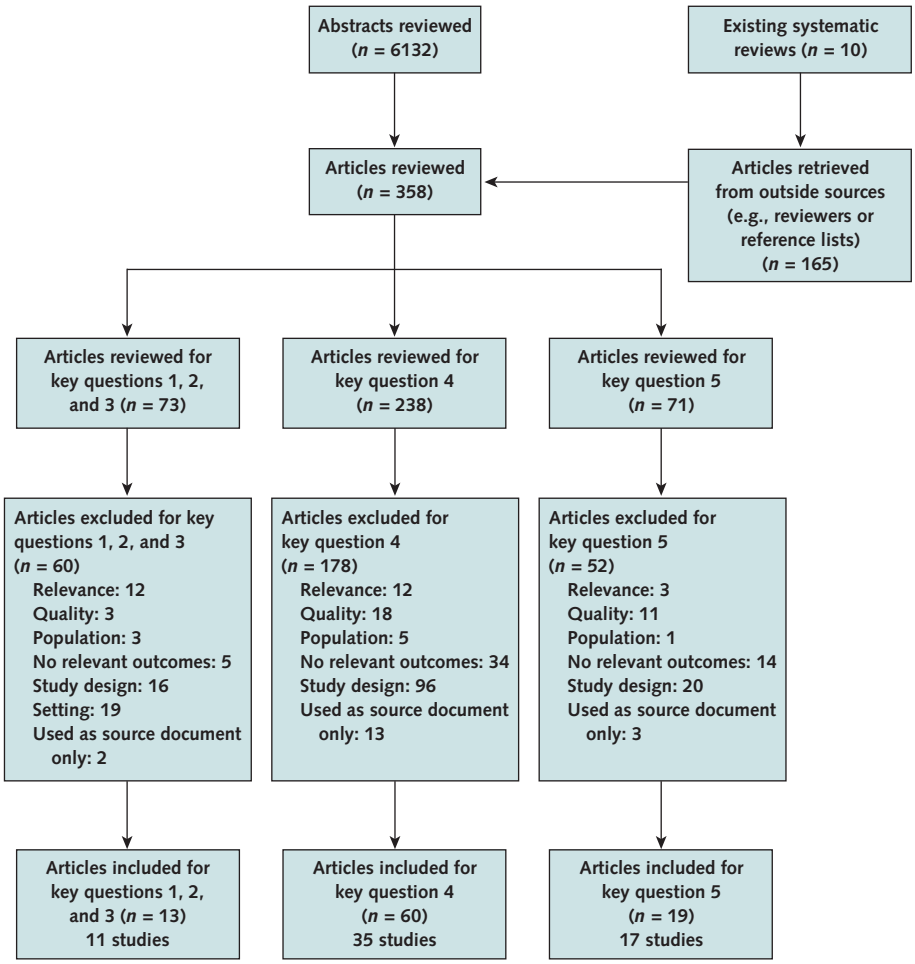


Key Questions

1. **Is there direct evidence that counseling patients on sun-protective behaviors (decreasing sun exposure, avoidance of indoor tanning, and using sunscreen) reduces intermediate outcomes (sunburns, nevi, or actinic keratoses) or skin cancer (melanoma, SCC, or BCC)?**
2. **Do primary care–relevant counseling interventions change sun-protective behaviors (decreasing sun exposure, avoidance of indoor tanning, and using sunscreen)?**
3. **Do primary care–relevant counseling interventions have adverse effects?**
4. **Is sun exposure (intentional or unintentional), indoor tanning, or sunscreen use associated with skin cancer outcomes?**
5. **Are sun-protective behaviors associated with adverse effects (e.g., paradoxical increase in sun exposure, reduced physical activity, dysphoric mood, vitamin D deficiency)?**

BCC = basal cell carcinoma; KQ = key question; SCC = squamous cell carcinoma.

Appendix Figure 2. **Summary of evidence search and selection.**



Appendix Table 1. Inclusion and Exclusion Criteria, by Key Question

Variable	Key Questions 1–3 (Counseling)	Key Questions 4 (Association) and 5 (Harms)
Study design		
Include	Randomized or controlled clinical trials	Trials or observational studies (including cohort or population-based case–control studies)
Exclude	Any observational study	Hospital-based case–control studies, ecological analyses, cross-sectional studies, case series, and case reports
Setting		
Include	English-speaking countries, primary care or setting judged to be generalizable to primary care	Any setting
Exclude	Inpatient hospital units, emergency departments, pharmacies, recreational or occupational settings, other community-based settings (e.g., schools or churches)	None
Population		
Include	Any age person without current or past skin cancer or precancerous skin lesions	Any sample (sample description must be reported)
Exclude	Persons with syndromes that substantially increase risk for skin cancer (e.g., xeroderma pigmentosum, albinism, persons being treated with psoralen or UV treatment, or familial syndromes or strong family history of melanoma)	
Intervention or exposure		
Include	Counseling involving individual-level identification of person, conducted in primary care, or judged to be feasible to be conducted in primary care (e.g., mailed or electronic interventions), or referable from primary care (i.e., delivered as part of the health care setting or widely available at a national level in the community)	Exposure to UV radiation (sun or indoor tanning) or sunscreen use, with description of how exposure was measured
Exclude	Noncounseling interventions, counseling for skin self-examinations, nonreferable interventions (through work or school), social marketing, or policy interventions	None
Outcome		
Include	Skin cancer incidence or associated morbidity or mortality; intermediate outcomes (sunburns, nevi, or actinic keratosis); behavioral outcomes (decrease in UV exposure through avoidance or reduction or midday or peak hours, wearing protective clothing, avoidance of indoor tanning, and use of sunscreen); adverse outcomes (e.g., paradoxical increase in sun exposure, reduced physical activity, dysphoric mood, vitamin D deficiency, increased incidence of nonskin cancer)	
Exclude	Any trial with >40% attrition or no behavioral outcome beyond 3 mo; attitude, knowledge, or ability changes	None

UV = ultraviolet.

Appendix Table 2. Associations Between Sun Exposure, Indoor Tanning, or Sunscreen Use and Skin Cancer (SCC, BCC, or Melanoma)

Study, Year (Reference); Quality Rating	Design; Setting; Sample	Total Sun Exposure (RR or OR [95% CI])*	Intermittent Sun Exposure (RR or OR [95% CI])*	Chronic Sun Exposure (RR or OR [95% CI])*	Adjustments Reported
Association between sun exposure and skin cancer (SCC or BCC)					
Chen et al, 2010 (60); fair	Case–control; Taiwan; 87 cases, 216 controls	Lifetime sun exposure (tertile) for SCC First: reference Second: 2.98 (1.36–6.53) Third: 3.95 (1.81–8.59)	**For SCC** Early-age sun exposure (tertile) First: reference Second: 1.49 (0.72–3.09) Third: 2.43 (1.25–4.75)	NR	Age, sex, smoking status, BMI
Gallagher et al, 1995 (61), Bajdik et al, 1996 (117); fair	Case–control; Alberta, Canada; 180 cases, 406 controls	Mean cumulative sun exposure per year for SCC <11.5 h/wk summer: reference 11.5–19 h/wk summer: 1.8 (0.9–3.3) 19–28 h/wk summer: 1.2 (0.6–2.3) ≥28 h/wk summer: 1.0 (0.4–2.1)	Mean recreational sun exposure per year **For SCC** **Age 0–19 y** <3.8 h/wk summer: reference 3.8–7.5 h/wk summer: 1.2 (0.6–2.5) 7.5–12.5 h/wk summer: 1.1 (0.5–2.6) ≥12.5 h/wk summer: 1.6 (0.6–4.5) **Lifetime** <2.8 h/wk summer: reference 2.8–5.6 h/wk summer: 0.6 (0.3–1.1) 5.6–8.5 h/wk summer: 0.8 (0.3–1.8) ≥8.5 h/wk summer: 0.3 (0.1–0.9)	Mean occupational sun exposure per year **For SCC** <3.5 h/wk summer: reference 3.5–14 h/wk summer: 0.8 (0.3–2.0) 14–25 h/wk summer: 1.5 (0.6–4.2) ≥25 h/wk summer: 1.4 (0.4–4.3)	Age, sex, mother's ethnic origin, hair color, skin color
Gallagher et al, 1995 (62), Bajdik et al, 1996 (117); fair	Case–control; Alberta, Canada; 226 cases, 406 controls	NR	Mean recreational sun exposure per year **For BCC** **Age 0–19 y** <3.8 h/wk summer: reference 3.8–7.5 h/wk summer: 1.1 (0.6–2.0) 7.5–12.5 h/wk summer: 1.4 (0.7–3.0) ≥12.5 h/wk summer: 2.6 (1.1–6.5) **Lifetime** <2.8 h/wk summer: reference 2.8–5.6 h/wk summer: 0.9 (0.5–1.7) 5.6–8.5 h/wk summer: 0.6 (0.3–1.3) ≥8.5 h/wk summer: 0.4 (0.2–1.0)	Mean occupational sun exposure per year **For BCC** <3.5 h/wk summer: reference 3.5–14 h/wk summer: 1.0 (0.6–1.8) 14–25 h/wk summer: 1.3 (0.8–2.3) ≥25 h/wk summer: 1.4 (0.8–2.4)	Age, sex, mother's ethnic origin, hair color, skin color
Green et al, 1996 (54), Nambour Skin Cancer Study; fair	Cohort; Queensland, Australia; n = 2095	NR	Leisure exposure **For SCC** Mainly indoors: reference Indoors/outdoors: 0.81 (0.37–1.80) Mainly outdoors: 1.29 (0.66–2.52) **For BCC** Mainly indoors: reference Indoors/outdoors: 0.93 (0.63–1.37) Mainly outdoors: 0.85 (0.59–1.21)	Occupational exposure **For SCC** Mainly indoors: reference Indoors/outdoors: 0.82 (0.47–1.43) Mainly outdoors: 1.37 (0.80–2.34) **For BCC** Mainly indoors: reference Indoors/outdoors: 1.07 (0.79–1.46) Mainly outdoors: 1.25 (0.88–1.78)	Age, sex, skin color
Grodstein et al, 1995 (55), NHS; good	Cohort; United States (11 states); n = 107 900	NR	Regular time outdoors in summer **For SCC** Yes (use sunscreen): reference Yes (no sunscreen): 0.9 (0.6–1.2) No: 0.7 (0.4–1.1)	NR	Age, smoking status, region, hair color, reaction to sun, lifetime number of sunburns
Han et al, 2006 (57), NHS; fair	Nested case–control; United States (11 states); 275 SCC cases, 283 BCC cases, 804 controls	NR	Total lifetime sun exposure while wearing a bathing suit (tertile) **For SCC** Low: reference Intermediate: 1.28 (0.85–1.93) High: 2.15 (1.45–3.19) **For BCC** Low: reference Intermediate: 1.71 (1.14–2.56) High: 2.05 (1.38–3.06)	NR	Age, constitutional susceptibility, family history of skin cancer, number of lifetime severe sunburns that blistered, sunlamp use or tanning salon attendance, region

Continued on following page

Appendix Table 2—Continued

Study, Year (Reference); Quality Rating	Design; Setting; Sample	Total Sun Exposure (RR or OR [95% CI])*	Intermittent Sun Exposure (RR or OR [95% CI])*	Chronic Sun Exposure (RR or OR [95% CI])*	Adjustments Reported
Hunter et al, 1990 (56), NHS; fair	Analytic cohort; United States (11 states); *n* = 73 366	NR	**For BCC** Regular time outdoors in summer Yes (with sunscreen): reference Yes (no sunscreen): 0.70 (0.60–0.82) No: 0.73 (0.59–0.90)	NR	Age, time period, region, time spent outdoors in summer and sunscreen habit, hair color, childhood tendency to burn, lifetime number of severe sunburns
Kricker et al, 1991 (58), Kricker et al, 1995 (25), Kricker et al, 1995 (91), English et al, 1998 (118), English et al, 1998 (20); fair	Case–control; Western Australia; 248 total cases; 226 BCC cases; 45 SCC cases; 1015 total controls; 1021 BCC controls; 1064 SCC controls	**For BCC** Total hours (thousands) sun exposure from 9 a.m.–5 p.m. **All ages** 0–40.5: reference 40.5–56.4: 0.99 (0.61–1.58) 56.4–81.6: 1.42 (0.86–2.35) ≥81.6: 0.77 (0.43–1.40) **Age ≥15 y** 0–14.7: reference 14.8–27.7: 1.25 (0.79–1.97) 27.8–49.3: 1.17 (0.72–1.90) ≥49.4: 0.86 (0.50–1.51) Total ambient sunlight in accumulated global radiance ($mWh/cm^2 \times 10^5$) 0–8.8: reference 8.8–10.1: 1.32 (0.69–2.55) 10.1–11.4: 1.72 (0.72–4.09) ≥11.4: 2.18 (0.82–5.82) **For SCC** Total ambient sunlight in accumulated global radiance ($mWh/cm^2 \times 10^5$) <8.84: reference 8.84–10.14: 1.4 (0.51–3.6) 10.1–11.5: 2.7 (0.84–8.6) ≥11.4510: 2.3 (0.62–8.3)	**For BCC** Intermittent sun exposure, age 15–19 y 0–40%: reference 41–58%: 1.49 (0.88–2.52) 59–99%: 1.82 (1.01–3.28) 100%: 3.86 (1.93–7.75) Lifetime hours of sun exposure on vacation 0–602: reference 602–2268: 1.65 (1.01–2.70) 2268–3794: 1.68 (1.00–2.80) ≥3794: 1.85 (1.09–3.13) Lifetime frequency of sunbathing None: reference 1–200: 1.57 (0.98–2.51) 201–700: 1.08 (0.68–1.72) 701–9000: 1.02 (0.63–1.64) **For SCC** Total hours of sun exposure on nonworking days 0–4999: reference 5000–8499: 2.0 (0.89–4.4) 8500–13 999: 1.9 (0.86–4.2) ≥14 000: 1.3 (0.57–2.9) Lifetime hours of sun exposure on vacations <600: reference 600–2268: 0.89 (0.44–1.8) 2269–3793: 1.0 (0.51–2.1) ≥3794: 0.93 (0.44–1.9)	**For BCC** NR **For SCC** Total hours of sun exposure on working days 0–11 499: reference 11 500–19 999: 0.93 (0.42–2.1) 20 000–32 999: 1.7 (0.81–3.8) ≥33 000: 1.3 (0.58–2.8)	Age, sex, ability to tan, total sun exposure (for recreational sun exposure)
Neale et al, 2007 (53), Nambour Skin Cancer Trial; fair	Cohort; Queensland, Australia; *n* = 1517	NR	**For BCC** Leisure exposure (head, trunk [respectively]) Indoors: reference Both: 0.93 (0.64–1.35); 1.15 (0.62–2.12) Outdoors: 0.99 (0.60–1.63); 0.84 (0.32–2.17)	**For BCC** Occupational exposure (head, trunk [respectively]) Indoors: reference Both: 0.95 (0.60–1.49); 1.07 (0.60–1.93) Outdoors: 0.86 (0.53–1.40); 1.12 (0.60–2.11)	Age, sex
Rosso et al, 1999 (59); fair	Case–control; Switzerland; 146 cases; 144 controls	Total lifetime hours **For SCC** <5000: reference 5001−64 200: 1.78 (0.18–17.67) ≥64 200: 1.42 (0.53–3.85) **For BCC** <5000: reference 15 001−15 800: 1.09 (0.62–1.92) 15 801−64 200: 0.99 (0.35–2.79) ≥64 200: 0.70 (0.20–2.39)	Lifetime hours at the beach on vacation **For SCC** Never: reference ≥2260: 0.78 (0.26–2.40) **For BCC** Never: reference <300: 1.46 (0.52–4.07) 381−1140: 1.39 (0.72–2.66) 1140−2260: 0.92 (0.44–1.91) ≥2260: 1.20 (0.61–2.34)	Lifetime hours of outdoor work **For SCC** Never: reference ≤47 900: 1.84 (0.30–11.09) 47 901−77 200: 2.02 (0.60–6.78) ≥77 200: 1.88 (0.30–11.70) **For BCC** Never: reference ≤12 000: 0.98 (0.58–1.66) 12 001−47 900: 1.30 (0.69–2.46) 47 901−77 200: 0.78 (0.52–1.19) ≥77 200: 0.90 (0.51–1.59)	Age, sex
van Dam et al, 1999 (52), HPFS; fair	Cohort; United States (multistate); *n* = 44 591	NR	**For BCC** Frequency outdoors in swimsuit as teenager in summer <1 time/wk: reference 1 time/wk: 1.30 (1.14–1.47) 2 times/wk: 1.34 (1.19–1.52) Several times/wk: 1.36 (1.22–1.52) Daily: 1.42 (1.24–1.63)	NR	Age, time period, region, hair color, eye color, skin reaction to sun, ancestry, BMI

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Appendix Table 2—Continued

Study, Year (Reference); Quality Rating	Design; Setting; Sample	Total Sun Exposure (RR or OR [95% CI])*	Intermittent Sun Exposure (RR or OR [95% CI])*	Chronic Sun Exposure (RR or OR [95% CI])*	Adjustments Reported
Vlajinac et al, 2000 (63); fair	Case–control; Yugoslavia; 200 cases, 399 controls	NR	Vacations at seaside before age 10 y **For BCC** Not statistically significant, OR not reported Average number of weeks per year spent at seaside 0: reference 1–6: NR ≥7: 1.81 (1.24–2.64)	NR	NR
Association between sun exposure and skin cancer (melanoma)					
Berwick et al, 1996 (65), Lea et al, 2007 (119), Chen et al, 1996 (120); fair	Case–control; Connecticut; 650 cases, 549 controls	Total lifetime sun exposure Light: reference Moderate: 1.26 (0.69–2.29) Heavy: 2.20 (1.21–4.01) Very heavy: 2.63 (1.25–5.54)	Total recreational sun exposure index, by body site Head/neck / Upper limb / Lower limb / Trunk Level 1: reference Level 2: 1.5 (0.7–3.3) / 0.9 (0.4–1.8) / 1.0 (0.5–2.2) / 1.7 (1.0–2.9) Level 3: 1.0 (0.7–2.1) / 1.0 (0.5–2.0) / 1.2 (0.6–2.7) / 1.4 (0.7–2.2) Level 4: 2.6 (1.2–5.6) / 2.4 (1.2–4.8) / 2.7 (1.2–5.8) / 2.7 (1.6–4.5) Number of vacations, age 0–15 y 0: reference 1–14: 1.1 (0.8–1.7) 15–90: 0.9 (0.5–1.4)	Total years in outdoor jobs, by body site Head/neck / Upper limb / Lower limb / Trunk 0: reference <5: 0.8 (0.4–1.5) / 0.7 (0.4–1.4) / 0.7 (0.3–1.3) / 0.7 (0.5–1.1) ≥5: 0.5 (0.2–1.1) / 0.6 (0.2–1.1) / 0.3 (0.1–0.9) / 0.9 (0.6–1.3)	Age, sex, skin self-examination, total nevi, family history skin cancer, skin type, hair/eye color, freckle, ever severely sunburned
Fargnoli et al, 2004 (66); fair	Case–control; central Italy; 100 cases, 200 controls	NR	Hours of recreational sun exposure per year <60: reference 60–120: 0.761 (0.420–1.378) 121–240: 1.641 (0.799–3.370) >240: 5.010 (2.110–11.891)	Occupational sun exposure No: reference Yes: 2.57 (1.40–4.73)	Age, sex, ethnicity, region, hair color, eye color, skin type
Gallagher et al, 1986 (69), Elwood et al, 1985 (121), Elwood et al, 1984 (122), Western Canada Melanoma Study; fair	Case–control; western Canada; 595 cases, 595 controls	Total hours annual sun exposure <49: reference 50–99: 1.5 (0.8–2.7) 100–149: 1.5 (0.9–2.7) 150–199: 1.6 (0.9–2.9) 200–299: 1.0 (0.6–1.7) 300–399: 1.1 (0.6–1.9) 400–499: 1.6 (0.9–2.7) ≥500: 1.2 (0.7–2.0)	Total hours of recreational exposure in summer <1: reference 1–19: 1.1 (0.7–1.6) 20–79: 1.7 (1.2–2.5) 80–159: 1.8 (1.2–2.7) ≥160: 1.7 (1.1–2.7) Total hours of vacation in summer <1: reference 1–6: 0.9 (0.7–1.3) 7–19: 0.9 (0.6–1.4) 20–39: 1.9 (1.3–3.0) ≥40: 1.5 (1.0–2.3) Total sunny vacations per decade of life 0: reference <1: 1.1 (1.0–1.1) 1–3: 1.3 (1.1–1.5) ≥4: 1.7 (1.2–2.3)	Occupation hours, summer season <1: reference 1–99: 1.8 (1.2–2.5) 100–199: 1.0 (0.7–1.5) 200–399: 0.9 (0.6–1.4) ≥400: 0.9 (0.6–1.5)	Age, sex, hair/skin color, freckling, ethnic origin
Garbe et al, 1989 (77); fair	Case–control; Germany; 200 cases, 200 controls	NR	NR	Occupational sun exposure None: reference Sometimes: 1.18 (0.56–2.48) Often: 11.62 (2.13–63.33)	Age, sex
Green and O'Rourke, 1985 (67), Green et al, 1986 (123); fair	Case–control; Queensland, Australia; 183 cases, 183 controls	Total hours sun exposure **Lifetime** <2000: reference 2000: 2.3 (1.0–5.1) 50 000: 1.7 (0.4–7.8) **Ages 10–19 y** <500: reference 500: 1.0 (0.5–2.0) 5000: 4.4 (1.8–184.5)	Recreational hours on the beach **Lifetime** 0: reference 1: 0.6 (0.2–1.4) 500: 0.3 (0.1–0.8) 5000: 1.3 (0.4–4.3) **Age 10–19 y** 0: reference 1: 1.1 (0.6–2.0) 500: 0.8 (0.4–1.9)	NR	Age, sex, presence of nevi on the arms, hair color, sunburn propensity

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Appendix Table 2—Continued

Study, Year (Reference); Quality Rating	Design; Setting; Sample	Total Sun Exposure (RR or OR [95% CI])*	Intermittent Sun Exposure (RR or OR [95% CI])*	Chronic Sun Exposure (RR or OR [95% CI])*	Adjustments Reported
Han et al, 2006 (57), NHS; fair	Nested case–control; United States (11 states); 200 cases, 804 controls	NR	Total lifetime sun exposure while wearing a bathing suit (tertile) Low: reference Intermediate: 1.20 (0.73–1.97) High: 2.37 (1.51–3.73)	NR	Age, constitutional susceptibility, family history of skin cancer, number of lifetime severe sunburns, indoor tanning, region
Holly et al, 1995 (68); fair	Case–control; San Francisco, CA; 452 cases, 930 controls	NR	Time spent outdoors on weekend **Previous 10 y** None: reference <25% of time: 0.72 (0.35–1.4) 25%–50% of time: 0.71 (0.37–1.4) 50%–75% of time: 0.86 (0.42–1.8) ≥75% of time: 0.84 (0.37–1.9) Frequency of sunbathing in typical year **Previous 10 y** Never: reference <Once/mo: 0.75 (0.52–1.1) Once/mo: 0.57 (0.36–0.89) 2–3 times/mo: 0.67 (0.46–0.98) ≥Once/wk: 0.79 (0.56–1.1)	Time spent outdoors on weekday **Previous 10 y** None: reference <25% of time: 0.71 (0.49–1.0) 25%–50% of time: 0.83 (0.53–1.3) ≥75% of time: 0.83 (0.46–1.5)	Age, sex, region
LeMarchand et al, 2006 (71); fair	Case–control; Hawaii; 278 cases, 278 controls	NR	Hours during summer in bathing suit **Age 8–10 y** 0: Men reference; Women reference 1–32: Men 1.2 (0.6–2.3); Women 2.1 (0.8–5.4) 33–80: Men 0.9 (0.4–1.8); Women 1.4 (0.5–3.7) ≥80: Men 2.0 (0.9–4.4); Women 3.4 (1.2–9.1) Hours during summer in bathing suit **Previous 5 y** 0: Men reference; Women reference 1–12: Men 1.4 (0.6–3.0); Women 2.1 (0.8–5.6) 13–24: Men 1.9 (0.8–4.4); Women 4.8 (1.7–13.4) ≥25: Men 2.5 (1.2–5.4); Women 3.3 (1.1–10.10)	Lifetime hours worked outdoors **Men** ≤438: reference 439–1644: 1.0 (0.5–2.0) 1645–3360: 0.7 (0.4–1.5) ≥3361: 1.3 (0.7–2.7) **Women** 0: reference 1–330: 1.3 (0.6–3.8) 331–864: 1.8 (0.8–4.2) ≥865: 1.2 (0.5–3.0)	Age, sex, height, education, hair color, ability to tan, drinking status
Nagore et al, 2010 (78); fair	Case–control; Valencia, Spain; 160 cases, 318 controls	NR	NR	Years of occupational sun exposure 0: reference ≤20: 0.6 (0.3–1.3) >20: 2.1 (1.1–4.0)	Age, hair color, personal history of NMSC, severe sunburns, smoking status, multiple nevi
Osterlind et al, 1988 (72), Osterlind et al, 1988 (124); fair	Case–control; East Denmark; 474 cases, 926 controls	NR	Sunbathing habits Never: reference At some time: 1.6 (1.1–2.4) 1–9 y: 1.9 (0.9–3.9) 10–24 y: 1.6 (1.1–2.5) 25–39 y: 1.7 (1.1–2.5) ≥40 y: 1.9 (1.3–2.9) Vacations spent in sun Never: reference Sunny: 1.0 (0.8–1.3) Very sunny: 1.4 (1.0–2.1)	NR	Sex, nevi, freckles, hair color, history of sunbathing, sunburning
Parr et al, 2009 (73), NOWAC; fair	Nested case–control; Norway; 162 cases, 1242 controls	NR	Sunbathing vacations, by age category **Age <10 y** Never: reference ≤1 per year: 2.10 (1.02–4.35) ≥2 per year: 1.11 (0.65–1.91) **Age 10–19 y** Never: reference ≤1 per year: 1.04 (0.59–1.84) ≥2 per year: 1.37 (0.86–2.21)	NR	Age, region, hair color

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Appendix Table 2—Continued

Study, Year (Reference); Quality Rating	Design; Setting; Sample	Total Sun Exposure (RR or OR [95% CI])*	Intermittent Sun Exposure (RR or OR [95% CI])*	Chronic Sun Exposure (RR or OR [95% CI])*	Adjustments Reported
Shors et al, 2001 (81), Soloman et al, 2004 (125); fair	Case–control; Washington; 386 cases, 727 controls	Lifetime average days with >4 h sun (quartile) First: reference Second: 1.3 (0.86–1.9) Third: 1.4 (0.92–2.0) Fourth: 1.4 (0.95–2.0) Lifetime overall UV exposure (quartile) **Men** First: reference Second: 0.51 (0.23–0.80) Third: 0.67 (0.31–1.03) Fourth: 1.24 (0.62–1.86) **Women** First: reference Second: 1.35 (0.64–2.05) Third: 2.45 (1.23–3.68) Fourth: 1.99 (0.95–3.03)	NR	NR	Age, sex, income, tendency to burn, number of sunburns age 2–10 y
Tabenkin et al, 1999 (79); fair	Case–control; Israel; 168 cases, 325 controls	Number of hours of sun exposure **Age 6–13 y** Statistically significant difference, OR not reported **Age ≥14 y** Not statistically significant, OR not reported	NR	Occupational sun exposure from age 21 y No: 2.44 (1.01–5.91) Yes: reference	Age, sex
Veierød et al, 2010 (64), Veierød et al, 2003 (126), Norwegian–Swedish Women's Lifestyle and Health Cohort Study; fair	Cohort; Norway and Sweden; *n* = 106 366	NR	Annual weeks on sunbathing vacation **Age 10–19 y** 0: reference 1: 1.12 (0.84–1.48) 2–3: 1.12 (0.84–1.48) ≥4: 1.87 (1.35–2.58) **Age 10–39 y** 0: reference ≥1: 1.54 (1.12–2.12)	NR	Age, region of residence, hair/skin color
Walter et al, 1999 (74), Walter et al, 1990 (127); fair	Case–control; Ontario, Canada; 583 cases, 608 controls	NR	Beach vacation in previous 5 y No: reference Yes: 1.04 (0.82–1.32)	NR	Age, sex, reaction to initial summer sun exposure
Weinstock et al, 1991 (75), NHS; fair	Nested case–control; United States (multistate); 130 cases, 300 controls	NR	Annual frequency of swimsuit use outdoors by skin type, age 15–20 y Sun resistant / Sun sensitive 0–10: reference 11–30: 0.6 (0.2–1.4) / 1.2 (0.6–2.6) ≥31: 0.3 (0.1–0.8) / 3.5 (1.3–9.3)	NR	NR
Westerdahl et al, 1994 (76), Westerdahl et al, 1994 (128), Westerdahl et al, 1995 (29); fair	Case–control; Sweden; 400 cases, 640 controls	NR	Frequent sunbathing during the summer No: reference Yes: 1.2 (0.9–1.7)	NR	Age, sex, region, indoor tanning, history of sunburns, hair color, number of nevi, history of malignant melanoma in immediate family
Westerdahl et al, 2000 (31); fair	Case–control; Sweden; 558 cases, 891 controls	NR	Frequency of sunbathing in summer, by sunscreen use Never / Ever <15 times: reference / 1.3 (0.8–2.2) ≥15 times: 0.9 (0.5–1.8) / 1.2 (0.7–2.0)	NR	Age, sex, region, sunburns after age 19 y, skin phototype, hair color
White et al, 1994 (80); fair	Case–control, Washington; 256 cases, 273 controls	Average hours of yearly sun exposure **Previous 10 y** 0: reference 1–201: 1.16 (0.72–1.87) 202–499: 0.80 (0.45–1.42) 500–2880: 0.88 (0.47–1.64)	NR	Lifetime occupational sun exposure None: reference <50%: 0.89 (0.60–1.32) ≥50%: 0.64 (0.33–1.23)	Age, sex, education

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Appendix Table 2—Continued

Study, Year (Reference); Quality Rating	Design; Setting; Sample	Total Sun Exposure (RR or OR [95% CI])*	Intermittent Sun Exposure (RR or OR [95% CI])*	Chronic Sun Exposure (RR or OR [95% CI])*	Adjustments Reported
Zanetti et al, 1992 (70); fair	Case–control; Turin, Italy; 260 cases, 416 controls	NR	Weeks of sunny vacation in childhood 0: reference 1–59: 2.8 (1.6–4.6) ≥60: 1.7 (1.0–2.9) Sunny vacations in lifetime 0: reference 1–29: 0.9 (0.5–1.6) 30–59: 1.6 (0.9–2.8) 60–89: 1.6 (0.9–2.9) 90–119: 1.5 (0.8–2.7) ≥120: 2.3 (1.4–3.8)	NR	Age, sex

Study, Year (Reference), Quality Rating	Design; Setting; Study Duration	Sample	Ever Use (RR or OR [95% CI])*	Frequency of Use (RR or OR [95% CI])*	Adjustments Reported
Association of indoor tanning and skin cancer (SCC or BCC)					
Gallagher et al, 1995 (61), Bajdik et al, 1996 (117); fair	Case–control; Alberta, Canada; 1983–1984	180 cases, 406 controls	**For SCC** Never: reference Ever use: 1.4 (0.7–2.7)	NR	Age, ethnic origin, skin and hair color, and lifetime occupational sun exposure
Gallagher et al, 1995 (62), Bajdik et al, 1996 (117); fair	Case–control; Alberta, Canada; 1983–1984	226 cases, 406 controls	**For BCC** Never: reference Ever use: 1.2 (0.7–2.2)	NR	Age, ethnic origin, skin and hair color, and lifetime occupational sun exposure
Han et al, 2006 (57), NHS; fair	Nested case–control; United States (11 states); 1989–2000	275 SCC cases, 283 BCC cases; 804 controls	**For SCC** Never: reference Ever use: 1.44 (0.93–2.24) **For BCC** Never: reference Ever use: 1.32 (0.87–2.03)	NR	Age, constitutional susceptibility, family history of skin cancer, number of lifetime severe sunburns, cumulative sun exposure while wearing a bathing suit, region
Karagas et al, 2002 (82); fair	Case–control; New Hampshire region; 1993–1995	286 total cases, 603 BCC cases, 293 SCC cases; 540 controls	**For SCC** Never: reference Ever use: 2.5 (1.7–3.8) **For BCC** Never: reference Ever use: 1.5 (1.1–2.1)	Age at first tanning device use **For SCC** <20 y: 3.6 (1.9–6.9) 20–35 y: 2.8 (1.4–5.5) **For BCC** <20 y: 1.8 (1.0–3.0) 20–35 y: 1.4 (0.8–2.3)	NR
Rosso et al, 1999 (59); fair	Case–control; Switzerland; 1994–1996	146 cases, 144 controls	**For SCC** NR **For BCC** Never: reference Ever use: 1.24 (0.53–2.88)	NR	Age, sex
Association of indoor tanning and skin cancer (melanoma)					
Bataille et al, 2005 (84); fair	Case–control; Sweden, Netherlands, United Kingdom, France, Belgium; 1998–2001	597 cases, 622 controls	Never: reference Ever use: 0.90 (0.71–1.14) Age <15 y Never: reference Ever use: 1.82 (0.92–3.62)	Total lifetime hours of use Never: reference <10: 0.95 (0.71–1.25) 10–30: 0.75 (0.50–1.11) 31–60: 0.75 (0.43–1.30) 61–100: 1.10 (0.55–2.24) >100: 1.19 (0.73–1.93)	Age, sex, skin phototype
Berwick et al, 1996 (65), Chen et al, 1998 (90); fair	Case–control; Connecticut; 1987–1989	624 cases, 512 controls	Never: reference Ever use: 1.13 (0.82–1.54)	Total lifetime sun lamp use Never: reference <10 times: 1.25 (0.84–1.84) ≥10 times: 1.15 (0.60–2.20) Age at first use of sun lamp Never: reference <25 y: 1.35 (0.88–2.08) 25–45 y: 1.02 (0.61–1.70)	Age, sex, cutaneous phenotype, total recreational sun exposure index

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Appendix Table 2—**Continued**

Study, Year (Reference), Quality Rating	Design; Setting; Study Duration	Sample	Ever Use (RR or OR [95% CI])*	Frequency of Use (RR or OR [95% CI])*	Adjustments Reported
Clough-Gorr et al, 2008 (83); fair	Case–control; New Hampshire; 1995–1998	423 cases, 678 controls	Sun lamp use Never: reference Ever use: 1.39 (1.00–1.96) Tanning bed use Never: reference Ever use: 1.14 (0.80–1.61)	Frequency of sun lamp use Never: reference <6 times: 1.29 (0.84–1.99) ≥6 times: 1.54 (0.93–2.57) Age at first sun lamp use Never: reference ≤20: 1.23 (0.81–1.88) >20: 1.71 (1.00–2.92) Frequency of tanning bed use Never: reference <10 times: 1.05 (0.67–1.64) ≥10 times: 1.25 (0.79–1.98) Age at first tanning bed use Never: reference ≤20 y: 1.78 (0.76–4.15) >20 y: 1.08 (0.75–1.55)	Age, sex, family history of melanoma, hair color, freckles, sun sensitivity, and total sun exposure hours
Fargnoli et al, 2004 (66); fair	Case–control; central Italy; 2000–2001	100 cases, 200 controls	Never: reference Ever use: 0.63 (0.25–1.63)	NR	Age, sex, ethnicity, region, hair/eye color, skin type
Han et al, 2006 (57), NHS; fair	Nested case–control; United States (11 states); 1989–1998/2000	200 cases, 804 controls	Never: reference Ever use: 2.06 (1.30–3.26)	NR	Age, constitutional susceptibility, family history of skin cancer; number of lifetime severe sunburns, cumulative sun exposure while wearing a bathing suit, region
Holly et al, 1995 (68); fair	Case–control; San Francisco, CA; 1981–1986	452 cases, 930 controls	Never: reference Ever use: 0.94 (0.74–1.2)	NR	None
Osterlind et al, 1988 (72), Osterlind et al, 1988 (124); fair	Case–control; eastern Denmark; 1982–1985	474 cases, 926 controls	Never: reference Ever use: 0.7 (0.5–1.0)	NR	Age, sex
Parr et al, 2009 (73), NOWAC; fair	Nested case–control; Norway; 1991–1997	162 cases, 1242 controls	Age 10–19 y Never: reference Ever use: 0.46 (0.06–3.63)	NR	Age, region, sunburn, sunbathing vacations
Veierød et al, 2010 (64), Veierød et al, 2003 (126), Norwegian–Swedish Women's Lifestyle and Health Cohort Study; fair	Cohort; Norway and Sweden; 1992–1992	n = 106 366	Age 10–19 y Never: reference Ever use: 1.19 (0.56–2.53)	Age 10–39 y Never: reference Rarely (<1/mo): 1.24 (0.96–1.61) ≥1/mo, 1 decade: 1.38 (0.98–1.94) ≥1/mo, 2–3 decades: 2.37 (1.37–4.08)	Age, region, hair/skin color, corresponding number of age-specific sunburns and weeks on annual summer vacations
Walter et al, 1999 (74), Walter et al, 1990 (127); fair	Case–control; Ontario, Canada; 1984–1986	583 cases, 608 controls	Never: reference Ever use: 1.54 (1.16–2.05)	Sex-stratified, age-adjusted only OR for total lifetime minutes used and age at first use	Age, sex, reaction to initial summer sun exposure, potential confounders
Westerdahl et al, 1994 (76), Westerdahl et al, 1994 (128), Westerdahl et al, 1995 (29); fair	Case–control; Sweden; 1988–1990	400 cases, 640 controls	Age <30 y Never: reference Ever use: 2.7 (0.7–9.8)	Times used per year **Age <30 y** Never: reference 1–10: 2.0 (0.5–8.0) >10: 7.7 (1.0–63.6) **Age 30–60 y** Never: reference 1–10: 1.0 (0.7–1.6) 10: 1.4 (0.7–2.7)	Age, sex, region, history of sunburns, hair/skin color, raised nevi, history of frequent sunbathing during the summer

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Appendix Table 2—Continued

Study, Year (Reference), Quality Rating	Design; Setting; Study Duration	Sample	Ever Use (RR or OR [95% CI])*	Frequency of Use (RR or OR [95% CI])*	Adjustments Reported
Westerdahl et al, 2000 (31), Westerdahl et al, 2000 (30); fair	Case–control; Sweden; 1995–1997	571 cases, 913 controls	Never: reference Sometimes use: 1.1 (0.8–1.4) Regular use: 1.8 (1.2–2.7)	Total lifetime use Never: reference 1–125: 2.8 (1.0–7.8) 126–250: 3.1 (1.3–7.1) >250: 1.5 (0.7–3.2) Age at first use Never: reference ≤35 y: 2.3 (1.2–4.2) >35 y: 1.6 (0.9–2.9)	Age, sex, region, hair color, number of raised nevi, skin type, number of sunburns
Association of sunscreen use and skin cancer (SCC or BCC)					
Green et al, 1999 (85), Green et al, 1994 (87), van der Pols et al, 2006 (89), Nambour Skin Cancer Prevention Trial; fair	RCT; Queensland, Australia; 1992	*n* = 1621	Regular sunscreen use (vs. usual sunscreen use) **For SCC** Regular use: 0.65 (0.45–0.94) **For BCC** Regular use: 1.02 (0.78–1.35)	NR	NR
Grodstein et al, 1995 (55), NHS; good	Cohort; United States (11 states); 1982–1990	*n* = 107 900	Persons who spent regular time outdoors **For SCC** Never use: 0.9 (0.6–1.2)	NR	Age, smoking, region, hair color, reaction to sun, lifetime number of sunburns
Hunter et al, 1990 (56), NHS; fair	Analytic cohort; United States (11 states); 1982–1990	*n* = 73 366	Persons who spent regular time outdoors **For BCC** Never use: 0.70 (0.60–0.82)	NR	Age, time period, region, time spent outdoors in summer, sunscreen habit, hair color, childhood tendency to burn, lifetime number of severe sunburns
Kricker et al, 1991 (58), Kricker et al, 1995 (25), Kricker et al, 1995 (91); fair	Case–control; Western Australia; 1987	226 BCC cases, 6 SCC cases, 1021 BCC controls	NR	**For BCC** Frequency and duration of use of SPF ≥10 half the time or longer 1–9 y: 1.92 (1.17–3.13) ≥10 y: 1.25 (0.82–1.90)	Age, sex, ability to tan, site
Rosso et al, 1999 (59); fair	Case–control; Switzerland; 1994–1996	146 cases, 144 controls	**For SCC** Ever use: 1.63 (0.41–6.53) **For BCC** Ever use: 1.69 (1.14–2.05)	NR	Age, sex
Association of sunscreen use and skin cancer (melanoma)					
Cho et al, 2005 (86), NHS and HPFS; fair	Analytic cohort; United States (multistate); 1986 for NHS, 1992 for HPFS	*n* = 178 155	Authors reported that use of sunscreen was not related to a reduced risk for melanoma; data otherwise NR	NR	NR
Fargnoli et al, 2004 (66); fair	Case–control; central Italy; 2000–2001	100 cases, 200 controls	Never: reference Ever use: 0.63 (0.25–1.63)	NR	Age, sex, ethnicity, region, hair/eye color, skin type
Holly et al, 1995 (68); fair	Case–control; San Francisco, CA; 1981–1986	452 cases (calculated), 930 controls	Almost always use: reference Sometimes use: 1.5 (1.1–2.2) Never use: 2.1 (1.5–3.0)	NR	Age, history of sunburn, skin type, hair color, number of large nevi, complexion, maternal ethnicity, history of skin cancer

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Appendix Table 2—**Continued**

Study, Year (Reference), Quality Rating	Design; Setting; Study Duration	Sample	Ever Use (RR or OR [95% CI])*	Frequency of Use (RR or OR [95% CI])*	Adjustments Reported
Westerdahl et al, 1994 (76), Westerdahl et al, 1994 (128), Westerdahl et al, 1995 (29); fair	Case–control; Sweden; 1988–1990	400 cases, 640 controls	Never: reference Sometimes use: 1.3 (0.9–1.9) Almost always use: 1.8 (1.1–2.8)	NR	Age, sex, region, history of sunburns, history of frequent sunbathing during the summer, outdoor employment during the summer, host factors (nevi, hair/eye color, freckling)
Westerdahl et al, 2000 (31), Westerdahl et al, 2000 (30); fair	Case–control; Sweden; 1995–1997	558 cases, 891 controls	Never: reference Sometimes use: 1.3 (0.9–1.9) Always initially and sometimes use: 0.9 (0.6–1.5) Always use: 1.8 (1.1–2.9)	Years of regular use of sunscreen None: reference 1–20 y: 4.3 (0.8–21.9) >20 y: 1.7 (0.5–5.6)	Age, sex, region, hair color, history of sunburns, frequency of sunbathing during the summer, duration of each sunbathing occasion

BCC = basal cell carcinoma; BMI = body mass index; HPFS = Health Professionals Follow-up Study; NHS = Nurses' Health Study; NMSC = nonmelanoma skin cancer; NOWAC = Norwegian Women and Cancer Study; NR = not reported; OR = odds ratio; RCT = randomized, controlled trial; RR = relative risk; SCC = squamous cell carcinoma; UV = ultraviolet.
* Adjusted unless otherwise stated.