


Original Investigation

International Prevalence of Indoor Tanning A Systematic Review and Meta-analysis

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IMPORTANCE Indoor tanning is a known carcinogen, but the scope of exposure to this hazard is not known.

OBJECTIVE To summarize the international prevalence of exposure to indoor tanning.

DATA SOURCES Studies were identified through systematic searches of PubMed (1966 to present), Scopus (1823 to present), and Web of Science (1898 to present) databases, last performed on March 16, 2013. We also hand searched reference lists to identify records missed by database searches and publicly available data not yet published in the scientific literature.

STUDY SELECTION Records reporting a prevalence of indoor tanning were eligible for inclusion. We excluded case-control studies, reports with insufficient study information, and reports of groups recruited using factors related to indoor tanning. Two independent investigators performed searches and study selection. Our search yielded 1976 unique records. After exclusions, 161 records were assessed for eligibility in full text, and 88 were included.

DATA EXTRACTION AND SYNTHESIS Two independent investigators extracted data on characteristics of study participants, inclusion/exclusion criteria, data collection format, outcomes, and statistical methods. Random-effects meta-analyses were used to summarize the prevalence of indoor tanning in different age categories. We calculated the population proportional attributable risk of indoor tanning in the United States, Europe, and Australia for nonmelanoma skin cancer (NMSC) and melanoma.

MAIN OUTCOMES AND MEASURES Ever and past-year exposure to indoor tanning.

RESULTS The summary prevalence of ever exposure was 35.7% (95% CI, 27.5%-44.0%) for adults, 55.0% (33.0%-77.1%) for university students, and 19.3% (14.7%-24.0%) for adolescents. The summary prevalence of past-year exposure was 14.0% (95% CI, 11.5%-16.5%) for adults, 43.1% (21.7%-64.5%) for university students, and 18.3% (12.6%-24.0%) for adolescents. These results included data from 406 696 participants. The population proportional attributable risk were 3.0% to 21.8% for NMSC and 2.6% to 9.4% for melanoma, corresponding to more than 450 000 NMSC cases and more than 10 000 melanoma cases each year attributable to indoor tanning in the United States, Europe, and Australia.

CONCLUSIONS AND RELEVANCE Exposure to indoor tanning is common in Western countries, especially among young persons. Given the large number of skin cancer cases attributable to indoor tanning, these findings highlight a major public health issue.

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Indoor tanning is a World Health Organization group 1 carcinogen¹ associated with malignant melanoma²⁻⁴ and nonmelanoma skin cancer (NMSC).⁵ Prior studies have estimated that indoor tanning accounts for more than 3400 cases of melanoma each year in Europe² and more than 170 000 cases of NMSC each year in the United States.⁵ The risk of all types of skin cancer is highest in those exposed at young ages, suggesting a susceptibility period in early life.^{2,5} Despite the mounting evidence of harms of indoor tanning, data on the scope of this problem, with which to guide public health efforts are missing.

The goal of this study was to summarize the international prevalence of exposure to indoor tanning. In addition to estimating the overall prevalence of indoor tanning, we were specifically interested in the prevalence among young adults and adolescents, groups that may be most susceptible to skin cancer from this exposure.

Methods

We carried out this review in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines⁶ and the Meta-analysis of Observational Studies in Epidemiology (MOOSE) guidelines.⁷

Data Sources and Literature Search

We defined *indoor tanning* as the use of a UV emission device to produce a cosmetic tan. The terminology used is diverse. In this analysis, we considered the following terms and their variations to be synonymous with indoor tanning: *indoor tanning, sunbed, sunlamp, tanning bed, tanning booth, solarium, artificial tanning, artificial UV tanning, and non-solar UV tanning*.

We identified studies through searches of the electronic databases PubMed (1966 to present), Scopus (1823 to present), and Web of Science (1898 to present), with no language restrictions. The last search was performed on March 16, 2013. We also reviewed identified articles and relevant reviews to locate published articles missed by the database searches and to locate publicly available data not yet published in the scientific literature. The specific search strategies used are detailed in the eMethods in the Supplement.

Study Selection

Two of us (M.R.W. and D.N.) independently assessed the eligibility of studies, using the title and abstract for initial screening, followed by review of the full text or its equivalent. Any disagreements were settled by consensus including a third investigator (E.L.). Studies in languages other than English were assessed for eligibility after translation.

Any record that reported a prevalence of exposure to indoor tanning was eligible for inclusion. We excluded records with no indoor tanning prevalence data available, records that did not report original data (editorials or reviews), records with no full text available (conference proceedings), records that did not report the number of participants, and case reports. To obtain prevalence estimates representative of the general popu-

lation, we excluded studies of groups recruited based on factors that could be related to indoor tanning (studies of indoor tanners, skin cancer screening participants, dermatology clinic patients, and patients with skin cancer). Case-control studies were also excluded for generalizability reasons because even the results from control groups are from populations specifically matched to groups of patients with disease, which may not be representative of a general population. For records reporting the same original data, we included the record reporting the most extensive relevant results, followed by the record with the earliest publication date.

Data Extraction

We used a data extraction sheet, which was developed on the basis of the Cochrane Consumers and Communication Review Group's data extraction template (<http://cccr.cochrane.org/author-resources>). We extracted the following data items from each record: characteristics of study participants (including age, sex, ethnicity, and geographic location), inclusion/exclusion criteria, data collection format (eg, interview or questionnaire), prevalence outcomes (including all prevalence measures, as well as those available by sex or age group), and statistical methods.

Data Synthesis and Statistical Analysis

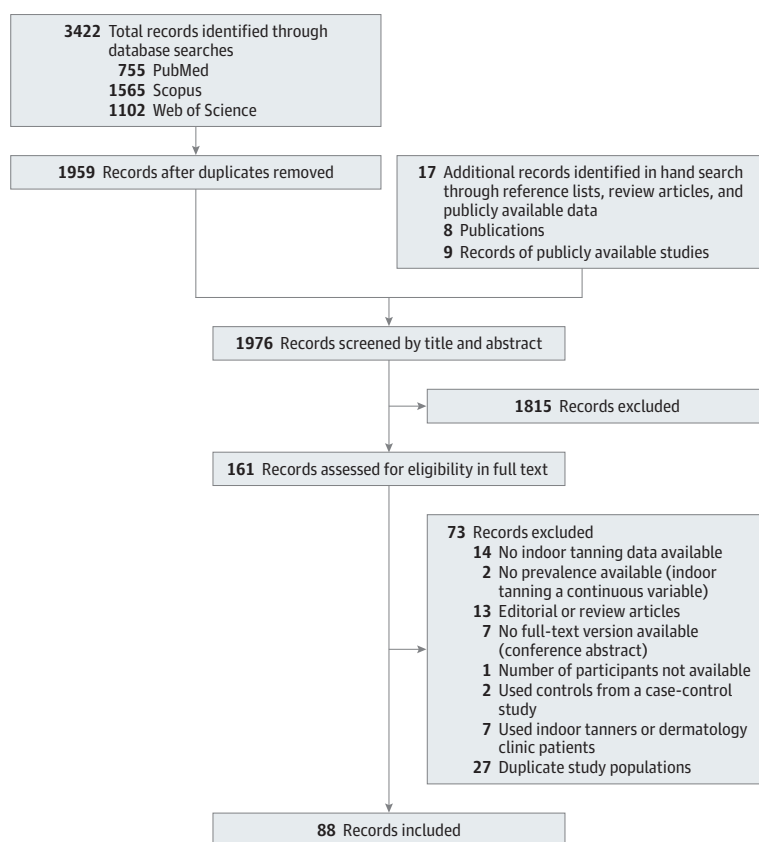
Primary Analyses

For the primary meta-analyses, we included records that reported the prevalence of ever exposure to indoor tanning (eg, participants were asked, "Have you ever used an indoor ultraviolet tanning device to produce a cosmetic tan?") or the prevalence of past-year exposure to indoor tanning (eg, participants were asked, "Have you used indoor tanning in the past 12 months?"). Records that did not report one of these exposure measures were excluded from primary analyses. Also excluded were records that assessed specific occupational groups. Primary analyses were performed separately for 3 geographic regions (United States and Canada, Northern and Western Europe, and Australia), as well as for all these regions combined.

Based on the age groups reported by the included studies, analyses were separated into 3 participant categories: (1) adults (aged ≥ 18 years), (2) university students (college, university, undergraduate, or graduate students), and (3) adolescents (≤ 19 years old). If a record reported a prevalence that included more than 1 participant category, we separated the results into those for adolescent, university student, or adult subsets and analyzed these separately wherever possible. If separating the results was not possible, we included them in the participant category that matched the majority of the study population. When sex-specific prevalences were available, our analyses were also stratified by sex. For records that reported data from several different time points, each time of data collection was considered to be an individual data point.

We used Stata, version 12, statistical software⁸ to perform random-effects model meta-analyses, yielding summary prevalences and 95% CIs. All statistical tests were 2 sided. Because very few studies reported standard errors or 95%

Figure 1. Study Selection Flow Diagram



This flow diagram shows the number of studies identified, screened, and included or excluded at each stage of study selection.

CI, we calculated the standard error for each study, assuming prevalence to be a Bernoulli random variable, p , with variance equal to $p(1 - p)$. In a few cases of very low prevalence in which the previous calculation yielded a negative lower 95% CI, we used an exact 95% CI calculation as the input into the analysis. To investigate variability (heterogeneity) in study outcomes, we used a χ^2 test for heterogeneity and an I^2 statistic. Small study effects and publication bias across studies were assessed by using funnel plots, which were reviewed visually, and using Begg's rank correlation and Egger's weighted linear regression tests for formal testing.

Sensitivity Analyses

We performed several sensitivity analyses to assess how our primary analyses estimates varied when we included records that did not meet our inclusion criteria for the primary analyses or that excluded studies with the potential to bias our summary estimates. Specifically, 4 separate sensitivity analyses were performed that (1) included records with exposure measures that did not fit our categories of ever exposure or past-year exposure⁹⁻¹⁵; (2) included records of specific occupational groups that are not representative of the general population: pilots and flight attendants,¹⁶ indoor office workers,¹⁷ outdoor workers,¹⁴ and health care workers¹⁸⁻²⁰; (3) excluded records reporting combined data for mixed participant categories; and (4) excluded records of potentially

lower methodologic quality, which did not report clear sampling methods, used convenience sampling, or had sample sizes less than 500 (details in eTable 1 and eTable 2 in the Supplement).

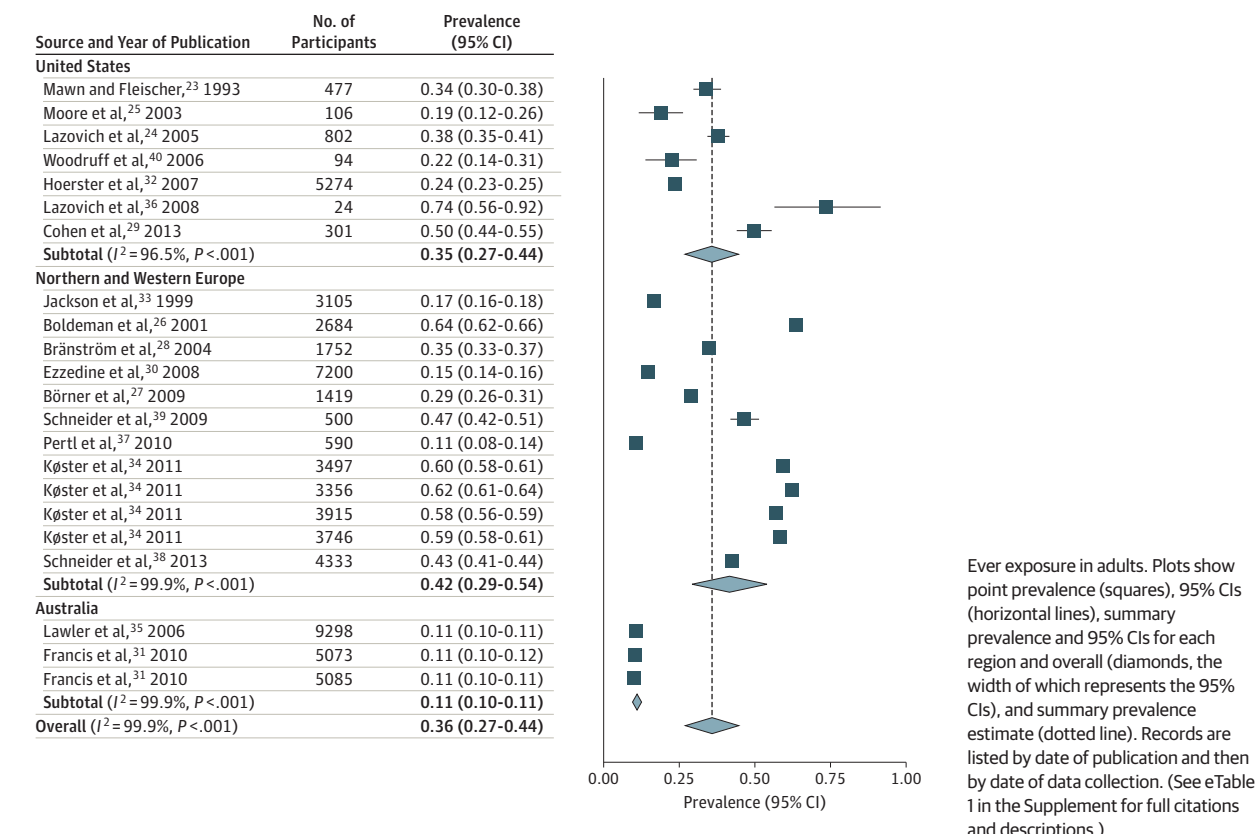
Trends Over Time

To address the possibility of changes in indoor tanning exposure over time, we separately examined past-year prevalence from records in the most recent 5 years of available data (2007-2012). Past-year prevalence was used instead of ever prevalence because it has greater potential to reflect changing exposure patterns over time. We also performed meta-regressions to evaluate the effect of the year of data collection on past-year indoor tanning exposure. If years of data collection were not reported, we used the year of publication. We used the median year if a range of data collection years was reported.

Population Proportional Attributable Risk

We calculated population proportional attributable risk as $(\text{prevalence of exposure} \times [\text{RR} - 1]) / (1 + \text{prevalence of exposure} \times [\text{RR} - 1])$, where RR is relative risk based on summary relative risks for NMSC and melanoma reported in 2 rigorous meta-analyses published in the last year,^{2,5} which together encompassed 38 studies with 20 756 skin cancer cases. To calculate the 95% CIs for the population proportional attrib-

Figure 2. Forest Plots of Primary Analyses: Ever Exposure in Adults



utable risks, we used the above formula with the upper and lower bounds of the 95% CIs of the prevalence of exposure that we found in this analysis. We calculated this for the 3 regions for which we had representative data on the incidence of NMSC and melanoma (United States, Australia, and Northern and Western Europe). We used the summary prevalence of ever exposure to indoor tanning in adults for each region: the United States, Australia, and Northern and Western Europe (based on studies from the United Kingdom, Ireland, France, Germany, Denmark, and Sweden). We calculated the number and range of skin cancer cases due to indoor tanning by multiplying population proportional attributable risk and its 95% CIs by published estimates of the incidences of the most common types of skin cancer: basal cell carcinoma and squamous cell carcinoma, together categorized as NMSC, and melanoma.

Results

Our search yielded 755 results on PubMed, 1565 on Scopus, and 1102 on Web of Science. After duplicates were removed, there were 1959 unique results. A hand search through reference lists, review articles, and publicly available data yielded 8 additional publications and 9 additional publicly available studies. We screened the 1976 unique records by titles and abstracts. After exclusions, 161 records were assessed for eligibility

in full text or its equivalent, and 88 records met inclusion criteria and were included (Figure 1). Three records were available only in German^{10,14,21} and 1 was available only in French²²; these were assessed for eligibility after translation.

The 88 records included in this review were published between 1992 and 2013, reported data from 1986 to 2012 from 16 Western countries, and included 491 492 participants (eTable 1 in the Supplement). The 88 included records contributed 115 individual data points. Seven studies used exposure measures other than ever or past-year exposure, and 6 assessed specific occupational groups (1 study overlapping). These 12 studies were excluded from primary analyses and used only in sensitivity analyses (see the Supplement). Seventy-six records with 406 696 total participants were included in the primary analyses. Thirty-four of these records reported prevalence in adults, 15 reported prevalence in university students, and 34 reported prevalence in adolescents.

The overall summary prevalence of ever exposure to indoor tanning was 35.7% (95% CI, 27.5%-44.0%) for adults, 55.0% (33.0%-77.1%) for university students, and 19.3% (14.7%-24.0%) for adolescents (Figures 2, 3, and 4).²³⁻⁶⁵ The summary prevalence of exposure to indoor tanning in the past year was 14.0% (95% CI, 11.5%-16.5%) for adults, 43.1% (21.7%-64.5%) for university students, and 18.3% (12.6%-24.0%) for adolescents (Figures 5, 6, and 7).^{*} Analyses stratified by sex

*References 31, 32, 34, 35, 38, 39, 44, 45, 47, 48, 58, 66-89

Figure 3. Forest Plots of Primary Analyses: Ever Exposure in University Students

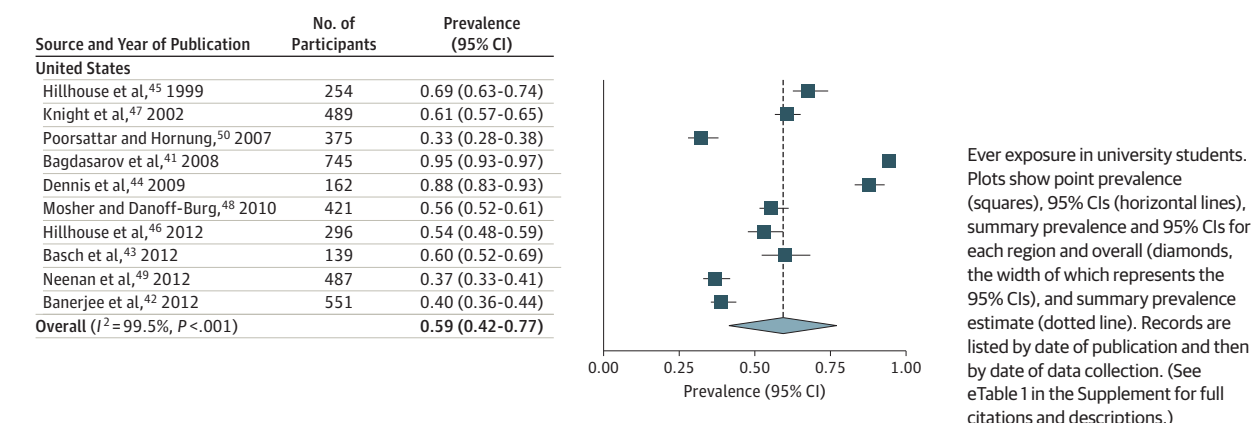
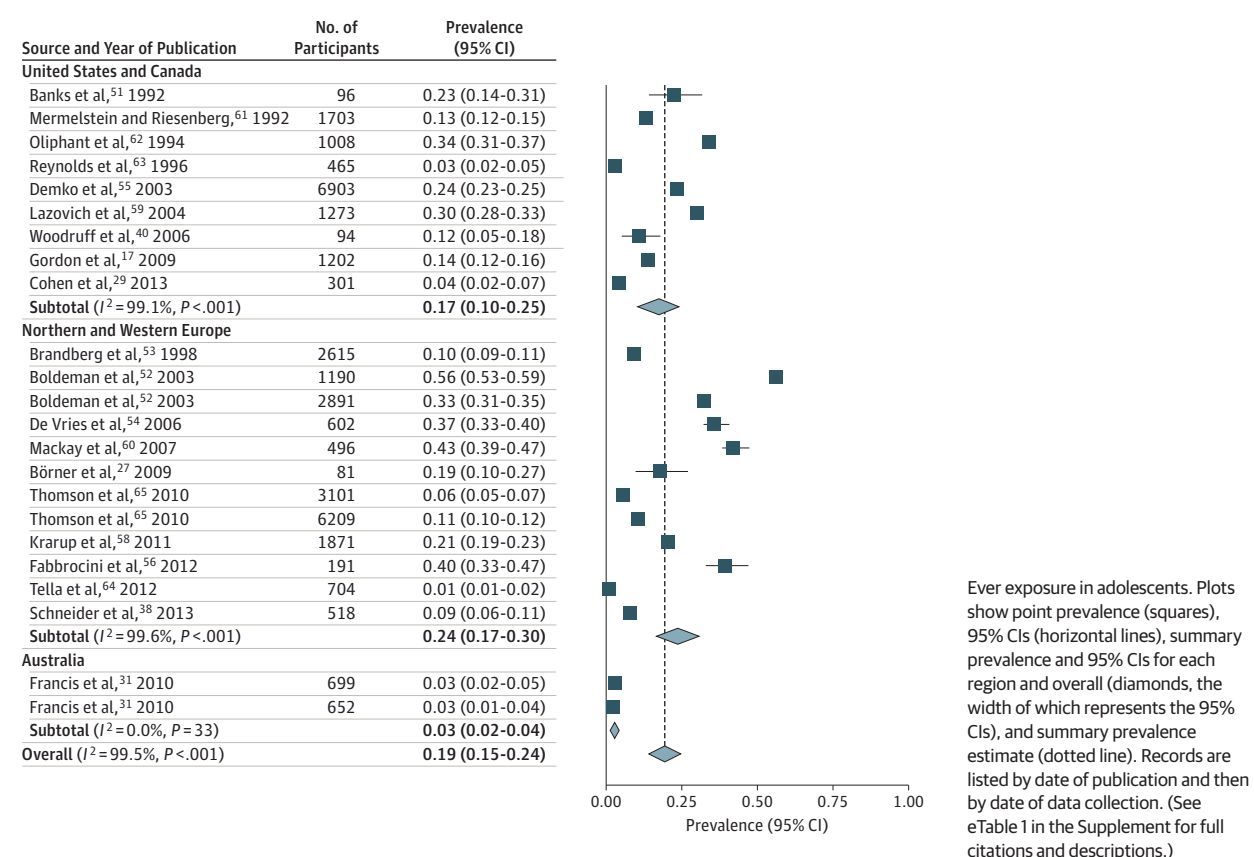


Figure 4. Forest Plots of Primary Analyses: Ever Exposure in Adolescents



showed a higher prevalence of indoor tanning among women compared with men in each category (Table 1). Analyses of adults and adolescents stratified by geographic region showed highest summary prevalences in Northern and Western Europe, followed closely by the United States and Canada, with Australia consistently having the lowest. Analyses of university students were based entirely on data from the United States (Figures 2-7).²³⁻⁸⁹

Heterogeneity across studies was significant ($P < .001$), and I^2 statistics were greater than 99% in adult, university stu-

dent, and adolescent analyses. The potential for bias due to small-study effects was also observed: funnel plots appeared somewhat asymmetrical, and the results were significant ($P < .05$) for Begg's rank correlation and/or Egger's weighted linear regression tests in all analyses except that of ever exposure in university students.

Sensitivity Analyses

The 4 sensitivity analyses (described in the Methods section) yielded results consistent with our main findings (eTable 2 in

Figure 5. Forest Plots of Primary Analyses: Past-Year Exposure in Adults

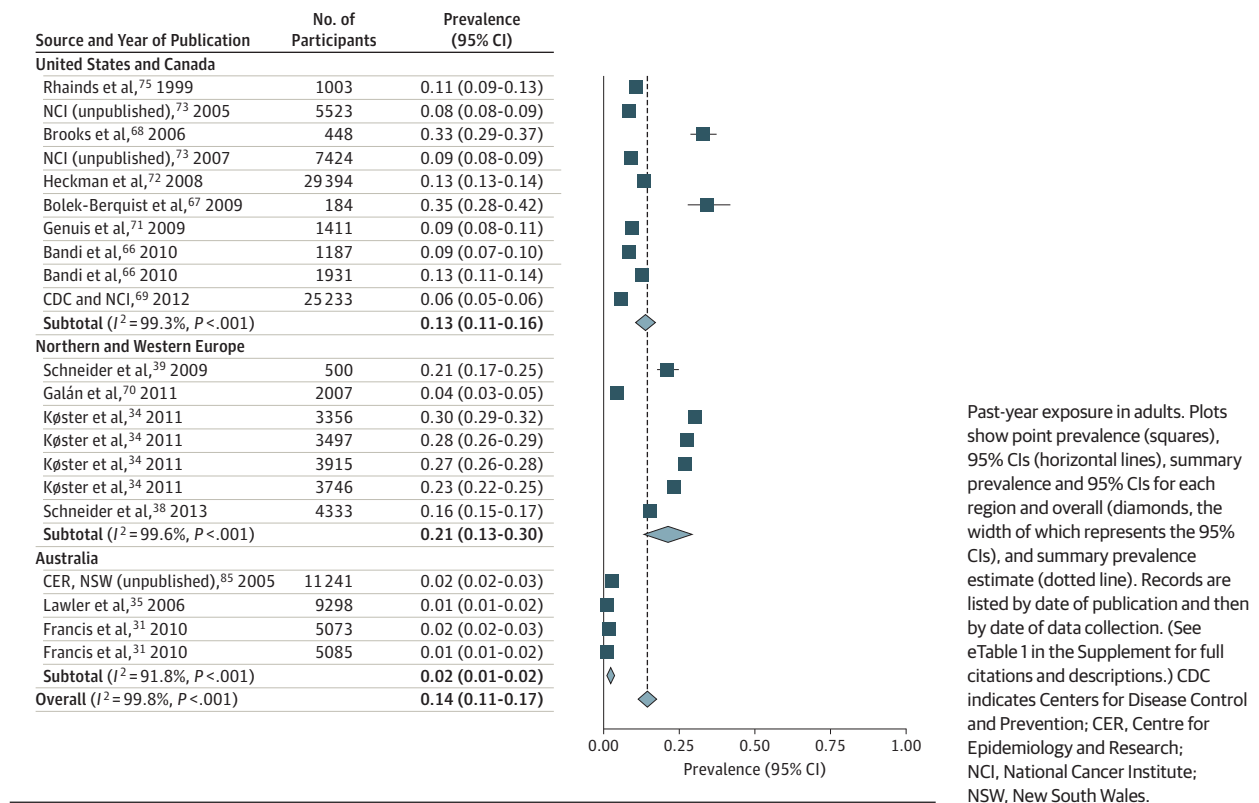
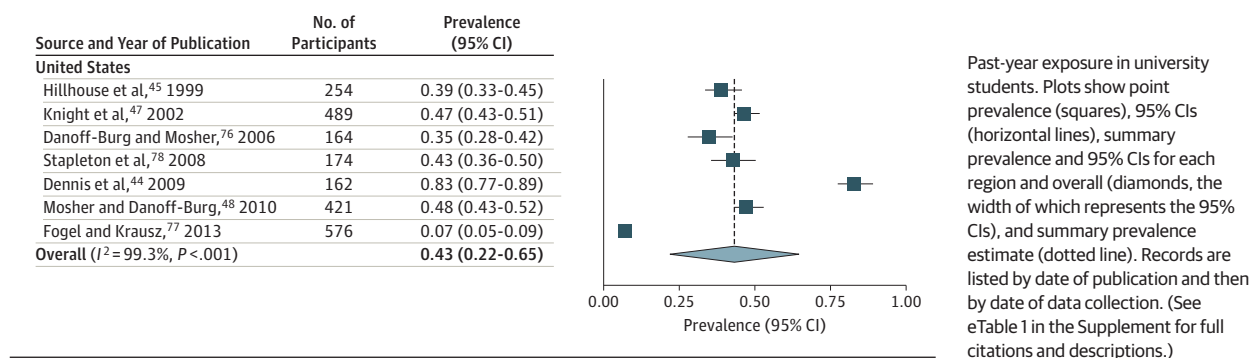


Figure 6. Forest Plots of Primary Analyses: Past-Year Exposure in University Students



the Supplement). Overall, all sensitivity analyses prevalence estimates were within an absolute 6% of the primary analyses estimates.

Trends Over Time

Estimates of past-year exposure to indoor tanning prevalence collected in the most recent 5 years of available data were higher than estimates including all time periods. A meta-analysis of the most recent estimates (2007-2012) of past-year exposure to indoor tanning yielded past-year prevalences of 18.2% (95% CI, 12.2%-24.1%) in adults, 45.2% (9.4%-81.0%) in university students, and 22.0% (17.2%-26.8%) in adolescents. These are absolute increases of 3.4% in adults, 2.1% in university students, and 1.7% in adolescents from the results of the

primary analyses. Meta-regressions examining the effect of the year of data collection on prevalence of indoor tanning exposure in the past year yielded no statistically significant associations between prevalence and year of data collection ($P = .44$ in adults, $P = .95$ in university students, and $P = .58$ in adolescents) (eFigure in the Supplement).

Population Proportional Attributable Risk

We applied our summary ever-exposure prevalence estimates for adults in the United States (35.4%), Northern and Western Europe (41.6%), and Australia (10.7%) to calculate the population proportional attributable risks for basal cell carcinoma, squamous cell carcinoma, and melanoma^{2,5,90-95} (Table 2). The population proportional attributable risk for

Figure 7. Forest Plots of Primary Analyses: Past-Year Exposure in Adolescents

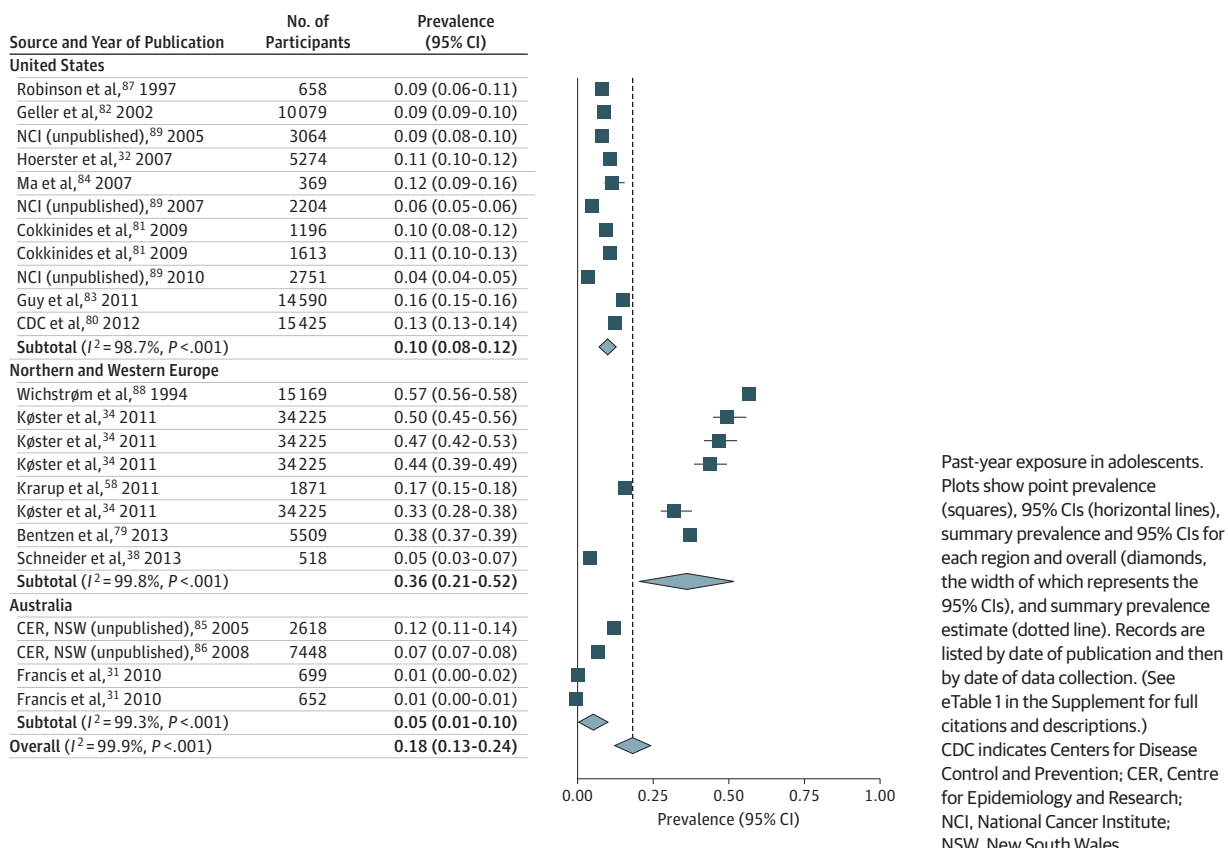


Table 1. Primary Analyses by Sex and Participant Category

Exposure by Group	Overall		Female Participants		Male Participants	
	Summary Prevalence (95% CI)	Records, No.	Summary Prevalence (95% CI)	No. of Records	Summary Prevalence (95% CI)	No. of Records
Adults						
Ever exposure	35.7 (27.5-44.0)	22	39.8 (30.0-49.7)	9	20.4 (12.4-28.3) ^a	7
Past-year exposure	14.0 (11.5-16.5)	21	19.0 (14.7-23.4)	15	9.0 (6.6-11.5)	13
University students						
Ever exposure	55.0 (33.0-77.1)	11	69.3 (45.4-93.2)	5	40.0 (14.1-66.0)	3
Past-year exposure	43.1 (21.7-64.5)	7	64.9 (41.2-88.5)	4	26.8 (15.6-37.9)	4
Adolescents						
Ever exposure	19.3 (14.7-24.0)	23	31.5 (22.3-40.8)	16	14.1 (10.5-17.7) ^a	17
Past-year exposure	18.3 (12.6-24.0)	23	21.3 (8.5-34.1)	14	7.5 (4.1-11.0) ^a	14

^a Including 1 or 2 individual prevalence estimates in which exact methods were used to calculate 95% CIs.

the 3 regions ranged from 3.0% to 10.8% for basal cell carcinoma, from 6.7% to 21.8% for squamous cell carcinoma, and from 2.6% to 9.4% for melanoma, corresponding to 388 079 cases of skin cancer in the United States, 23 408 in Northern and Western Europe, and 18 441 in Australia. Overall, we estimate 419 039 cases of basal and squamous cell carcinoma (NMSC) and 10 888 cases of melanoma each year attributable to indoor tanning. To put this in perspective, approximately 362 941 cases of lung cancer are attributable to smoking each year in these regions (using the most recent estimates of

annual incidence of lung cancer of 226 160 in the United States,⁹⁶ 166 915 in Northern and Western Europe,⁹² and 10 193 in Australia,⁹¹ assuming that 90% of lung cancer cases are attributable to smoking).⁹⁷⁻⁹⁹

Discussion

In this systematic review and meta-analysis of more than 490 000 participants and 88 studies from 16 countries, we

Table 2. Skin Cancer Cases Attributable to Indoor Tanning in US, Northern and Western European, and Australian Adults

Type of Cancer by Region	RR ^a	Yearly Cancer Incidence	Population Proportional Attributable Risk (95% CI)	Cases Attributable to Ever Exposure (95% CI)
United States (ever-exposure prevalence: 35.4% [26.8%-44.0%]) ^b				
BCC	1.29	2 630 770 ^c	9.3 (7.2-11.3)	244 930 (189 719-279-900)
SCC	1.67	876 923 ^c	19.2 (15.2-22.8)	168 115 (133 491-199 658)
MM	1.25	76 250 ^d	8.1 (6.3-9.9)	6199 (4788-7556)
Total skin cancer cases	...	...	...	419 254 (327 997-504 914)
Northern and Western Europe (ever-exposure prevalence: 41.6% [29.0%-54.2%]) ^b				
BCC	1.29	142 882 ^e	10.8 (7.8-13.6)	15 382 (11 084-19 408)
SCC	1.67	28 576 ^f	21.8 (16.2-26.6)	6229 (4649-7613)
MM	1.25	51 740 ^g	9.4 (6.8-11.9)	4874 (3498-6174)
Total skin cancer cases	...	...	...	23 408 (17 014-29 313)
Australia (ever-exposure prevalence: 10.7% [10.3%-11.2%]) ^b				
BCC	1.29	296 000 ^h	3.0 (2.9-3.1)	8908 (8585-9312)
SCC	1.67	138 000 ^h	6.7 (6.5-7.0)	9231 (8909-9633)
MM	1.25	11 545 ⁱ	2.6 (2.5-2.7)	301 (290-314)
Total skin cancer cases	...	...	...	18 441 (17 784-19 259)
All regions				
NMSC (BCC and SCC)	...	...	...	452 796 (356 436-543 322)
Melanoma	...	...	...	11 374 (8575-14 045)
Total skin cancer cases	...	...	...	464 170 (365 011-557 367)

Abbreviations: BCC, basal cell carcinoma; MM, malignant melanoma; NMSC, nonmelanoma skin cancer; RR, relative risk; SCC, squamous cell carcinoma of the skin.

^a Relative risks obtained from Wehner et al⁵ (BCC and SCC) and Boniol et al² (MM).

^b Prevalence of ever exposure to indoor tanning in adults (95% CIs in brackets).

^c Incidence estimate for 2006, with NMSCs divided into 75% BCCs and 25% SCCs (source: Rogers et al⁹⁵).

^d Incidence estimate for 2012 (source: US National Cancer Institute⁹³).

^e Incidence estimate calculated using a yearly incidence rate of 50 per 100 000 (lower-bound conservative estimate from Lomas et al⁹⁴ for 2000-2005) multiplied by the 2008 Northern and Western European population of 285 763 000 (source: International Agency for Research on Cancer [IARC] GLOBOCAN database⁹²).

^f Incidence estimate calculated using a yearly incidence rate of 10 per 100 000 (lower-bound conservative estimate from Lomas et al⁹⁴ for 2000-2005) multiplied by the 2008 Northern and Western European population of 285 763 000 (source: IARC GLOBOCAN database⁹²).

^g Incidence estimate for 2008 (source: IARC GLOBOCAN database⁹²).

^h Incidence estimate for 2008 (source: Australian Institute of Health and Welfare⁹⁰).

ⁱ Incidence estimate for 2009 (source: Australian Institute of Health and Welfare⁹¹).

found a high prevalence of indoor tanning exposure. Specifically, 35% of adults had been exposed to indoor tanning, with 14% within the past year. Exposures to indoor tanning were highest for university students: 55% had been exposed to indoor tanning, with 43% within the past year. Approximately 19% of adolescents had been exposed to indoor tanning, with 18% within the past year. Ever and past-year indoor tanning exposure was higher for women than men, as has been reported elsewhere.¹⁰⁰

To our knowledge, this is the first summary of the international prevalence of indoor tanning exposure. Prior reviews have focused on high-risk groups,^{100,101} correlates,^{102,103} and motivations⁴⁴ for indoor tanning but have not addressed the absolute prevalence of this exposure. Because the risk of melanoma and NMSC is highest in those exposed to indoor tanning in early life,^{2,5} our finding that the majority of university students and approximately 1 in 5 adolescents have been exposed is concerning. It is possible that skin cancer rates in this highly susceptible group will be even higher in the coming decades as this younger generation ages.

Our estimate of more than 450 000 new cases of skin cancer attributable to indoor tanning each year in the regions examined is alarming. To put this number into context, we show that the number of skin cancer cases due to indoor tanning is higher than the number of lung cancer cases due to smoking in the same regions. Clearly, the mortality associated with lung cancer is far greater than that for skin cancer, and smoking causes many other health risks. However, it is striking that although the population proportional attributable risks of these 2 behaviors are quite different (approximately 3%-22% for skin cancer compared with approximately 90% for lung cancer), the extremely high incidence of skin cancer means that there are more skin cancer cases attributable to indoor tanning than lung cancer cases attributable to smoking. Furthermore, indoor tanning is a relatively new behavior that may be growing in popularity, whereas smoking rates are declining in Western regions,^{104,105} so it is possible that the number of skin cancer cases due to indoor tanning will continue to surpass the number of lung cancer cases due to smoking in coming years.

In addition to providing context, we believe that the comparison between indoor tanning and smoking is worth considering from a public health standpoint. Both indoor tanning and smoking are voluntary, modifiable behaviors with minimal to no health benefits. Both are also significant problems among young persons. We believe that we should learn from the public health efforts geared toward reducing smoking and apply these lessons to reducing indoor tanning. Approaches that have been successful for tobacco prevention should be implemented and tailored to reduce indoor tanning exposure, including advertising bans, taxation, restriction on use by adolescents, and broader policies that facilitate public education and changing social norm. Indoor tanning restrictions for minors have increased during the past decade, although many regions included in this review still have no such restrictions.¹⁰⁶

Our study had several limitations. Most of the included data come from Western countries and are not representative of indoor tanning exposure worldwide. Many of the included studies are made up primarily of whites or excluded non-white participants. However, skin cancer and indoor tanning are issues affecting mostly Western white populations, making our results most relevant to those at risk. All the data available for university students came from the United States, which may limit the international generalizability of this particular subset. Furthermore, some of the included

studies used convenience sampling and had small study sizes. Our sensitivity analyses that excluded these studies had results that were consistent with our primary results, however. Moreover, the included studies span a broad period from the 1980s to the present, and data summarized from such a span of years may not be representative of current exposure. Finally, our study is limited by heterogeneity and evidence of small-study effects and publication bias. We used random-effects methods to account for heterogeneity. Results of detailed sensitivity analyses that addressed study quality and heterogeneity were consistent with our primary results.

Conclusions

Our findings suggest that exposure to indoor tanning is common in Western countries, especially among young persons. This is especially concerning because the risk of melanoma and NMSC is highest in those exposed to indoor tanning in early life. Indoor tanning is a major public health problem, accounting for nearly half a million new cancer diagnoses each year. It is time to open the debate about and pursue additional research into appropriate and effective policy and prevention strategies with the potential to significantly reduce skin cancer risks.

ARTICLE INFORMATION

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Study concept and design: Wehner, Nead, Linos.
Acquisition of data: Wehner, Nameth, Choudhry, Gaskins.

Analysis and interpretation of data: All authors.
Drafting of the manuscript: Wehner, Nameth, Linos.
Critical revision of the manuscript for important intellectual content: Wehner, Chren, Choudhry, Gaskins, Nead, Boscardin, Linos.

Statistical analysis: Wehner, Nameth, Nead, Boscardin, Linos.

Obtained funding: Linos.

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Study supervision: Linos.

Conflict of Interest Disclosures: Dr Chren reports serving as a consultant for Genentech.

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REFERENCES

1. El Ghissassi F, Baan R, Straif K, et al; WHO International Agency for Research on Cancer Monograph Working Group. A review of human carcinogens—part D: radiation. *Lancet Oncol*. 2009;10(8):751-752.
2. Boniol M, Autier P, Boyle P, Gandini S. Cutaneous melanoma attributable to sunbed use: systematic review and meta-analysis. *BMJ*. 2012;345:e4757.
3. Gallagher RP, Spinelli JJ, Lee TK. Tanning beds, sunlamps, and risk of cutaneous malignant melanoma. *Cancer Epidemiol Biomarkers Prev*. 2005;14(3):562-566.
4. International Agency for Research on Cancer Working Group on Artificial Ultraviolet Light and Skin Cancer. The association of use of sunbeds with cutaneous malignant melanoma and other skin cancers: a systematic review. *Int J Cancer*. 2007;120(5):1116-1122.
5. Wehner MR, Shive ML, Chren MM, Han J, Qureshi AA, Linos E. Indoor tanning and non-melanoma skin cancer: systematic review and meta-analysis. *BMJ*. 2012;345:e5909.
6. Moher D, Liberati A, Tetzlaff J, Altman DG; PRISMA Group. Preferred Reporting Items for Systematic Reviews and Meta-Analyses: the PRISMA statement. *BMJ*. 2009;339:b2535. doi:10.1136/bmj.b2535.
7. Stroup DF, Berlin JA, Morton SC, et al; Meta-analysis of Observational Studies in Epidemiology (MOOSE) Group. Meta-analysis of

Observational Studies in Epidemiology: a proposal for reporting. *JAMA*. 2000;283(15):2008-2012.

8. Stata statistical software [computer program]. Release 12. College Station, TX: StataCorp; 2011.

9. Jakusova V, Capova K, Poliacsek I, Cap I, Jakus J. Ultraviolet radiation: level of knowledge and health protection of college students in Slovakia: an educational-questionnaire study. *Komunikacie*. 2012;14(1):89-95.

10. Schauburger G, Keck G, Cabaj A. Verbreitung und Nutzung von Solarien in Osterreich [Spread and use of solarium in Austria]. *Aktuelle Dermatologie*. 1992;18(9-10):303-308.

11. Gillen MM, Markey CN. The role of body image and depression in tanning behaviors and attitudes. *Behav Med*. 2012;38(3):74-82.

12. Lucci A, Citro HW, Wilson L. Assessment of knowledge of melanoma risk factors, prevention, and detection principles in Texas teenagers. *J Surg Res*. 2001;97(2):179-183.

13. Hamlet N, Kennedy K. Reconnaissance study of sunbed use by primary school children in Lanarkshire. *J Public Health (Oxf)*. 2004;26(1):31-33.

14. Unverricht I, Knuschke P. Verhalten von im freien Beschäftigten gegenüber solarer UV-Strahlung in Beruf und Alltag [Behavior of outdoor workers concerning solar UV exposure in occupation and leisure time]. *Dermatologie in Beruf und Umwelt*. 2007;55(4):159-166.

15. Robinson JK, Rigel DS, Amonette RA. Trends in sun exposure knowledge, attitudes, and behaviors: 1986 to 1996. *J Am Acad Dermatol*. 1997;37(2, pt 1):179-186.

16. Rafnsson V, Hrafnkelsson J, Tulinius H, Sigurgeirsson B, Olafsson JH. Risk factors for cutaneous malignant melanoma among aircrews and a random sample of the population. *Occup Environ Med*. 2003;60(11):815-820.
17. Gordon LG, Hirst NG, Green AC, Neale RE. Tanning behaviors and determinants of solarium use among indoor office workers in Queensland, Australia. *J Health Psychol*. 2012;17(6):856-865.
18. Amir Z, Wright A, Kernohan EEM, Hart G. Attitudes, beliefs and behaviour regarding the use of sunbeds amongst healthcare workers in Bradford. *Eur J Cancer Care (Engl)*. 2000;9(2):76-79.
19. Isvy A, Beauchet A, Saiag P, Mahé E. Medical students and sun prevention: knowledge and behaviours in France. *J Eur Acad Dermatol Venereol*. 2013;27(2):e247-e251.
20. Zhang MF, Qureshi AA, Geller AC, Frazier L, Hunter DJ, Han JL. Use of tanning beds and incidence of skin cancer. *J Clin Oncol*. 2012;30(14):1588-1593.
21. Solarium visits: important role model: like mother, like daughter [in German]. *Hautarzt*. 2011;62(7):489-489.
22. Civatte J, Bazex J. À propos de l'utilisation des cabines à bronzer [Report on the use of tanning booths]. *Bull Acad Natl Med*. 2009;193(5):1195-1196.
23. Mawn VB, Fleischer AB Jr. A survey of attitudes, beliefs, and behavior regarding tanning bed use, sunbathing, and sunscreen use. *J Am Acad Dermatol*. 1993;29(6):959-962.
24. Lazovich D, Sweeney C, Forster J. Prevalence of indoor tanning use in Minnesota, 2002. *Arch Dermatol*. 2005;141(4):523-524.
25. Moore J, Zelen D, Hafeez I, Ganti AK, Beal J, Potti A. Risk-awareness of cutaneous malignancies among rural populations. *Med Oncol*. 2003;20(4):369-374.
26. Boldeman C, Bränström R, Dal H, et al. Tanning habits and sunburn in a Swedish population age 13-50 years. *Eur J Cancer*. 2001;37(18):2441-2448.
27. Börner FU, Schütz H, Wiedemann P. A population-based survey on tanning bed use in Germany. *BMC Dermatology*. 2009;9:6.
28. Bränström R, Ullén H, Brandberg Y. Attitudes, subjective norms and perception of behavioural control as predictors of sun-related behaviour in Swedish adults. *Prev Med*. 2004;39(5):992-999.
29. Cohen L, Brown J, Haukness H, Walsh L, Robinson JK. Sun protection counseling by pediatricians has little effect on parent and child sun protection behavior. *J Pediatr*. 2013;162(2):381-386.
30. Ezzedine K, Malvy D, Mauger E, et al. Artificial and natural ultraviolet radiation exposure: beliefs and behaviour of 7200 French adults. *J Eur Acad Dermatol Venereol*. 2008;22(2):186-194.
31. Francis K, Dobbins S, Wakefield M, Girgis A. Solarium use in Australia, recent trends and context. *Aust N Z J Public Health*. 2010;34(4):427-430.
32. Hoerster KD, Mayer JA, Woodruff SI, Malcarne V, Roesch SC, Clapp E. The influence of parents and peers on adolescent indoor tanning behavior: findings from a multi-city sample. *J Am Acad Dermatol*. 2007;57(6):990-997.
33. Jackson A, Wilkinson C, Pill R. Moles and melanomas--who's at risk, who knows, and who cares? a strategy to inform those at high risk. *Br J Gen Pract*. 1999;49(440):199-203.
34. Køster B, Thorgaard C, Philip A, Clemmensen IH. Sunbed use and campaign initiatives in the Danish population, 2007-2009: a cross-sectional study. *J Eur Acad Dermatol Venereol*. 2011;25(11):1351-1355.
35. Lawler SP, Kvaskoff M, DiSipio T, et al. Solarium use in Queensland, Australia. *Aust N Z J Public Health*. 2006;30(5):479-482.
36. Lazovich D, Stryker JE, Mayer JA, et al. Measuring nonsolar tanning behavior: indoor and sunless tanning. *Arch Dermatol*. 2008;144(2):225-230.
37. Pertl M, Hevey D, Thomas K, Craig A, Chuinneagáin SN, Maher L. Differential effects of self-efficacy and perceived control on intention to perform skin cancer-related health behaviours. *Health Educ Res*. 2010;25(5):769-779.
38. Schneider S, Diehl K, Bock C, et al. Sunbed use, user characteristics, and motivations for tanning: results from the German population-based SUN-Study 2012. *JAMA Dermatol*. 2013;149(1):43-49.
39. Schneider S, Zimmermann S, Diehl K, Breitbart EW, Greiner R. Sunbed use in German adults: risk awareness does not correlate with behaviour. *Acta Derm Venereol*. 2009;89(5):470-475.
40. Woodruff SI, Mayer JA, Clapp E. Effects of an introductory letter on response rates to a teen/parent telephone health survey. *Eval Rev*. 2006;30(6):817-823.
41. Bagdasarov Z, Banerjee S, Greene K, Campo S. Indoor tanning and problem behavior. *J Am Coll Health*. 2008;56(5):555-561.
42. Banerjee SC, Hay JL, Greene K. College students' cognitive rationalizations for tanning bed use: an exploratory study. *Arch Dermatol*. 2012;148(6):761-762.
43. Basch CH, Hillyer GC, Basch CE, Neugut AI. Improving understanding about tanning behaviors in college students: a pilot study. *J Am Coll Health*. 2012;60(3):250-256.
44. Dennis LK, Kancherla V, Snetselaar LG. Adolescent attitudes towards tanning: does age matter? *Pediatr Health*. 2009;3(6):565-578.
45. Hillhouse J, Turrissi R, Holwiski F, McVeigh S. An examination of psychological variables relevant to artificial tanning tendencies. *J Health Psychol*. 1999;4(4):507-516.
46. Hillhouse JJ, Baker MK, Turrissi R, et al. Evaluating a measure of tanning abuse and dependence. *Arch Dermatol*. 2012;148(7):815-819.
47. Knight JM, Kirincich AN, Farmer ER, Hood AF. Awareness of the risks of tanning lamps does not influence behavior among college students. *Arch Dermatol*. 2002;138(10):1311-1315.
48. Mosher CE, Danoff-Burg S. Indoor tanning, mental health, and substance use among college students: the significance of gender. *J Health Psychol*. 2010;15(6):819-827.
49. Neenan A, Lea CS, Lesesky EB. Reasons for tanning bed use: a survey of community college students in North Carolina. *N C Med J*. 2012;73(2):89-92.
50. Poorsattar SP, Hornung RL. UV light abuse and high-risk tanning behavior among undergraduate college students. *J Am Acad Dermatol*. 2007;56(3):375-379.
51. Banks BA, Silverman RA, Schwartz RH, Tunnessen WW Jr. Attitudes of teenagers toward sun exposure and sunscreen use. *Pediatrics*. 1992;89(1):40-42.
52. Boldeman C, Jansson B, Dal H, Ullén H. Sunbed use among Swedish adolescents in the 1990s: a decline with an unchanged relationship to health risk behaviors. *Scand J Public Health*. 2003;31(3):233-237.
53. Brandberg Y, Ullén H, Sjöberg L, Holm LE. Sunbathing and sunbed use related to self-image in a randomized sample of Swedish adolescents. *Eur J Cancer Prev*. 1998;7(4):321-329.
54. De Vries H, Willems K, Mesters I, Reubsat A. Skin cancer prevention behaviours during summer holidays in 14 and 18-year-old Belgian adolescents. *Eur J Cancer Prev*. 2006;15(5):431-438.
55. Demko CA, Borawski EA, Debanne SM, Cooper KD, Stange KC. Use of indoor tanning facilities by white adolescents in the United States. *Arch Pediatr Adolesc Med*. 2003;157(9):854-860.
56. Fabbrocini G, Mazzella C, Marasca C, De Vita V, Savastano R, Monfrecola G. Sunbathing and sunlamp exposure: awareness and risk among Italian teenagers. *Photodermatol Photoimmunol Photomed*. 2012;28(4):224-225.
57. Gordon D, Guenther L. Tanning behavior of London-area youth. *J Cutan Med Surg*. 2009;13(1):22-32.
58. Krarup AF, Køster B, Thorgaard C, Philip A, Clemmensen IH. Sunbed use by children aged 8-18 years in Denmark in 2008: a cross-sectional study. *Br J Dermatol*. 2011;165(1):214-216.
59. Lazovich D, Forster J, Sorensen G, et al. Characteristics associated with use or intention to use indoor tanning among adolescents. *Arch Pediatr Adolesc Med*. 2004;158(9):918-924.
60. Mackay H, Lowe D, Edwards D, Rogers SN. A survey of 14 to 16 year olds as to their attitude toward and use of sunbeds. *Health Educ J*. 2007;66(2):141-152. doi:10.1177/0017896907076753.
61. Mermelstein RJ, Riesenber LA. Changing knowledge and attitudes about skin cancer risk factors in adolescents. *Health Psychol*. 1992;11(6):371-376.
62. Oliphant JA, Forster JL, McBride CM. The use of commercial tanning facilities by suburban Minnesota adolescents. *Am J Public Health*. 1994;84(3):476-478.
63. Reynolds KD, Blaum JM, Jester PM, Weiss H, Soong SJ, Diclemante RJ. Predictors of sun exposure in adolescents in a southeastern U.S. population. *J Adolesc Health*. 1996;19(6):409-415.
64. Tella E, Beauchet A, Vouldoukis I, et al. French teenagers and artificial tanning. *J Eur Acad Dermatol Venereol*. 2012;27(3):e428-e432. doi:10.1111/jdv.12015.
65. Thomson CS, Woolnough S, Wickenden M, Hiom S, Twelves CJ. Sunbed use in children aged 11-17 in England: face to face quota sampling surveys in the National Prevalence Study and Six Cities Study. *BMJ*. 2010;340:c877.

66. Bandi P, Cokkinides VE, Weinstock MA, Ward E. Sunburns, sun protection and indoor tanning behaviors, and attitudes regarding sun protection benefits and tan appeal among parents of U.S. adolescents—1998 compared to 2004. *Pediatr Dermatol*. 2010;27(1):9-18.
67. Bolek-Berquist J, Elliott ME, Gangnon RE, et al. Use of a questionnaire to assess vitamin D status in young adults. *Public Health Nutr*. 2009;12(2):236-243.
68. Brooks K, Brooks D, Dajani Z, et al. Use of artificial tanning products among young adults. *J Am Acad Dermatol*. 2006;54(6):1060-1066.
69. Centers for Disease Control and Prevention. National Health Interview Survey. <http://www.cdc.gov/nchs/nhis.htm>. Accessed February 8, 2013.
70. Galán I, Rodríguez-Laso Á, Díez-Gañán L, Cámara E. Prevalence and correlates of skin cancer risk behaviors in Madrid (Spain). *Gac Sanit*. 2011;25(1):44-49.
71. Genuis SJ, Schwalfenberg GK, Hiltz MN, Vaselenak SA. Vitamin D status of clinical practice populations at higher latitudes: analysis and applications. *Int J Environ Res Public Health*. 2009;6(1):151-173.
72. Heckman CJ, Coups EJ, Manne SL. Prevalence and correlates of indoor tanning among US adults. *J Am Acad Dermatol*. 2008;58(5):769-780.
73. National Cancer Institute. Health Information National Trends Survey 2005 & 2007. <http://hints.cancer.gov/question-details.aspx?dataset=2005&method=cati&qid=805>; <http://hints.cancer.gov/question-details.aspx?dataset=2007&method=combined&qid=805>. Accessed January 23, 2013.
74. Centre for Epidemiology and Research. 2005 Report on adult health from the New South Wales Population Health Survey. 2006. <http://www0.health.nsw.gov.au/pubs/2006/pdf/adultreport2005.pdf>. Accessed January 23, 2013.
75. Rhainds M, De Guire L, Claveau J. A population-based survey on the use of artificial tanning devices in the province of Québec, Canada. *J Am Acad Dermatol*. 1999;40(4):572-576.
76. Danoff-Burg S, Mosher CE. Predictors of tanning salon use: behavioral alternatives for enhancing appearance, relaxing and socializing. *J Health Psychol*. 2006;11(3):511-518.
77. Fogel J, Krausz F. Watching reality television beauty shows is associated with tanning lamp use and outdoor tanning among college students. *J Am Acad Dermatol*. 2013;68(5):784-789.
78. Stapleton J, Turrisi R, Hillhouse J. Peer crowd identification and indoor artificial UV tanning behavioral tendencies. *J Health Psychol*. 2008;13(7):940-945.
79. Bentzen J, Krarup AF, Castberg IM, Jensen PD, Philip A. Determinants of sunbed use in a population of Danish adolescents. *Eur J Cancer Prev*. 2013;22(2):126-130.
80. Centers for Disease Control and Prevention (CDC). Use of indoor tanning devices by adults—United States, 2010. *MMWR Morb Mortal Wkly Rep*. 2012;61(18):323-326.
81. Cokkinides V, Weinstock M, Lazovich D, Ward E, Thun M. Indoor tanning use among adolescents in the US, 1998 to 2004. *Cancer*. 2009;115(1):190-198.
82. Geller AC, Colditz G, Oliveria S, et al. Use of sunscreen, sunburning rates, and tanning bed use among more than 10 000 US children and adolescents. *Pediatrics*. 2002;109(6):1009-1014.
83. Guy GP Jr, Tai E, Richardson LC. Use of indoor tanning devices by high school students in the United States, 2009. *Prev Chronic Dis*. 2011;8(5):A116.
84. Ma F, Collado-Mesa F, Hu S, Kirsner RS. Skin cancer awareness and sun protection behaviors in white Hispanic and white non-Hispanic high school students in Miami, Florida. *Arch Dermatol*. 2007;143(8):983-988.
85. Centre for Epidemiology and Research. New South Wales School Students Health Behaviours Survey: 2005 report. <http://www0.health.nsw.gov.au/publichealth/surveys/hss/index.asp>. Accessed January 23, 2013.
86. Centre for Epidemiology and Research. New South Wales School Students Health Behaviours Survey: 2008 report. <http://www0.health.nsw.gov.au/publichealth/surveys/hss/index.asp>. Accessed January 23, 2013.
87. Robinson JK, Rademaker AW, Sylvester JA, Cook B. Summer sun exposure: knowledge, attitudes, and behaviors of Midwest adolescents. *Prev Med*. 1997;26(3):364-372.
88. Wichstrøm L. Predictors of Norwegian adolescents' sunbathing and use of sunscreen. *Health Psychol*. 1994;13(5):412-420.
89. National Cancer Institute. Cancer Trends Progress Report—2011/2012 Update. http://progressreport.cancer.gov/doc_detail.asp?pid=1&did=2011&chid=101&coid=1011&mid. Accessed January 23, 2013.
90. 2008 Cancer Australia and Australian Institute of Health and Welfare. Non-melanoma skin cancer: general practice consultations, hospitalisation and mortality. Cancer series no. 43. <http://www.aihw.gov.au/publication-detail/?id=6442468158>. Accessed January 23, 2013.
91. Australian Institute of Health and Welfare. ACIM (Australian cancer incidence and mortality) books. 2012. <http://www.aihw.gov.au/acim-books/>. Accessed January 23, 2013.
92. Ferlay JSH, Bray F, Forman D, Mathers C, Parkin DM. GLOBOCAN 2008 v2.0, Cancer Incidence and Mortality Worldwide: IARC CancerBase No. 10. 2010. <http://globocan.iarc.fr>. Accessed January 23, 2013.
93. US National Cancer Institute. Melanoma. <http://www.cancer.gov/cancertopics/types/melanoma>. Accessed January 23, 2013.
94. Lomas A, Leonardi-Bee J, Bath-Hextall F. A systematic review of worldwide incidence of nonmelanoma skin cancer. *Br J Dermatol*. 2012;166(5):1069-1080.
95. Rogers HW, Weinstock MA, Harris AR, et al. Incidence estimate of nonmelanoma skin cancer in the United States, 2006. *Arch Dermatol*. 2010;146(3):283-287.
96. American Cancer Society. Cancer facts & figures 2012. 2012. <http://www.cancer.org/acs/groups/content/@epidemiologysurveillance/documents/document/acspc-031941.pdf>. Accessed January 23, 2013.
97. Centers for Disease Control and Prevention. Lung cancer risk factors. http://www.cdc.gov/cancer/lung/basic_info/risk_factors.htm - 2. Accessed February 4, 2013.
98. Parkin DM, Boyd L, Walker LC. 16. The fraction of cancer attributable to lifestyle and environmental factors in the UK in 2010. *Br J Cancer*. 2011;105(suppl 2):S77-S81.
99. Agudo A, Bonet C, Travier N, et al. Impact of cigarette smoking on cancer risk in the European Prospective Investigation Into Cancer and Nutrition Study. *J Clin Oncol*. 2012;30(36):4550-4557.
100. Schneider S, Krämer H. Who uses sunbeds? a systematic literature review of risk groups in developed countries. *J Eur Acad Dermatol Venereol*. 2010;24(6):639-648.
101. Coups EJ, Phillips LA. A more systematic review of correlates of indoor tanning. *J Eur Acad Dermatol Venereol*. 2011;25(5):610-618.
102. Lazovich D, Forster J. Indoor tanning by adolescents: prevalence, practices and policies. *Eur J Cancer*. 2005;41(1):20-27.
103. Buller DB, Cokkinides V, Hall HI, et al. Prevalence of sunburn, sun protection, and indoor tanning behaviors among Americans: review from national surveys and case studies of 3 states. *J Am Acad Dermatol*. 2011;65(5)(Suppl 1):S114-S123.
104. Centers for Disease Control and Prevention (CDC). Vital signs: current cigarette smoking among adults aged ≥ 18 years with mental illness - United States, 2009-2011. *MMWR Morb Mortal Wkly Rep*. 2013;62(5):81-87.
105. Union OE. Tobacco consumption among adults: health at a glance: Europe 2010. 2010. <http://dx.doi.org/10.1787/97892640316-26-en>. Accessed January 23, 2013.
106. Pawlak MT, Bui M, Amir M, Burkhardt DL, Chen AK, Dellavalle RP. Legislation restricting access to indoor tanning throughout the world. *Arch Dermatol*. 2012;148(9):1006-1012.