Melanoma prognosis in the United States: Identifying barriers for improved care

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Background: Despite improvements in melanoma mortality, disparities in melanoma survival persist. We evaluated possible sociodemographic and health care–based predictors of differences in melanoma survival in the United States by using the melanoma mortality-to-incidence ratio (MIR).

Methods: State-based MIRs were calculated by using US cancer statistics data from 1999 to 2014. Pearson correlations and linear regressions were used to determine associations between MIR and dermatologist density, primary care provider density, number of physicians by state, number of National Cancer Institute–designated cancer centers, health care spending per capita, average household income, racial/ethnic makeup of the population, percentage of uninsured individuals, and percentage with a bachelor's degree.

Results: The mean overall MIR was 0.15 ± 0.04; only Alaska was an outlier (0.24). No state MIRs increased significantly over time; MIR decreased for most states. Multivariable analysis revealed that states with more active physicians ($P = .02$) and a higher percentage non-Hispanic whites ($P = .004$) had higher MIRs (poorer survival). Significant Pearson correlations were seen between MIR and melanoma incidence ($r = -0.72$, $P < .001$), melanoma mortality ($r = 0.38$, $P < .001$), dermatologist density ($r = 0.32$, $P < .001$), and National Cancer Institute–designated cancer center count ($r = -0.12$, $P = .001$).

Conclusions: Melanoma survival is improved in higher-incidence areas and areas with higher dermatologist density. These findings highlight areas of poorer melanoma survival and the need for local studies evaluating disparities in melanoma survival. (J Am Acad Dermatol 2019;80:1256-62.)

Key words: barriers to care; dermatology; disparities; epidemiology; health care access; melanoma; mortality-to-incidence ratio; prognosis.

Even as melanoma care evolves and improves, survival disparities persist.[1-4] The mortality-to-incidence ratio (MIR) is a useful tool for understanding and comparing melanoma survival between geographic areas and subgroups. It measures the ratio of standardized mortality rates to incidence rates, thus approximating case-based survival. By comparing MIRs with time- and geography-matched data, we can identify subpopulations with disproportionately poorer survival. Previous MIR analyses found decreased melanoma survival associated with low socioeconomic status, lower levels of

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Drs Secrest and Hopkins had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.

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education, lower health care system ranking, and lower levels of health care spending.[2,3,5]

We sought to identify both sociodemographic- and health care–based factors that contribute to disparities in state-based melanoma survival. These factors included race, education level, household income, health insurance status, health care spending per capita, physician density, and number of state National Cancer Institute–designated Cancer Centers (NCIDCCs).

CAPSULE SUMMARY

- Mortality-to-incidence ratio approximates melanoma survival and can help identify survival disparities.
- States with increased melanoma incidence and dermatologist density had better melanoma survival. States with more active physicians and more non-Hispanic whites had worse melanoma survival. Efforts to improve survival should occur locally, as local differences explain most survival variations.

METHODS

State-based melanoma mortality and incidence rates were retrieved from the US Cancer Statistics website, which provides data published by the US Centers for Disease Control and Prevention.[6] State-based age-standardized rates per 100,000 person-years for invasive melanoma incidence and mortality in the United States were retrieved for the period from 1999 to 2014.[6] Because in situ melanomas carry no mortality risk, they were not included in the database. MIR essentially acts as a standardized mortality rate to approximate survival, and including lesions with no mortality risk can artificially increase the approximation of survival and potentially obscure disparities in mortality. Each state's MIR was calculated by dividing the mortality rate by the incidence rate. Increases in mortality without proportional increases in incidence signify increased case mortality.

We explored both health care–related and sociodemographic predictors of MIR. Health care–related variables included dermatologist density, measured as people per dermatologist; primary care provider density, measured as people per internal medicine physician; number of total practicing physicians; number of NCIDCCs; and health care spending per capita. Sociodemographic variables included average household income; percentage of uninsured individuals; percentage of the population with a bachelor's degree; and percentage of the population by race (non-Hispanic white, black, Hispanic, Asian, Native American/Native Alaskan, Native Hawaiian/other Island Pacific, or 2 or more races).[7-10] Dermatologist density data were available only for 2013, and counts for NCIDCCs could be retrieved only from the National Cancer Institute's current website; historical data were not available.

To investigate temporal changes in each state's MIR over time, simple linear regression was performed. Negative and significant regression coefficients equate to decreasing MIR or an improving survival rate. Conversely, positive, significant regression coefficients equate to increasing MIR or worsening survival. To evaluate potential factors associated with MIR, univariable and multivariable regressions were performed on so-called panel data, meaning that data were organized by time-series observations collected for multiple groups (states) that made up the panels. Fixed effects modeling was necessary for this analysis given that group differences were expected to be present, no time-invariant variables were included in the model, and the goal of the analysis was prediction rather than marginal analysis. Nonetheless, for all regressions, the Durbin-Wu-Hausman test was used to assist in deciding between a fixed-effect or random-effects model; ultimately a fixed-effect model was chosen. Autocorrelation was assessed for each regression using the Wooldridge test, and none was found. Shapiro-Wilk W-tests for normality were performed and were significant for our regressions; thus, robust standard errors were used to correct for heteroscedasticity.

Because data for both dermatologist density and number of NCIDCCs per state were available for only a single year, pairwise Pearson correlations were used to compare state MIRs with these 2 variables. Additionally, univariable regressions were performed by repeating the 1-year data for dermatologist density and NCIDCCs for each year. These variables were not included in multivariable modeling because of this extrapolation and the fact that time-invariant variables cannot be included in fixed effects models. Pearson's correlations were also used for exploratory analysis of the relationship between melanoma incidence and mortality. These highly correlated associations between MIR and incidence/mortality were not included in the regression models.

A P value less than .05 was considered significant for all analyses. Regression coefficients and 95% confidence intervals were included for all hypothesis tests. All analyses were conducted with STATA software (version 14.2, StataCorp, College Station, TX).

Abbreviations used:

MIR: mortality-to-incidence ratio
NCIDCC: National Cancer Institute–designated Cancer Center
SD: standard deviation

RESULTS

A box-and-whisker plot was used to display each state's mean MIR, distribution, and outlier observations (Fig 1). Thermal plots of mean melanoma incidence and MIR from 1999 to 2014 for each state are shown in Figure 2, *A* and *B*. The overall mean (plus or minus the standard deviation [SD]) MIR was 0.15 ± 0.04. State-based mean MIR ranged from 0.09 ± 0.03 (Hawaii) to 0.24 ± 0.03 (Alaska). State means were assessed relative to the overall mean and twice the SD to identify outliers, with Alaska being the only outlier.

Changes in each state's MIR over time were plotted with best-fit lines showing trends (Fig 3). Regression coefficients, 95% confidence intervals, and *P* values were also calculated for each state. MIR decreased to varying degrees over time for all states except Arizona, Colorado, Connecticut, Hawaii, Indiana, Maine, Massachusetts, Michigan, Nevada, New Hampshire, New Mexico, Rhode Island, South Carolina, Texas, Vermont, and West Virginia. The only state for which MIR was increasing was Alaska. However, only 2 MIR data points were available, so only a coefficient (slope) was calculated (thus, statistics regarding trend over time could not be calculated). Likewise, mortality data were not available for the District of Columbia; thus, regression data were not included.

Univariable and multivariable regression analyses were performed to explore associations of health care system–related and sociodemographic factors with MIR (Table I). Factors significantly and negatively associated with MIR included health care spending per capita ($P < .001$), NCIDCCs per state ($P = .02$); number of physicians ($P = .002$); primary care provider density ($P = .001$); percentage of the population with a bachelor's degree ($P < .001$); and percentages of the population that are black ($P < .001$), Native American/Native Alaskan ($P = .01$), Asian ($P = .01$), and Native Hawaiian/other islander ($P < .001$). Factors positively associated with MIR included dermatologist density ($P < .001$), average household income ($P = .01$), and percentage of the population that is non-Hispanic white ($P < .001$). Percentage of uninsured individuals was not significantly associated with MIR. In multivariable regression analysis, only the number of active physicians ($P = .02$) and percentage of the population that is non-Hispanic white ($P = .004$) remained significantly associated with MIR. The variance in MIR due to state grouping was 99.0%.

Lastly, we calculated pairwise Pearson correlations between MIR and melanoma incidence ($r = -0.72$, $P < .001$), melanoma mortality ($r = 0.38$, $P < .001$), dermatologist density ($r = 0.32$, $P < .001$), and NCIDCC count ($r = -0.12$, $P = .001$).

DISCUSSION

Overall melanoma survival has been increasing, a trend that is expected to continue as incidence increases and mortality remains static.[11] However, some states' MIR is not improving (Fig 3). Thus, although our data suggest an overall downward trend in MIR (better survival) nationally, there are several states in which targeted efforts may prove beneficial. Furthermore, despite innovations in therapies to improve survival, disparities in these benefits may persist (Fig 2). We have shown that states with a higher incidence of melanoma experience better MIR ($r = -0.72$, $P < .001$, Fig 2, *A* and *B*). This may be the result of improved access to treatments and dermatologists, educational campaigns, or perhaps health care systems that are better tuned to effectively respond to cases given past experience.

In a comparison of state-based MIRs, only Alaska's MIR was 2 SDs above the mean MIR. Given Alaska's remote location and unique geography, access to care could be a contributor to this finding. Within-state MIR distributions were generally tight, with few outliers (Fig 1) that mostly occurred earlier (in 1999-2001), and information may be gleaned by understanding how these systems dramatically reduced their MIR. Additionally, states with higher year-to-year MIR variation could perhaps be evaluated for ways to improve consistency.

After multivariable modeling, the only health care–related variable significantly associated with MIR was the overall number of physicians in each state (more physicians equated to worse survival). This finding is counterintuitive and unexpected. However, at the state level, 1 possible reason behind this may reflect a degree of reverse causality. For example, states with large medical centers and many physicians are likely to have tertiary care or cancer centers that see more complex or severe cases. Similarly, states with higher numbers of physicians may have more hospital-based or academic dermatologists, who compared with dermatologists in small private offices, treat patients with higher-stage disease and send specimens to hospital-based

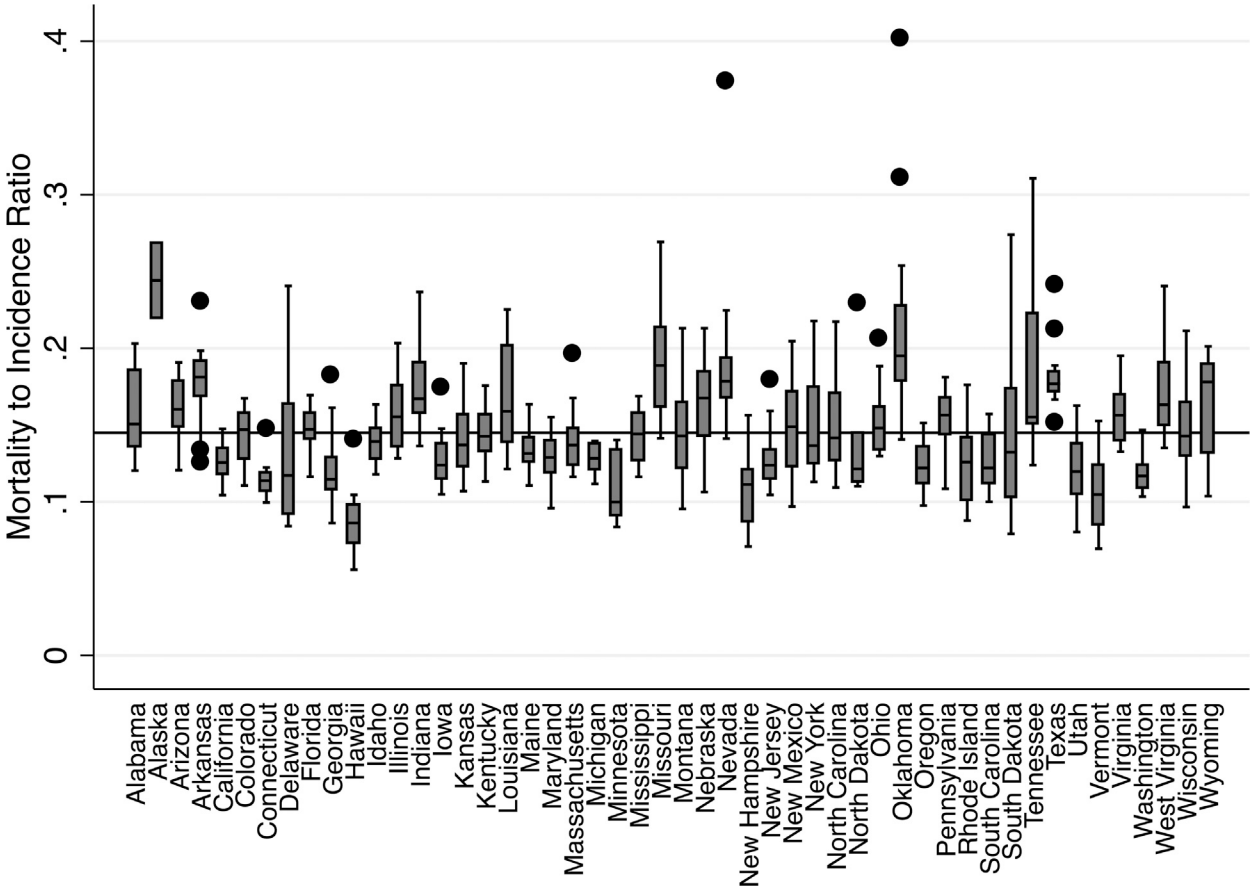

Fig 1. Mortality-to-incidence ratio (MIR) distribution. Box-and-whisker plot demonstrating spread of MIR data by year for each state. Outliers are denoted by black dots. Black horizontal line represents mean overall MIR for the United States (0.145).

laboratories that may be more likely to report melanoma cases..[11,12]

The only sociodemographic variable associated with MIR after multivariable modeling was percentage of the state's population that was non-Hispanic white (higher percentages predicting worse survival). In contrast, Shaikh et al found that melanoma survival improved among all subgroups studied from the period 1989-2009, except for nonblack minorities.[13] Shaikh et al, however, used the Surveillance, Epidemiology, and End Results database, so demographics were tied to the actual cases of melanoma, whereas by using state census data, we evaluated the racial composition of each state rather than the racial composition of those individuals in whom melanoma had been diagnosed, which may differ. Thus, our positive association between MIR and non-Hispanic whites in a population may instead reflect the fact that this population is at higher risk of melanoma. This finding was a somewhat strong predictor and warrants additional investigation.

Dermatologist density was significantly and positively associated with MIR in univariable and correlational analysis. However, this relationship could not be evaluated with our multivariable model, so these results should be taken cautiously. This finding could represent overdiagnosis. Dermatologists may be more apt to find early in situ lesions or severely dysplastic nevi with no mortality risk. Thus, to minimize overdiagnosis error, we excluded in situ melanomas from the analysis. Finally, although not possible in this study, future studies should include dermatologist practice type in the analysis, as different practice types have different likelihoods of reporting melanoma cases to state database registries, which would affect state MIR.[11,12]

We also postulated that states with more NCIDCCs would have better survival because of a theoretically higher access to high-level care. Although a survival benefit was significant in univariable models, NCIDCC count only had data from a single year and could not be included in multivariable modeling.

Health care spending per capita and melanoma MIR correlations have been demonstrated previously in Europe; however, although significant in univariable regression, this association disappeared in our

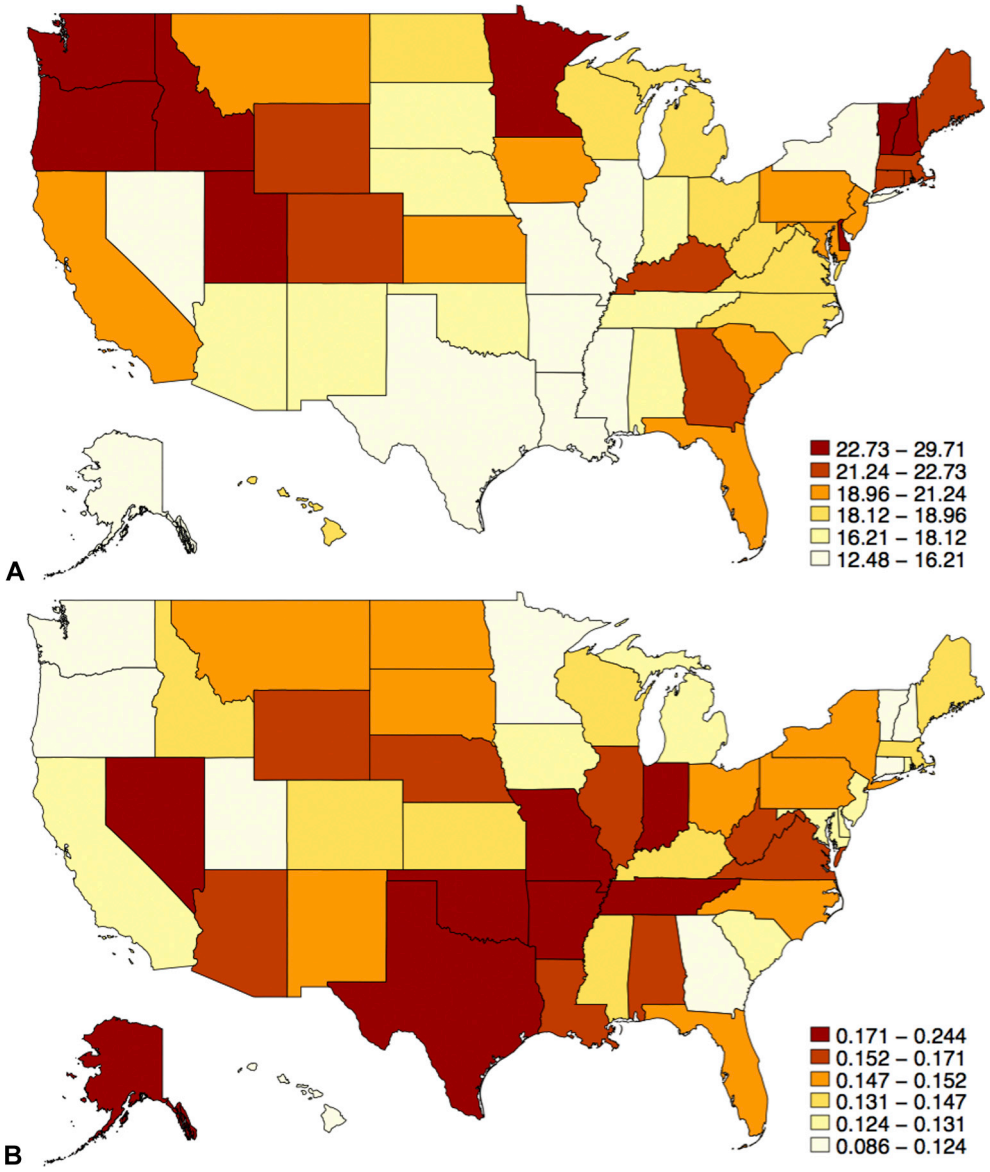

Fig 2. Melanoma incidence and mortality-to-incidence ratio (MIR). Thermal plots of the United States with data broken into sextiles. Darker colors represent higher values. **A,** Melanoma incidence per 100,000 people. **B,** Melanoma MIR. Higher MIRs signify worse survival.

multivariable model.[2] One reason for this may be that we investigated overall spending as compared with dermatology-specific health care spending. Tan et al proposed that health care spending in dermatology may be associated with better melanoma outcomes through increased chemodestructive procedures in areas with increased dermatologist density.[14] Thus, dermatology-specific spending may drive differences, and future investigations using more specific spending metrics, if available, may yield different results.

Average household income and education levels were not associated with melanoma survival, contrary to prior research by Geller et al.[3] However, the results obtained by Geller et al came from a single state (Massachusetts), were based only on individuals in whom melanoma had been diagnosed, and thus may not reflect the demographics of the entire state. These state-based findings are not directly comparable with our national data.

The vast majority of variance in MIR (99%) predicted in the model came from differences at the state level, arguing that intrinsic state-level differences have much greater impact on MIR variance than large state-based factors do. Within-state factors could include things such as local policy,

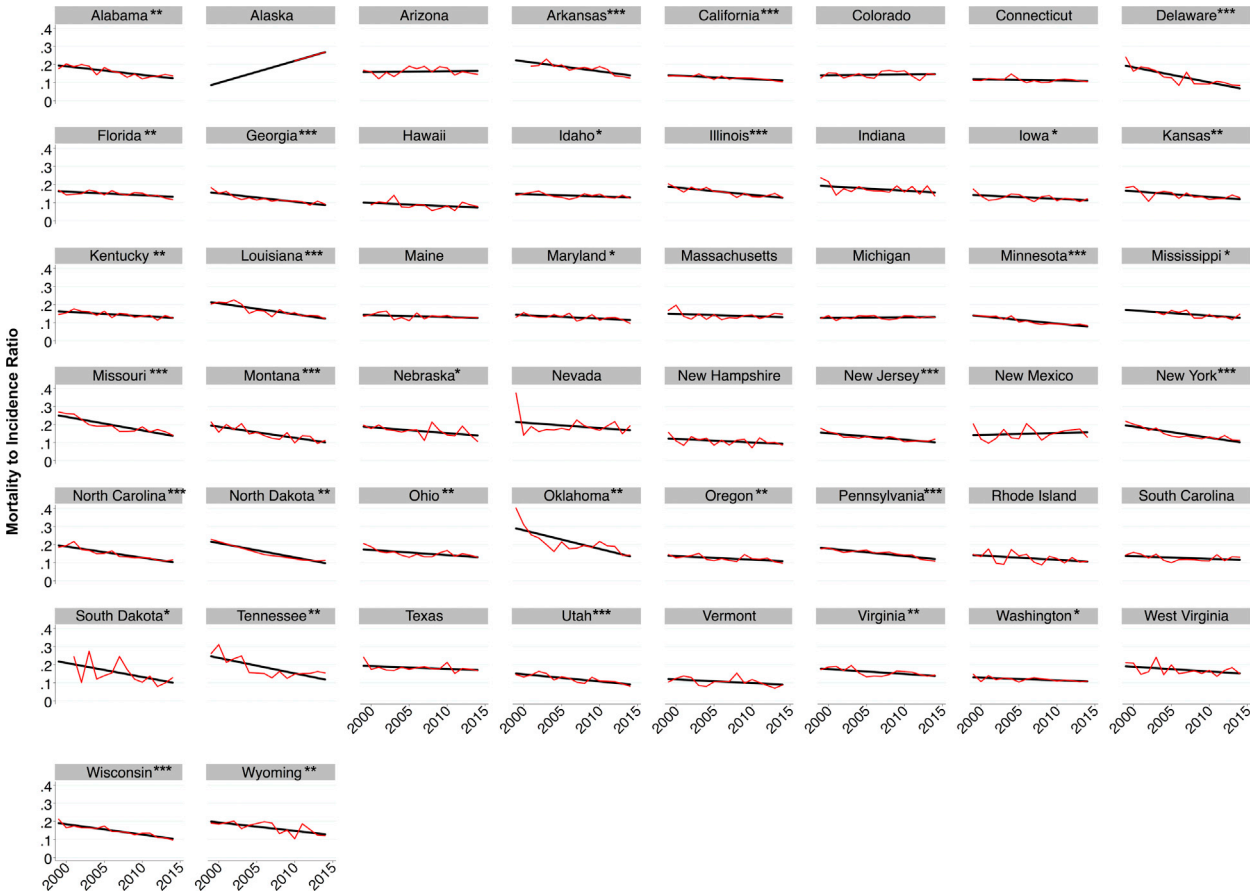

Fig 3. Mortality-to-incidence ratio (MIR) trends by state. State trends in MIR over time. Best fit lines were calculated by using linear regression. States with a significantly changing MIR are shown with asterisks (***$P < .001$; **$P < .01$; *$P < .05$).

Table I. Univariable and multivariable linear regression models between MIR and several actionable targets

Variable	RC	95% CI	*P* value	aRC	a95% CI	*P* value
Health care spending per capita*	−11.4	−12.7 to −10.1	<.001	−10.0	−30.0 to 3.00	.11
People per dermatologist†	1.00	1.00-2.00	<.001	—	—	—
No. of NCI-designated cancer centers†	−0.3	−0.6 to −0.04	.02	—	—	—
No. of active physicians‡	−2.00	−4.00 to −0.90	.002	20.0	2.00-30.0	.02
People per primary care provider‡	−8.00	−10.0 to −3.00	.001	−10.0	−50.0 to 20.0	.39
Average household income*	2.00	1.00-4.00	.008	−1.00	−3.00 to 1.00	.32
Percentage of uninsured individuals	0.03	−0.2 to 0.2	.76	−0.10	−0.40 to 0.20	.50
Percentage with a bachelor's degree	−42.0	−54.0 to −30.0	<.001	0.20	−35.0 to 35.0	.99
Race						
White	35.0	20.0-51.0	<.001	61.0	20.0-103	.004
Black/African American	−112	−167 to −55.0	<.001	−117	−243 to 9.00	.07
American Indian	−90.0	−161 to −19.0	.01	−55.0	−202 to 93.0	.46
Asian	−18.0	−31.0 to −5.00	.007	63	−1.00 to 128	.05
Hawaiian	−21.0	−32.0 to −9.00	<.001	−25.0	−103 to 54.0	.53
≥Races	−16.0	−46.0 to 15.0	.31	31.0	−44.0 to 107	.41

Regression coefficients were multiplied by 100 to convert MIR to percent mortality, which it estimates. Other adjustments have been made for readability and are noted individually.

a95% CI, 95% Confidence interval adjusted from multivariable logistic modeling; *aRC*, regression coefficient adjusted from multivariable logistic modeling; *95% CI*, 95% confidence interval; *MIR*, mortality-to-incidence ratio; *NCI*, National Cancer Institute; *RC*, regression coefficient.

*Regression coefficients adjusted to per $10,000.

†Data only available for a single year; thus, only univariable regression was performed. Coefficients adjusted to per 10,000 people.

‡Regression coefficients adjusted to per 100 physicians.

budgets, distance/access to hospitals, and quality measures, which are difficult to ascertain at the state level. Our data suggest that local individualized efforts will likely supply bigger gains than would broad-spectrum or national policy changes.

This study has several limitations. First, melanoma can be treated and diagnosed in the clinic setting, creating unique reporting difficulties and database inaccuracies. Studies have suggested that states are heterogeneous in terms of their accuracy of melanoma reporting. Dermatologist practice type, dermatologist understanding of reporting duties, and use of different types of laboratories for histologic diagnosis can have significant effects on reporting.[11,12,15,16] Second, data on melanoma thickness or staging were not available in these databases, limiting the ability to explain these findings. Also, sociodemographic variables were obtained from census data and are subject to limitations of survey-based data. Because we used census-based demographic data and not demographic data from the melanoma outcomes database, overall state demographics may not correlate well with the demographics of those who develop melanoma. This was by design, as this study's purpose was to investigate state-level factors affecting MIR. As dermatologist density and NCIDCC counts were available for only a single year, our model could not account for changes over time or how these changes might have affected MIR. Lastly, data more granular than state-level data were not available for this analysis, so intrastate disparities were not explored. Despite these limitations, these data highlight important trends and potential disparities in statewide melanoma survival.

CONCLUSION

We found that states with more physicians (ie, a higher total physician count, not just more dermatologists) per capita and a larger percentage of non-Hispanic whites had higher MIRs, or worse survival. We also found that intrinsic differences between states account for the vast majority of variance in MIR, suggesting the need for local evaluation and policy changes. Although not verified by our multivariable model, we also found preliminary univariable data suggesting that more dermatologists per capita and greater NCIDCC counts are correlated with lower MIR or improved survival. More data are needed to verify these relationships. These data can alert dermatologists, researchers, and policymakers to high-risk groups and guide public policy and future within-state investigations.

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