ARTICLE

Melanoma Incidence Among Non-Hispanic Whites in All 50 US States From 2001 Through 2015

Aaron P. Thrift , Franciska J. Gudenkauf

See the Notes section for the full list of authors' affiliations.

Correspondence to: Aaron P. Thrift, PhD, Baylor College of Medicine, One Baylor Plaza, MS BCM307, Houston, TX 77030-3498 (e-mail: aaron.thrift@bcm.edu).

Abstract

Background: The United States has large regional variation in primary prevention campaigns for skin cancer. We collected data from all 50 states to examine changes in melanoma incidence and performed age-period-cohort analyses to describe the simultaneous effects of age, period, and cohort on incidence rates.

Methods: Annual melanoma incidence rates for non-Hispanic whites from 2001 to 2015 were extracted from the US Cancer Statistics registry. Secular trends were examined overall and by sex and state. We used joinpoint regression to compute annual percent change and average annual percent change and corresponding 95% confidence intervals (CIs). We also analyzed incidence trends by 5-year age group and birth cohort using incidence rate ratios and age-period-cohort modeling.

Results: Melanoma incidence increased from 20.7 per 100 000 (95% CI = 20.5 to 20.9) in 2001 to 28.2 per 100 000 (95% CI = 28.0 to 28.5) in 2015, increasing by 3.90% (95% CI = 2.36% to 5.48%) annually between 2001 and 2005 and 1.68% (95% CI = 1.37% to 1.99%) annually from 2005 through 2015. The average annual percent change in melanoma incidence rates were similar for men (2.34%, 95% CI = 1.91 to 2.78) and women (2.25%, 95% CI = 1.60 to 2.91). Age-specific relative risk by birth cohort increased from circa 1921 to 1981 before decreasing. Compared with adults born circa 1956, those born circa 1991 had lower melanoma risk (incidence rate ratio = 0.85; 95% CI = 0.77 to 0.94). Geographic variation was observed; some states still have melanoma rates trending upwards in all birth cohorts.

Conclusions: The continued increase in melanoma incidence among non-Hispanic whites, particularly in states where rates continue to rise among recent and current birth cohorts, underscores the need for increased public health campaigns aimed at reducing sun exposure.

In the United States, the incidence of invasive melanoma has increased over the past 40 years (1). In more recent years, the fastest increases in incidence have been observed for melanoma in situ and thin invasive tumors. However, incidence of thicker, more aggressive tumors has also increased, indicating that the rising incidence of melanoma represents a real increase in disease burden and not overdiagnosis as a result of increased diagnostic intervention (2). Further, studies have projected that melanoma incidence rates will continue to rise in the United States (3).

Most US studies describing trends in melanoma incidence rates used only data from the National Cancer Institute's Surveillance, Epidemiology, and End Results (SEER) program (2, 4). However, the full set of registries (SEER 18) covers only 28% of

the US population from limited specific geographic locales (5), impacting the generalizability of its findings, particularly for cancers with large underlying geographic differences in incidence. In the few studies that have used data from all 50 states, none have examined whether or not overall melanoma incidence rates or trends in rates have varied by geographic region (6,7). Examining data from all 50 states both individually and collectively will provide a more representative picture of melanoma trends nationwide. This is especially important given that primary prevention efforts (eg, promotion of sun protection and legislation on indoor tanning) vary greatly between states (8,9).

We performed a comprehensive examination of the overall burden as well as secular trends in melanoma incidence rates

Received: April 5, 2019; Revised: June 13, 2019; Accepted: July 16, 2019

© The Author(s) 2019. Published by Oxford University Press. All rights reserved. For permissions, please email: journals.permissions@oup.com

at both national and state levels in all 50 states of the United States between 2001 and 2015. This included a novel evaluation of contemporary trends (overall and by state) using age-period-cohort modeling, which discerns age effects, period effects, and cohort effects. Here, we use age-period-cohort models to disentangle factors that equally influence all age groups at a particular calendar time ("period effects"; eg, depletion of the ozone layer resulting in higher levels of ambient ultraviolet radiation) from those that vary by generation ("cohort effects"; eg, educational awareness and prevention campaigns targeting certain age groups; widespread use of indoor tanning among younger people starting in the 1980s).

Methods

Data Source and Study Population

We obtained data on incident invasive melanoma cases diagnosed between 2001 and 2015 from the US Cancer Statistics (USCS) registry (10). In 2015, the USCS registry data covered 100% of the US population (11). We included microscopically confirmed invasive melanomas of the skin, defined by International Classification of Diseases for Oncology, 3rd edition (ICD-O-3) site codes C440–C449 and ICD-O-3 histology codes 8720–8790. We used incidence data for non-Hispanic whites only because the incidence rates for melanoma in other racial and/or ethnic subgroups in the United States are very low (12). Melanoma in situ cases were excluded.

Statistical Analysis

Annual incidence rates for melanoma were obtained using standard formulae implemented in SEER*Stat software version 8.3.5 (<https://seer.cancer.gov/seerstat/>), using the number of cases as the numerator and the corresponding population size (based on US Census Bureau data) as the denominator (10). The corresponding 95% confidence intervals (CI) were calculated using the Tiwari method (13). We present both age group-specific rates as well as age-standardized (2000 US standard population) rates.

We used a statistical algorithm to determine whether there were any statistically significant changes in the magnitude or direction of melanoma incidence trends over time. Specifically, we fit a least-squares regression line to the natural logarithm of the incidence rate, and used calendar year of diagnosis as a regressor variable, to estimate the annual percent change (APC) in melanoma incidence rates. We allowed a maximum of two joinpoints with a minimum of four observations required between two joinpoints (14). Monte Carlo permutation tests were used to examine trends for each combination of joinpoints, and we selected the trend line that provided the best fit to the data (15). The APC for each single linear segment and average annual percent change (AAPC) for the entire study period (ie, 2001–2015) were computed for each joinpoint model. We used Joinpoint Software version 4.1.1 (<http://surveillance.cancer.gov/joinpoint/>), and all tests were two-sided with a statistical significance level of $\alpha = 0.05$.

We assessed geographic patterns in age-standardized incidence rates for melanoma. We created national "heat maps" highlighting the age-standardized incidence rate in each state for four study periods: 2001–2002, 2005–2006, 2009–2010, and 2014–2015. Age-standardized rates for each state were categorized using cut-points determined based on incidence rates in 2001–2002. We identified the five states with the largest

increases in age-adjusted melanoma incidence rates in the most recently reported 5-year period (2011–2015) and assessed trends in incidence rates over the entire study period in the five most populous states.

Finally, we used age-period-cohort models to examine for patterns in secular incidence trends according to age at diagnosis (age), year of diagnosis (period), and year of birth (cohort). Age-period-cohort models were fit using the National Cancer Institute's Age-Period-Cohort web tool (<https://analysistools.nci.nih.gov/apc/>), which produces estimates of, for example, net drifts (APC in the expected age-adjusted rates over time), local drifts (APC in the expected age-specific rates over time), and cohort rate ratios (ratio of age-specific rates in each birth cohort relative to the reference cohort), and enables statistical testing of equality of observed trends (16). We used 13 5-year age groups (20–24 years through 80–84 years) and 3 5-year calendar-periods (2001–2005 through 2011–2015), spanning 15 partially overlapping birth cohorts referred to by mid-year of birth (1921 through 1991). Age-period-cohort models were assessed based on overdispersion (σ^2), with values near 1.0 indicating successful fit (17). Default reference groups were used for comparisons (ie, the median calendar period [2006–2010] and the median birth cohort [1956]).

Results

Overall Trends

There were 881 465 melanoma cases diagnosed among non-Hispanic whites in the United States between 2001 and 2015 according to the USCS registry (Table 1). In 2015 alone, there were 73 355 new melanoma cases, representing a 63% increase in the absolute number of cases reported in 2001 ($n = 44\,984$). The age-adjusted incidence rate for melanoma among non-Hispanic whites increased from 20.7 per 100 000 (95% CI = 20.5 to 20.9) in 2001 to 28.2 per 100 000 (95% CI = 28.0 to 28.5) in 2015, representing an AAPC of 2.31% (95% CI = 1.88% to 2.75%). Joinpoint regression identified one statistically significant inflection point (2005) and thus two distinct linear segments (trends). Age-standardized incidence rates for melanoma rose by 3.90% (95% CI = 2.36% to 5.48%) annually between 2001 and 2005 (Table 2). The rate of annual increase slowed in subsequent years to 1.68% between 2005 and 2015; however, this increase remained statistically significant (APC = 1.68%, 95% CI = 1.37% to 1.99%).

Age

Most melanoma cases (83.5%) diagnosed between 2001 and 2015 were among adults aged 45 years and older, with 41.4% occurring in those aged 50–69 years and only 3.4% in adults aged 20–29 years. Melanoma incidence showed continued statistically significant increases in all age groups aged 35 years and older (Table 2). In contrast, age-specific incidence rates for melanoma have decreased in persons aged 20–24 and 25–29 years. Joinpoint regression analyses showed increasing incidence among persons aged 20–24 and 25–29 years from 2001 to 2006; however, there were statistically significant decreases in rates since 2006 for persons aged 20–24 years (APC = -4.70% , 95% CI = -3.51% to -5.87%) and 25–29 years (APC = -2.95% , 95% CI = -1.81% to -4.07%).

Sex

Men comprised the majority (58.6%) of melanoma cases. There were increases in age-standardized incidence rates for

melanoma in both men and women over the study period; age-adjusted rates increased from 25.7 (95% CI=25.4 to 26.0) to 34.7 (95% CI=34.4 to 35.1) per 100 000 in men and from 17.1 (95% CI=16.9 to 17.4) to 23.4 (95% CI=23.2 to 23.7) per 100 000 in

Table 1. Annual frequencies and age-adjusted incidence rates of invasive melanoma among non-Hispanic whites in the United States between 2001 and 2015

Year	Incident melanomas	Age-adjusted rate per 100 000* (95% CI)
2001	44 984	20.7 (20.5 to 20.9)
2002	46 373	21.2 (21.0 to 21.4)
2003	47 117	21.1 (20.9 to 21.3)
2004	50 699	22.5 (22.3 to 22.7)
2005	55 021	24.2 (24.0 to 24.4)
2006	55 201	24.0 (23.8 to 24.2)
2007	57 418	24.6 (24.4 to 24.8)
2008	59 264	25.0 (24.8 to 25.2)
2009	61 508	25.7 (25.5 to 25.9)
2010	61 385	25.3 (25.1 to 25.5)
2011	63 842	25.9 (25.7 to 26.1)
2012	65 584	26.3 (26.1 to 26.5)
2013	68 293	26.9 (26.7 to 27.1)
2014	71 421	27.7 (27.5 to 28.0)
2015	73 355	28.2 (28.0 to 28.5)

*Direct adjustment performed using the 2000 US standard population. CI = confidence interval.

women, respectively (Supplementary Figure 1, available online). The AAPC in melanoma incidence rates were similar in men (AAPC = 2.34%, 95% CI=1.91 to 2.78) and women (AAPC = 2.25%, 95% CI=1.60 to 2.91) between 2001 and 2015 (Table 2). The largest APC in rates occurred between 2001 and 2005 (3.76% and 4.19% in men and women, respectively; both $P < .001$), followed by a smaller statistically significant increase in subsequent years in men (APC = 1.78%, 95% CI=1.47 to 2.09) and women (APC = 1.49%, 95% CI=1.02 to 1.96) between 2005 and 2015 (Table 2).

Geography

The highest age-standardized incidence rates for melanoma over the study period were in Hawaii. In 2001–2002, 24 of the 50 states had age-standardized incidence rates for melanoma less than 21 per 100 000; this number decreased to 19 states by 2005–2006, 8 states by 2009–2010, and only 3 states by 2014–2015 (Figure 1). In contrast, the number of states with age-standardized incidence rates for melanoma greater than 30 per 100 000 increased from 2 states (Hawaii and New Mexico) in 2001–2002 to 9 states by 2005–2006, 11 states by 2009–2010, and 15 states by 2014–2015. For the five most populous states (California, Texas, Florida, New York, and Pennsylvania), the 2015 age-adjusted melanoma incidence rate per 100 000 was highest in California (37.0 per 100 000; 95% CI=36.2 to 37.9), followed in decreasing order by Florida (31.8 per 100 000; 95% CI=30.9 to 32.7), Pennsylvania (27.1 per 100 000; 95% CI=26.2 to

Table 2. Annual and average annual percent change in invasive melanoma incidence rates among non-Hispanic whites over time in the United States, overall and by age and sex*

Population	Joinpoint segment year start	Joinpoint segment year end	APC (95% CI)	Joinpoint segment year start	Joinpoint segment year end	AAPC (95% CI)
Overall US population	2001	2005	3.90 (2.36 to 5.48)	2001	2015	2.31 (1.88 to 2.75)
	2005	2015	1.68 (1.37 to 1.99)	—	—	—
Age-group at diagnosis, y						
20–24	2001	2006	2.35 (–0.24 to 5.01)	2001	2015	–2.24 (–3.27 to –1.19)
	2006	2015	–4.70 (–5.87 to –3.51)	—	—	—
25–29	2001	2006	2.17 (–0.44 to 4.86)	2001	2015	–1.15 (–2.18 to –0.11)
	2006	2015	–2.95 (–4.07 to –1.81)	—	—	—
30–34	2001	2015	0.38 (–0.15 to 0.91)	2001	2015	0.38 (–0.15 to 0.91)
35–39	2001	2015	0.92 (0.25 to 1.58)	2001	2015	0.92 (0.25 to 1.58)
40–44	2001	2015	0.50 (0.12 to 0.88)	2001	2015	0.50 (0.12 to 0.88)
45–49	2001	2015	1.01 (0.50 to 1.52)	2001	2015	1.01 (0.50 to 1.52)
50–54	2001	2015	1.52 (1.13 to 1.90)	2001	2015	1.52 (1.13 to 1.90)
55–59	2001	2015	1.64 (1.31 to 1.98)	2001	2015	1.64 (1.31 to 1.98)
60–64	2001	2015	2.10 (1.73 to 2.48)	2001	2015	2.10 (1.73 to 2.48)
65–69	2001	2005	5.01 (3.43 to 6.61)	2001	2015	3.23 (2.79 to 3.66)
	2005	2015	2.52 (2.23 to 2.82)	—	—	—
70–74	2001	2015	3.09 (2.78 to 3.40)	2001	2015	3.09 (2.78 to 3.40)
75–79	2001	2005	7.12 (5.68 to 8.58)	2001	2015	4.26 (3.86 to 4.67)
	2005	2015	3.14 (2.84 to 3.44)	—	—	—
80–84	2001	2011	5.45 (4.97 to 5.93)	2001	2015	4.59 (4.08 to 5.10)
	2011	2015	2.48 (0.88 to 4.10)	—	—	—
≥85	2001	2008	5.88 (4.99 to 6.78)	2001	2015	5.06 (4.58 to 5.55)
	2008	2015	4.25 (3.61 to 4.89)	—	—	—
Sex						
Male	2001	2005	3.76 (2.21 to 5.33)	2001	2015	2.34 (1.91 to 2.78)
	2005	2015	1.78 (1.47 to 2.09)	—	—	—
Female	2001	2005	4.19 (1.84 to 6.59)	2001	2015	2.25 (1.60 to 2.91)
	2005	2015	1.49 (1.02 to 1.96)	—	—	—

*AAPC = average annual percent change; APC = annual percent change; CI = confidence interval.

Figure 1. State-level heat maps showing age-adjusted invasive melanoma incidence rates among non-Hispanic whites in 2001–2002, 2005–2006, 2009–2010, and 2014–2015.

28.1), New York (25.4 per 100 000; 95% CI = 24.5 to 26.2), and Texas (19.9 per 100 000; 95% CI = 19.2 to 20.7). The age-standardized incidence rates for melanoma underwent statistically significant increases and continued to increase in California (AAPC = 1.97%, 95% CI = 1.53 to 2.42), Florida (AAPC = 2.43%, 95% CI = 1.82 to 3.05), New York (AAPC = 4.02%, 95% CI = 2.33 to 5.75), and Pennsylvania (AAPC = 2.84%, 95% CI = 2.05 to 3.63) between 2001 and 2015; however, rates remained unchanged between 2001 and 2015 in Texas (AAPC = -0.41%, 95% CI = -1.08 to 0.25). The five states with the greatest statistically significant increase in overall age-standardized melanoma incidence rates during the latest 5-year period (2011–2015) were Maryland (AAPC = 7.41%, 95% CI = 2.50 to 12.6), Oklahoma (AAPC = 6.59%, 95% CI = 0.90 to 12.6), Indiana (AAPC = 6.23%, 95% CI = 0.46 to 12.3), Ohio (AAPC = 6.07%, 95%

CI = 0.49 to 12.0), and Utah (AAPC = 5.82%, 95% CI = 1.30 to 10.6). The state with the lowest overall age-adjusted incidence rate between 2011 and 2015 was Alaska (17.1 per 100 000, 95% CI = 15.3 to 18.9) (Supplementary Table 1, available online).

Age-Period-Cohort Models

Age-period-cohort modeling demonstrated evidence for both period and cohort effects. Supplementary Figure 2 (available online) shows period and cohort deviations generally statistically significantly different from zero. However, the analysis demonstrated a strikingly larger cohort effect than period effect (cohort deviations were 50-fold higher than period deviations). Further, the local drift was statistically significant for all ages, with the

Figure 2. Summary age-specific annual percent change (ie, local drift) and birth cohort rate ratios of invasive melanoma incidence rates among non-Hispanic whites in the United States. **A)** Local drift: summary age-specific annual percent change for melanoma. **B)** Incidence rate ratios by birth cohort for melanoma (referent cohort = 1956). Shaded bands indicate 95% confidence interval. RR = rate ratio.

exception of adults aged 30 to 34 years (Figure 2A), consistent with the age-specific trend for that group (Table 2). Age-specific trends by birth cohort are presented as incidence rate ratios (IRRs) using the 1956 cohort as the referent group. Figure 2B shows the age interaction as a generational or birth cohort effect. Melanoma incidence rates among non-Hispanic whites born circa 1981 were 14% (IRR=1.14, 95% CI=1.08 to 1.21) greater than those born circa 1956. However, relative to the 1956 birth cohort, incidence rates among those born circa 1986 were no different (IRR=1.03, 95% CI=0.96 to 1.11), whereas rates for those born circa 1991 were statistically significantly lower (IRR=0.85, 95% CI=0.77 to 0.94).

Despite the overall national trend of decreasing incidence rates among recent birth cohorts, nine states have melanoma rates that are higher, and some still trending upwards, in the most recent birth cohorts compared with the referent group (Figure 3; Supplementary Figure 3, available online). For example, in Utah, the state with the second highest age-adjusted incidence rate in 2015 (46.0 per 100 000), persons born circa 1991 have more than twofold higher risk (IRR=2.33, 95% CI=1.60 to 3.38) of melanoma than those born circa 1956. Likewise, in Georgia, the state with the third highest age-adjusted incidence rate in 2015 (40.9 per 100 000), persons born circa 1991 had 1.7-fold higher risk (IRR=1.73, 95% CI=1.20 to 2.49) of melanoma than those born circa 1956.

Discussion

In this population-based study with data from all 50 states, we found that the overall age-adjusted incidence rates for invasive melanoma among non-Hispanic whites increased between 2001 and 2015 from 20.7 per 100 000 to 28.2 per 100 000. The rate of increase was fastest for the period between 2001 and 2005, where rates increased by 3.90% annually. Melanoma incidence rates in the United States continued to rise between 2005 and 2015, albeit at a slower rate (1.68% per year). However, despite the overall increasing trend in recent years, melanoma incidence rates decreased between 2006 and 2015 among person younger than 30 years. For the first time, we observed an overall national

trend of decreasing incidence rates among recent and current birth cohorts; compared to those born circa 1956, those born circa 1991 had 15% lower melanoma incidence rates.

We observed geographic variations in melanoma incidence rates and trends, with Hawaii, Utah, and Georgia having the highest rates in the nation. However, the increase in melanoma rates has affected most states, with only 3 states still having overall age-adjusted melanoma incidence rates less than 21 per 100 000 in 2014–2015 compared to 24 states in 2001–2002. We also observed state-by-state differences in the cohort effect. Although there was an overall national trend of decreasing incidence rates among recent and current birth cohorts, rates in some states are still increasingly higher in recent and current birth cohorts relative to the reference cohort of 1956. In these states, melanoma incidence rates among persons born circa 1986 and 1991 were up to two- to threefold higher than those observed among persons born circa 1956.

Findings from our national level analysis support those from previous studies showing a continued rise in incidence of melanoma in the United States (1). Although it is unclear whether or not earlier detection is having an impact (ie, reduced melanoma-related mortality), there is strong evidence that the documented increase represents a true rise in disease burden and not an artifact of increased skin cancer awareness, or screening and detection of indolent disease (2). It is concerning that studies project that the burden of melanoma will continue to rise in the United States through 2030 (3). However, results from our age-period-cohort analysis reveal, for the first time, an overall national level trend of decreasing incidence rates among recent and current birth cohorts. Mounessa et al. (18) previously showed a reduction in both melanoma incidence and mortality rates between 2003 and 2013 in only the New England region, where skin cancer prevention programs have been in place for over a decade. Consistent with this, we found decreasing trends of the cohort effect for all states in this region. Our results also support previous findings of declining melanoma rates among Americans aged younger than 30 years (19). In contrast to prior findings (19), however, we found an increase in rates among persons aged 35–44 years because of a trending up of rates during 2012–2015.

Figure 3. Incidence rate ratios by birth cohort for invasive melanoma (referent cohort = 1956) among non-Hispanic whites in select states. Shaded bands indicate 95% confidence interval. RR = rate ratio.

The majority of melanoma cases in the United States are caused by exposure to ultraviolet radiation, including natural exposure (ie, from sunlight) or artificial exposure (eg, from indoor tanning). As such, the US Surgeon General's 2014 Call to Action to Prevent Skin Cancer promoted increased sun protection in outdoor settings and reduction in the harms from indoor tanning (8). However, although many states employ a combination of education and regulation strategies in their skin cancer prevention programs, priorities and stringency are by no means uniform (8,9). To increase awareness about skin cancer, some states and communities have incorporated educational programs into their school system's health curriculum (8). For example, in Arizona, the SunWise program teaches students about sun safety, and all public schools are required by law to implement the program (8). In Nevada, the Sun Smart Schools program applies effective health promotion to target student-specific health beliefs, in addition to teaching about sun safety and offering access to shade and sunscreen (20). We observed a

decreasing trend in the birth cohort effect for Arizona and Nevada. Yet, although these interventions are effective (20), few states support such programs (8).

Additionally, legislation regarding sun safety and protection varies by state (8). To address policies that prohibit students from accessing sun protection during school, such as the use of sunscreen (which, as an over-the-counter drug, may be banned from school property), 13 states have adopted legislation allowing sunscreen use during school hours (20). As of June 2018, Hawaii was not one of these states (20), despite its striking melanoma incidence rates. Further, in California, by law, schools must allow students to wear sun-protective clothing and products during school hours, in addition to sunscreen (8).

Although ultraviolet tanning beds have been classified as carcinogenic to humans (21), use of indoor tanning remains common in the United States (22,23), and regulations around their use by minors younger than 18 years vary considerably (8). Currently, California, Delaware, District of Columbia, Hawaii,

Illinois, Kansas, Louisiana, Massachusetts, Minnesota, Nevada, New Hampshire, New York, North Carolina, Oklahoma, Oregon, Rhode Island, Texas, Vermont, Washington, and West Virginia ban the use of tanning beds for all minors younger than 18 years (20,24). However, other states, including some with melanoma rates trending upwards in all birth cohorts (eg, Utah and Georgia), have less strict restrictions (eg, require parent permission, ban for younger minors) or none at all (20,24). We found increasing rates among recent birth cohorts in Midwest states (Illinois, Iowa, and Minnesota), which have the highest rates of indoor tanning among teens and young adults in the United States (25).

The strengths of our study include that the data used are more representative of the entire US population than the SEER database that is commonly used to describe melanoma incidence trends. This is especially important given our finding that rates and secular trends varied geographically and that the cohort effect was not consistent from state to state. Furthermore, as the registries collected data prospectively and independently of our study hypotheses, our results cannot be influenced by systematic recall or information bias.

A limitation of our study is that it was based on cancer registry data and no information on individual risk factors or population-level screening was available. As such, our study cannot provide any direct evidence about the role of specific exposures or interventions on the period and cohort effects we observed for the melanoma incidence trends. Also, underreporting and delays in melanoma reporting might result in an underestimate of cases in most recent years and may explain part of the observed slowing of the rate of increase in incidence (26). Furthermore, variations between states in extent of incomplete and delayed ascertainment of cases may contribute to the observed geographic variation in trends. For states with continued increases in incidence in recent and current birth cohorts, the rate of increase and magnitude of cancer burden may be higher than we report. We excluded in situ cases where diagnosis is problematic and underreporting is highly likely and variable geographically. Finally, the most recent data (2015) are several years old, because current requirements for reporting cancer registry data are rigorous and require multiple steps.

In summary, we found overall increasing invasive melanoma incidence rates among non-Hispanic whites in the United States. However, the rate of increase has slowed since 2005, and incidence rates at the national level are now lower among persons in most recent and current birth cohorts compared to earlier generations. Nonetheless, despite the overall national trend of decreasing incidence rates among recent birth cohorts, rates continue to rise among recent and current birth cohorts in some individual states.

Funding

None.

Notes

Affiliations for authors: Section of Epidemiology and Population Sciences, Department of Medicine, Baylor College of Medicine, Houston, TX (APT, FJG); Dan L Duncan Comprehensive Cancer Center, Baylor College of Medicine, Houston, TX (APT);

University of Texas Health Science Center at Houston School of Public Health, Houston, TX (FJG).

The authors have no conflicts of interest to disclose.

References

1. Siegel RL, Miller KD, Jemal A. Cancer statistics, 2019. *CA Cancer J Clin*. 2019; 69(1):7–34.
2. Shaikh WR, Dusza SW, Weinstock MA, Oliveria SA, Geller AC, Halpern AC. Melanoma thickness and survival trends in the United States, 1989 to 2009. *J Natl Cancer Inst*. 2015;108(1). pii: djv294.
3. Whiteman DC, Green AC, Olsen CM. The growing burden of invasive melanoma: projections of incidence rates and numbers of new cases in six susceptible populations through 2031. *J Invest Dermatol*. 2016;136(6):1161–1171.
4. Olsen CM, Green AC, Pandeya N, Whiteman DC. Trends in melanoma incidence rates in eight susceptible populations through 2015. *J Invest Dermatol*. 2019;139(6):1392–1395.
5. Printz C. Changes underway for SEER: program leaders work to increase the breadth and depth of information. *Cancer*. 2015;121(18):3183–3184.
6. Glazer AM, Winkelman RR, Farberg AS, Rigel DS. Analysis of trends in US melanoma incidence and mortality. *JAMA Dermatol*. 2017;153(2):225–226.
7. Watson M, Geller AC, Tucker MA, Guy GP Jr, Weinstock MA. Melanoma burden and recent trends among non-Hispanic whites aged 15–49 years, United States. *Prev Med*. 2016;91:294–298.
8. U.S. Department of Health and Human Services. Reports of the surgeon general. In: *The Surgeon General's Call to Action to Prevent Skin Cancer*. Washington, DC: Office of the Surgeon General (US); 2014.
9. Lazovich D, Choi K, Vogel RI. Time to get serious about skin cancer prevention. *Cancer Epidemiol Biomarkers Prev*. 2012;21(11):1893–1901.
10. National Cancer Institute Surveillance, Epidemiology, and End Results Program SEER 18 Regs Research Data, Nov 2017 Sub (2001–2015). National Cancer Institute, DCCPS, Surveillance Research Program, Surveillance Systems Branch. <http://www.seer.cancer.gov>. Accessed September 15, 2018.
11. US Cancer Statistics Working Group. US Cancer Statistics Data Visualizations Tool, Nov 2017 Sub (1999–2015). US Department of Health and Human Services, Centers for Disease Control and Prevention, and National Cancer Institute. www.cdc.gov/cancer/dataviz. Accessed March 5, 2019.
12. Noone AM, Howlander N, Krapcho M, et al. *SEER Cancer Statistics Review, 1975–2015*. Bethesda, MD: National Cancer Institute; 2018.
13. Tiwari RC, Clegg LX, Zou Z. Efficient interval estimation for age-adjusted cancer rates. *Stat Methods Med Res*. 2006;15(6):547–569.
14. Yu B, Barrett MJ, Kim H-J, Feuer EJ. Estimating joinpoints in continuous time scale for multiple change-point models. *Comput Stat Data Anal*. 2007;51(5):2420–2427.
15. Kim HJ, Fay MP, Feuer EJ, Midthune DN. Permutation tests for joinpoint regression with applications to cancer rates. *Stat Med*. 2000;19(3):335–351.
16. Rosenberg PS, Check DP, Anderson WF. A web tool for age-period-cohort analysis of cancer incidence and mortality rates. *Cancer Epidemiol Biomarkers Prev*. 2014;23(11):2296–2302.
17. McCullagh P, Nelder JA. *Generalized Linear Models*. New York: Chapman and Hall; 1989.
18. Mounessa JS, Caravaglio JV, Dellavalle RP. Comparison of regional and state differences in melanoma rates in the United States: 2003 vs 2013. *JAMA Dermatol*. 2017;153(3):345–347.
19. Holman DM, Freeman MB, Shoemaker ML. Trends in melanoma incidence among non-Hispanic whites in the United States, 2005 to 2014. *JAMA Dermatol*. 2018;154(3):361–362.
20. Centers for Disease Control and Prevention (CDC). *Skin Cancer Prevention Progress Report 2018*. Atlanta, GA: CDC, US Dept of Health and Human Services; 2018.
21. El Ghissassi F, Baan R, Straif K, et al. A review of human carcinogens—part D: radiation. *Lancet Oncol*. 2009;10(8):751–752.
22. Guy GP Jr, Berkowitz Z, Everett Jones S, Holman DM, Garnett E, Watson M. Trends in indoor tanning among US high school students, 2009–2013. *JAMA Dermatol*. 2015;151(4):448–450.
23. Guy GP Jr, Berkowitz Z, Holman DM, Hartman AM. Recent changes in the prevalence of and factors associated with frequency of indoor tanning among US adults. *JAMA Dermatol*. 2015;151(11):1256–1259.
24. National Conference of State Legislatures. Indoor tanning restrictions for minors. A state-by-state comparison, 2019. <http://www.ncsl.org/research/health/indoor-tanning-restrictions.aspx>. Accessed March 26, 2019.
25. Hartman AM, Guy GP Jr, Saraiya M, Plescia M. Use of indoor tanning devices by adults—United States, 2010. *MMWR Morb Mortal Wkly Rep*. 2012;61(18):323–326.
26. Clegg LX, Feuer EJ, Midthune DN, Fay MP, Hankey BF. Impact of reporting delay and reporting error on cancer incidence rates and trends. *J Natl Cancer Inst*. 2002;94(20):1537–1545.