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

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Abstract

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.

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Study concept and design: Wehner, Nead, Linos. *Acquisition of data*: Wehner, Nameth, Choudhry, Gaskins.
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Conflict of Interest Disclosures: Dr Chren reports serving as a consultant for Genentech.

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.

Indoor tanning is a World Health Organization group 1 carcinogen[1] associated with malignant melanoma[2-4] and nonmelanoma skin cancer (NMSC).[5] Prior studies have estimated that indoor tanning accounts for more than 3400 cases of melanoma each year in Europe[2] 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) guidelines[6] 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 *nonsolar 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 population, 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://cccrg.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 software[8] 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% CIs, 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 exposure[9-15]; (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 workers[18-20]; (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 (prevalence of exposure × [RR − 1])/(1 + prevalence of exposure × [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 attributable 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 French[22]; 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).[23-66] 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 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

[*]References 31, 32, 34, 35, 38, 39, 44, 45, 47, 48, 59, 67-90

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).[23-90]

Heterogeneity across studies was significant ($P < .001$), and I^2 statistics were greater than 99% in adult, university student, 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 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[2,5,91-96] (**Table 2**). The population proportional attributable risk for 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 419 245 cases of skin cancer in the United States, 26 484 in Northern and Western Europe, and 18 441 in Australia. Overall, we estimate 452 796 cases of basal and squamous cell carcinoma (NMSC) and 11 374 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,[97] 166 915 in Northern and Western Europe,[93] and 10 193 in Australia,[92] assuming that 90% of lung cancer cases are attributable to smoking).[98-100]

Discussion

In this systematic review and meta-analysis of more than 490 000 participants and 88 studies from 16 countries, we 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.[101]

To our knowledge, this is the first summary of the international prevalence of indoor tanning exposure. Prior reviews have focused on high-risk groups,[101,102] correlates,[103,104] and motivations[44] 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,[105,106] 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.[107]

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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 nonwhite 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.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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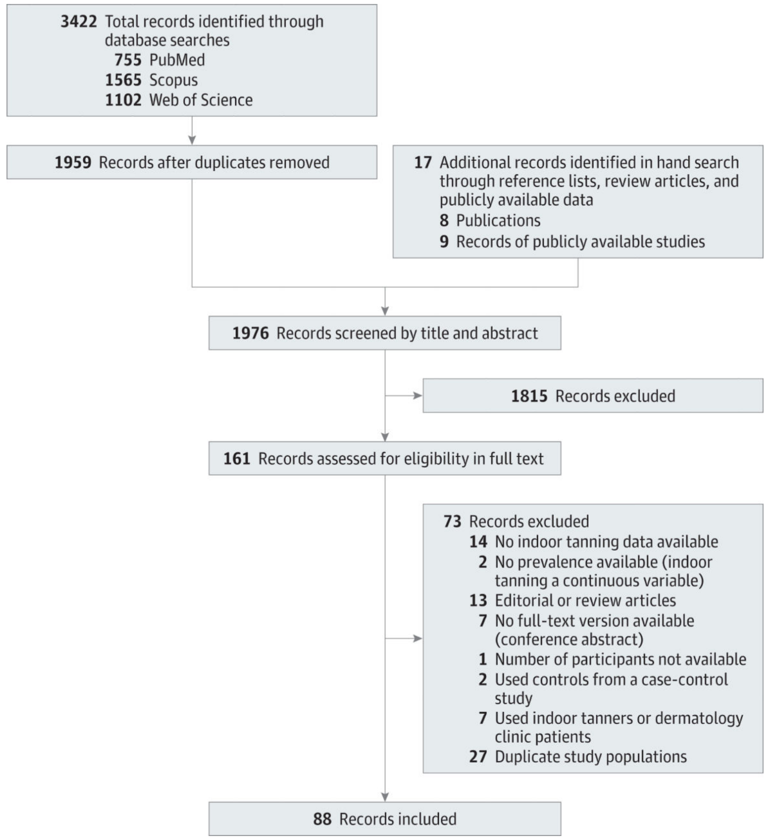

Figure 1. Study Selection Flow Diagram

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

Source and Year of Publication	No. of Participants	Prevalence (95% CI)
United States		
Mawn and Fleischer,[23] 1993	477	0.34 (0.30-0.38)
Moore et al,[25] 2003	106	0.19 (0.12-0.26)
Lazovich et al,[24] 2005	802	0.38 (0.35-0.41)
Woodruff et al,[40] 2006	94	0.22 (0.14-0.31)
Hoerster et al,[32] 2007	5274	0.24 (0.23-0.25)
Lazovich et al,[36] 2008	24	0.74 (0.56-0.92)
Cohen et al,[29] 2013	301	0.50 (0.44-0.55)
Subtotal (I^2 = 96.5%, P < .001)		**0.35 (0.27-0.44)**
Northern and Western Europe		
Jackson et al,[33] 1999	3105	0.17 (0.16-0.18)
Boldeman et al,[26] 2001	2684	0.64 (0.62-0.66)
Bränström et al,[28] 2004	1752	0.35 (0.33-0.37)
Ezzedine et al,[30] 2008	7200	0.15 (0.14-0.16)
Börner et al,[27] 2009	1419	0.29 (0.26-0.31)
Schneider et al,[39] 2009	500	0.47 (0.42-0.51)
Pertl et al,[37] 2010	590	0.11 (0.08-0.14)
Køster et al,[34] 2011	3497	0.60 (0.58-0.61)
Køster et al,[34] 2011	3356	0.62 (0.61-0.64)
Køster et al,[34] 2011	3915	0.58 (0.56-0.59)
Køster et al,[34] 2011	3746	0.59 (0.58-0.61)
Schneider et al,[38] 2013	4333	0.43 (0.41-0.44)
Subtotal (I^2 = 99.9%, P < .001)		**0.42 (0.29-0.54)**
Australia		
Lawler et al,[35] 2006	9298	0.11 (0.10-0.11)
Francis et al,[31] 2010	5073	0.11 (0.10-0.12)
Francis et al,[31] 2010	5085	0.11 (0.10-0.11)
Subtotal (I^2 = 99.9%, P < .001)		**0.11 (0.10-0.11)**
Overall (I^2 = 99.9%, P < .001)		**0.36 (0.27-0.44)**

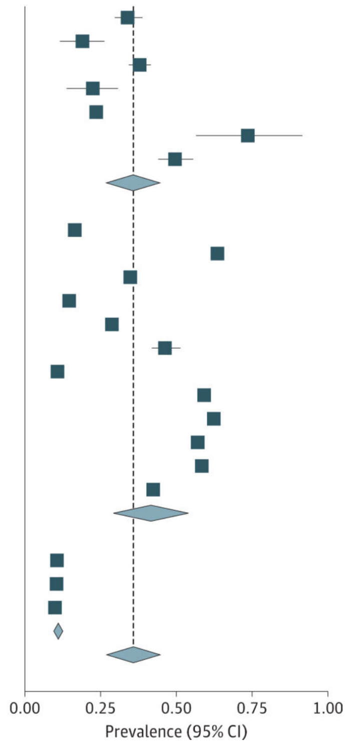

Figure 2. Forest Plots of Primary Analyses: Ever Exposure in Adults

Ever exposure in adults. Plots show point prevalence (squares), 95% CIs (horizontal lines), summary prevalence and 95% CIs for each region and overall (diamonds, the width of which represents the 95% CIs), and summary prevalence estimate (dotted line). Records are listed by date of publication and then by date of data collection. (See eTable 1 in the Supplement for full citations and descriptions.)

Source and Year of Publication	No. of Participants	Prevalence (95% CI)
United States		
Hillhouse et al,[45] 1999	254	0.69 (0.63-0.74)
Knight et al,[47] 2002	489	0.61 (0.57-0.65)
Poorsattar and Hornung,[50] 2007	375	0.33 (0.28-0.38)
Bagdasarov et al,[41] 2008	745	0.95 (0.93-0.97)
Dennis et al,[44] 2009	162	0.88 (0.83-0.93)
Mosher and Danoff-Burg,[48] 2010	421	0.56 (0.52-0.61)
Hillhouse et al,[46] 2012	296	0.54 (0.48-0.59)
Basch et al,[43] 2012	139	0.60 (0.52-0.69)
Neenan et al,[49] 2012	487	0.37 (0.33-0.41)
Banerjee et al,[42] 2012	551	0.40 (0.36-0.44)
Subtotal (I^2 = 99.5%, P < .001)		**0.59 (0.42-0.77)**
Northern and Western Europe		
Monfrecola et al,[51] 2000	764	0.12 (0.10-0.15)
Overall (I^2 = 99.7%, P < .001)		**0.55 (0.33-0.77)**

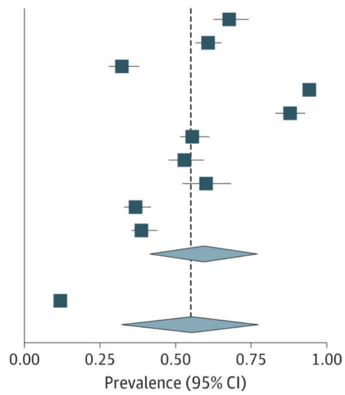

Figure 3. Forest Plots of Primary Analyses: Ever Exposure in University Students

Ever exposure in university students. Plots show point prevalence (squares), 95% CIs (horizontal lines), summary prevalence and 95% CIs for each region and overall (diamonds, the width of which represents the 95% CIs), and summary prevalence estimate (dotted line). Records are listed by date of publication and then by date of data collection. (See eTable 1 in the Supplement for full citations and descriptions.)

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Source and Year of Publication	No. of Participants	Prevalence (95% CI)
United States and Canada		
Banks et al,[52] 1992	96	0.23 (0.14-0.31)
Mermelstein and Riesenberg,[62] 1992	1703	0.13 (0.12-0.15)
Oliphant et al,[63] 1994	1008	0.34 (0.31-0.37)
Reynolds et al,[64] 1996	465	0.03 (0.02-0.05)
Demko et al,[56] 2003	6903	0.24 (0.23-0.25)
Lazovich et al,[60] 2004	1273	0.30 (0.28-0.33)
Woodruff et al,[40] 2006	94	0.12 (0.05-0.18)
Gordon et al,[17] 2009	1202	0.14 (0.12-0.16)
Cohen et al,[29] 2013	301	0.04 (0.02-0.07)
Subtotal (I^2 = 99.1%, P < .001)		**0.17 (0.10-0.25)**
Northern and Western Europe		
Brandberg et al,[54] 1998	2615	0.10 (0.09-0.11)
Boldeman et al,[53] 2003	1190	0.56 (0.53-0.59)
Boldeman et al,[53] 2003	2891	0.33 (0.31-0.35)
De Vries et al,[55] 2006	602	0.37 (0.33-0.40)
Mackay et al,[61] 2007	496	0.43 (0.39-0.47)
Börner et al,[27] 2009	81	0.19 (0.10-0.27)
Thomson et al,[66] 2010	3101	0.06 (0.05-0.07)
Thomson et al,[66] 2010	6209	0.11 (0.10-0.12)
Krarup et al,[59] 2011	1871	0.21 (0.19-0.23)
Fabbrocini et al,[57] 2012	191	0.40 (0.33-0.47)
Tella et al,[65] 2012	704	0.01 (0.01-0.02)
Schneider et al,[38] 2013	518	0.09 (0.06-0.11)
Subtotal (I^2 = 99.6%, P < .001)		**0.24 (0.17-0.30)**
Australia		
Francis et al,[31] 2010	699	0.03 (0.02-0.05)
Francis et al,[31] 2010	652	0.03 (0.01-0.04)
Subtotal (I^2 = 0.0%, P = 33)		**0.03 (0.02-0.04)**
Overall (I^2 = 99.5%, P < .001)		**0.19 (0.15-0.24)**

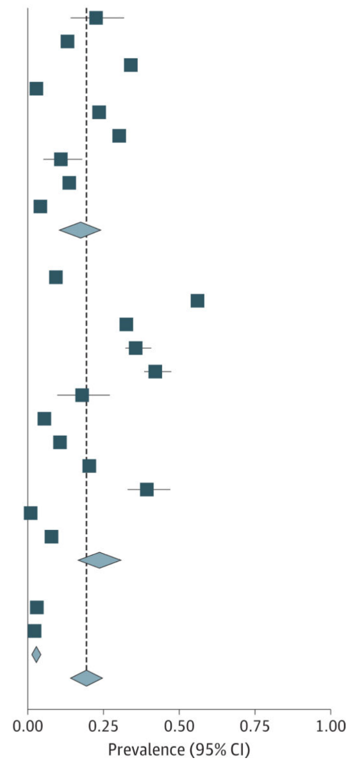

Figure 4. Forest Plots of Primary Analyses: Ever Exposure in Adolescents

Ever exposure in adolescents. Plots show point prevalence (squares), 95% CIs (horizontal lines), summary prevalence and 95% CIs for each region and overall (diamonds, the width of which represents the 95% CIs), and summary prevalence estimate (dotted line). Records are listed by date of publication and then by date of data collection. (See eTable 1 in the Supplement for full citations and descriptions.)

Source and Year of Publication	No. of Participants	Prevalence (95% CI)
United States and Canada		
Rhainds et al,[76] 1999	1003	0.11 (0.09-0.13)
NCI (unpublished),[74] 2005	5523	0.08 (0.08-0.09)
Brooks et al,[69] 2006	448	0.33 (0.29-0.37)
NCI (unpublished),[74] 2007	7424	0.09 (0.08-0.09)
Heckman et al,[73] 2008	29 394	0.13 (0.13-0.14)
Bolek-Berquist et al,[68] 2009	184	0.35 (0.28-0.42)
Genuis et al,[72] 2009	1411	0.09 (0.08-0.11)
Bandi et al,[67] 2010	1187	0.09 (0.07-0.10)
Bandi et al,[67] 2010	1931	0.13 (0.11-0.14)
CDC and NCI,[70] 2012	25 233	0.06 (0.05-0.06)
Subtotal (I^2 = 99.3%, *P* <.001)		**0.13 (0.11-0.16)**
Northern and Western Europe		
Schneider et al,[39] 2009	500	0.21 (0.17-0.25)
Galán et al,[71] 2011	2007	0.04 (0.03-0.05)
Køster et al,[34] 2011	3356	0.30 (0.29-0.32)
Køster et al,[34] 2011	3497	0.28 (0.26-0.29)
Køster et al,[34] 2011	3915	0.27 (0.26-0.28)
Køster et al,[34] 2011	3746	0.23 (0.22-0.25)
Schneider et al,[38] 2013	4333	0.16 (0.15-0.17)
Subtotal (I^2 = 99.6%, *P* <.001)		**0.21 (0.13-0.30)**
Australia		
CER, NSW (unpublished),[86] 2005	11 241	0.02 (0.02-0.03)
Lawler et al,[35] 2006	9298	0.01 (0.01-0.02)
Francis et al,[31] 2010	5073	0.02 (0.02-0.03)
Francis et al,[31] 2010	5085	0.01 (0.01-0.02)
Subtotal (I^2 = 91.8%, *P* <.001)		**0.02 (0.01-0.02)**
Overall (I^2 = 99.8%, *P* <.001)		**0.14 (0.11-0.17)**

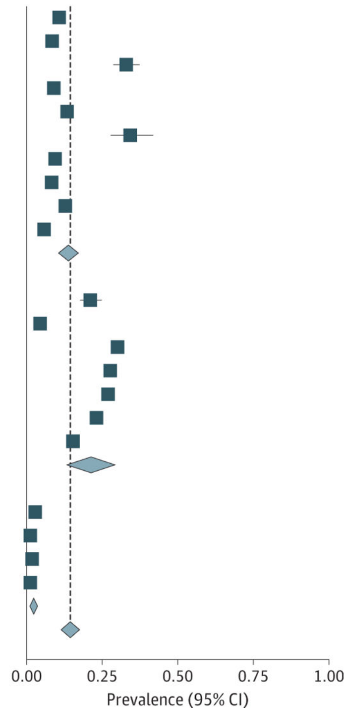

Figure 5. Forest Plots of Primary Analyses: Past-Year Exposure in Adults

Past-year exposure in adults. Plots show point prevalence (squares), 95% CIs (horizontal lines), summary prevalence and 95% CIs for each region and overall (diamonds, the width of which represents the 95% CIs), and summary prevalence estimate (dotted line). Records are listed by date of publication and then by date of data collection. (See eTable 1 in the Supplement for full citations and descriptions.) CDC indicates Centers for Disease Control and Prevention; CER, Centre for Epidemiology and Research; NCI, National Cancer Institute; NSW, New South Wales.

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Source and Year of Publication	No. of Participants	Prevalence (95% CI)
United States		
Hillhouse et al,[45] 1999	254	0.39 (0.33-0.45)
Knight et al,[47] 2002	489	0.47 (0.43-0.51)
Danoff-Burg and Mosher,[77] 2006	164	0.35 (0.28-0.42)
Stapleton et al,[79] 2008	174	0.43 (0.36-0.50)
Dennis et al,[44] 2009	162	0.83 (0.77-0.89)
Mosher and Danoff-Burg,[48] 2010	421	0.48 (0.43-0.52)
Fogel and Krausz,[78] 2013	576	0.07 (0.05-0.09)
Overall (I^2 = 99.3%, P <.001)		**0.43 (0.22-0.65)**

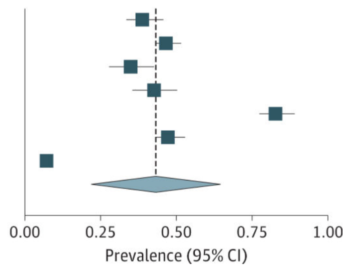

Figure 6. Forest Plots of Primary Analyses: Past-Year Exposure in University Students

Past-year exposure in university students. Plots show point prevalence (squares), 95% CIs (horizontal lines), summary prevalence and 95% CIs for each region and overall (diamonds, the width of which represents the 95% CIs), and summary prevalence estimate (dotted line). Records are listed by date of publication and then by date of data collection. (See eTable 1 in the Supplement for full citations and descriptions.)

Source and Year of Publication	No. of Participants	Prevalence (95% CI)
United States		
Robinson et al,[88] 1997	658	0.09 (0.06-0.11)
Geller et al,[83] 2002	10079	0.09 (0.09-0.10)
NCI (unpublished),[90] 2005	3064	0.09 (0.08-0.10)
Hoerster et al,[32] 2007	5274	0.11 (0.10-0.12)
Ma et al,[85] 2007	369	0.12 (0.09-0.16)
NCI (unpublished),[90] 2007	2204	0.06 (0.05-0.06)
Cokkinides et al,[82] 2009	1196	0.10 (0.08-0.12)
Cokkinides et al,[82] 2009	1613	0.11 (0.10-0.13)
NCI (unpublished),[90] 2010	2751	0.04 (0.04-0.05)
Guy et al,[84] 2011	14590	0.16 (0.15-0.16)
CDC et al,[81] 2012	15425	0.13 (0.13-0.14)
Subtotal (I^2=98.7%, P<.001)		**0.10 (0.08-0.12)**
Northern and Western Europe		
Wichstrøm et al,[89] 1994	15169	0.57 (0.56-0.58)
Køster et al,[34] 2011	34225	0.50 (0.45-0.56)
Køster et al,[34] 2011	34225	0.47 (0.42-0.53)
Køster et al,[34] 2011	34225	0.44 (0.39-0.49)
Krarup et al,[59] 2011	1871	0.17 (0.15-0.18)
Køster et al,[34] 2011	34225	0.33 (0.28-0.38)
Bentzen et al,[80] 2013	5509	0.38 (0.37-0.39)
Schneider et al,[38] 2013	518	0.05 (0.03-0.07)
Subtotal (I^2=99.8%, P<.001)		**0.36 (0.21-0.52)**
Australia		
CER, NSW (unpublished),[86] 2005	2618	0.12 (0.11-0.14)
CER, NSW (unpublished),[87] 2008	7448	0.07 (0.07-0.08)
Francis et al,[31] 2010	699	0.01 (0.00-0.02)
Francis et al,[31] 2010	652	0.01 (0.00-0.01)
Subtotal (I^2=99.3%, P<.001)		**0.05 (0.01-0.10)**
Overall (I^2=99.9%, P<.001)		**0.18 (0.13-0.24)**

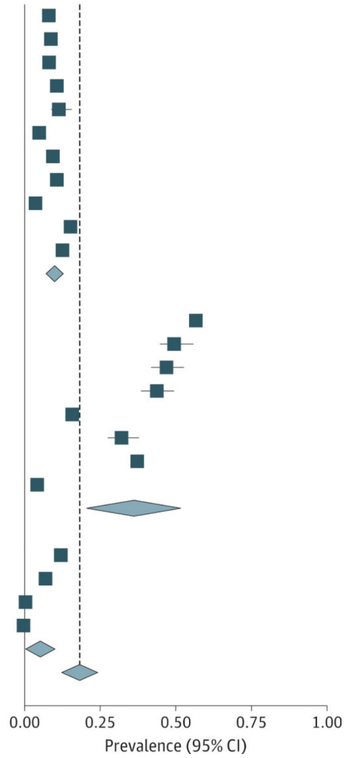

Figure 7. Forest Plots of Primary Analyses: Past-Year Exposure in Adolescents

Past-year exposure in adolescents. Plots show point prevalence (squares), 95% CIs (horizontal lines), summary prevalence and 95% CIs for each region and overall (diamonds, the width of which represents the 95% CIs), and summary prevalence estimate (dotted line). Records are listed by date of publication and then by date of data collection. (See eTable 1 in the Supplement for full citations and descriptions.) CDC indicates Centers for Disease Control and Prevention; CER, Centre for Epidemiology and Research; NCI, National Cancer Institute; NSW, New South Wales.

Table 1

Primary Analyses by Sex and Participant Category

Exposure by Group	Overall		Female Participants		Male Participants	
	Summary Prevalence (95% CI)	Records, No.	SummaryPrevalence (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.

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)	244930 (189719-279-900)
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	...	...	...	419245 (327997-504914)
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 (11 084-19408)
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	...	...	...	26484 (19231-33 195)
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	...	...	...	18441 (17 784-19 259)
All regions				
NMSC (BCC and SCC)	...	...	...	452796 (356436-543 322)
Melanoma	...	...	...	11 374 (8575-14045)
Total skin cancer cases	...	...	...	464170 (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 fromWehner et al[5] (BCC and SCC) and Boniol et al[2] (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 al[96]).

[d] Incidence estimate for 2012 (source: US National Cancer Institute[94]).

[e] Incidence estimate calculated using a yearly incidence rate of 50 per 100 000 (lower-bound conservative estimate from Lomas et al[95] 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 database[93]).

[f]Incidence estimate calculated using a yearly incidence rate of 10 per 100 000 (lower-bound conservative estimate from Lomas et al[95] for 2000-2005) multiplied by the 2008 Northern and Western European population of 285 763 000 (source: IARC GLOBOCAN database[93]).

[g]Incidence estimate for 2008 (source: IARC GLOBOCAN database[93]).

[h]Incidence estimate for 2008 (source: Australian Institute of Health and Welfare[91]).

[i]Incidence estimate for 2009 (source: Australian Institute of Health and Welfare[92]).