Association of Increased Dermatologist Density With Lower Melanoma Mortality

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Objective: To determine whether there is an association between dermatologist density and melanoma mortality.

Design: A regression model was developed to test the association between melanoma mortality and dermatologist density, controlling for county demographics, health care infrastructure, and socioeconomic factors. Data were collected from the Area Resource File, US Centers for Disease Control and Prevention, and National Cancer Institute’s Surveillance, Epidemiology, and End Results program and National Program for Cancer Registries.

Setting: US counties.

Patients: Melanoma mortality and incidence data were reported as age-adjusted mean rates per 100,000 people from January 2002, through December 2006.

Main Outcome Measure: The primary outcome measure was melanoma mortality rate per 100,000 people at the county level.

Results: Geographic variation exists in the distribution of dermatologists across the United States. Multivariate analysis demonstrated that the presence of 0.001 to 1 dermatologist per 100,000 people was associated with a 35.0% reduction in the melanoma mortality rate (95% CI, 13.4%-56.6%) when compared with counties with no dermatologist. The presence of 1.001 to 2 dermatologists per 100,000 people was associated with a 53.0% reduction in the melanoma mortality rate (95% CI, 30.6%-75.4%). Having more than 2 dermatologists per 100,000 people did not further lower melanoma mortality rates.

Conclusion: Within a given county, a greater dermatologist density is associated with lower melanoma mortality rates compared with counties that lacked a dermatologist.

Physician density influences health care outcomes.1-3 Some investigators have suggested that having more specialists may not be as valuable as increasing the numbers of primary care physicians.4,5 Yet, specialists are associated with improved outcomes in dermatology, urology, neonatology, colorectal surgery, and orthopedic surgery.1-6,10 Each year younger dermatologists replace aging practitioners, which decreases the availability of medical dermatologic care because younger physicians are more prone to engage in education, research, surgery, or cosmetics.11 An unmet demand for dermatologic care in the United States has led to greater use of physician assistants, nurse practitioners, and nonphysician medical professionals in some practices.11-13 Dermatologist and subspecialist (eg, pediatric dermatology, dermatopathology, and Mohs surgery) density varies from city to city, and such physicians are absent in certain areas.14 An understanding of the regional distribution of dermatologists is necessary to develop health care policies that will positively affect patient outcomes.

Melanoma mortality and/or extent of disease may be predicted by factors such as physician specialty density, neighborhood racial heterogeneity, and median household income.1,15-18 We sought to determine whether there is an association between melanoma mortality and dermatologist density at the county level in the United States.

Methods

This study received an exemption for approval from the Case Western Reserve University Institutional Review Board.

Sources of Data

Melanoma mortality and incidence data were obtained from a merged data set from the National Program for Cancer Registries; National Cancer Institute’s Surveillance, Epidemiology, and End Results (SEER); and the US Centers for Disease Control and Prevention’s National Vital Statistics System.19 Using this merged data set, mortality and incidence data were reported as age-adjusted mean rates per 100,000 people from January 2002, through December 2006. Incidences and mortality rates were assigned to coun-

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ties based on each patient's residence at the time of diagnosis and death. A total of 669 rural counties were excluded from the analysis, given insufficient data, because mortality data were reported for less than 2.5% of these counties and less than 5.0% of these counties had any dermatologists.

Dermatologist density, geographic classification, and population data were provided by the 2008 Area Resource File, published by the Health Resource and Services Administration of the US Department of Health and Human Services. Dermatologist densities were calculated as 5-year means for the years 2002 to 2006. Dermatologist density was categorized as 0, 0.001 to 1, 1.001 to 2, 2.001 to 4, or more than 4 dermatologists per 100,000 people.

County distribution was determined by the 2000 US Census, which divided the United States into 3141 counties. Primary care physicians were defined as those trained in the fields of pediatrics, family medicine, and general internal medicine. The percentage of the population with health insurance was obtained from the US Census Small Area Health Insurance Estimates 2000. Access to nondermatologic oncology care was estimated by the number of hospitals with oncology services in 2006. Metropolitan, nonmetropolitan, or rural status of each county was defined using the Department of Agriculture Rural/Urban Continuum Codes, which consider population size, degree of urbanization, and adjacency to a metropolitan area.

**RESULTS**

We included 2472 counties in our analysis because rural counties were excluded. Within the counties in our analysis, the total population was 225,981,679. The percentage of males was 48.9% and the percentage of females was 51.1%. A total of 72.8% were white, 13.2% were black or African American, 4.3% were Asian, and 0.6% were American Indian and Alaskan Native. The median age was 34.9 years, and the percentage of the population older than 65 years was 11.88%.

Predictors of melanoma mortality are listed in the Table. Greater dermatologist density at the county level is associated with lower melanoma mortality rates (Table). The presence of 0.001 to 1 dermatologist per 100,000 people is associated with a 35.0% reduction in mortality (95% CI, 13.4%-56.6%). More than 1 to 2 dermatologists per 100,000 people is associated with a 35.0% reduction in mortality (95% CI, 30.6%-75.4%). The addition of more than 2 dermatologists per 100,000 people does not further decrease mortality rates.

In the reference group, the absolute melanoma mortality rate was 1.45 (95% CI, 0.71-2.18; P < .001) based on a prevalence of 19 cases per 100,000 people. The presence of 0.001 to 1 dermatologist per 100,000 people is associated with a −0.51 absolute reduction in mortality (P = .002). 1.001 to 2 dermatologists with a −0.77 absolute reduction in melanoma mortality (P < .001), 2.001 to 4.0 dermatologists with a −0.56 absolute reduction in melanoma mortality (P < .001), and more than 4 dermatologists with a −0.66 absolute reduction in melanoma mortality (P < .001).

A slightly lower melanoma mortality rate is associated with the presence of hospitals with oncology departments (1.9%; 95% CI, 0.6%-3.1%). Metropolitan status of a county is associated with a 30.3% (95% CI, 17.3%-43.3%) reduction in the mortality rate.

Melanoma mortality rates are greater in counties with a higher incidence of melanoma (2.3%; 95% CI, 1.6%-3.1%), greater non-Hispanic white population (1.5%; 93% CI, 1.1%-1.9%), and greater health-insured populations (1.5%; 95% CI, 0.2%-2.8%).

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**Table. Predictors in Melanoma Mortality: Results of Multivariate Regression**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Reduction in Melanoma Mortality Rate (95% CI), %</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dermatologists per 100,000 people</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.001-1 vs 0</td>
<td>−34.98 (−56.57 to −13.35)</td>
<td>.002</td>
</tr>
<tr>
<td>1.001-2 vs 0</td>
<td>−52.97 (−75.40 to −30.55)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>2.001-4 vs 0</td>
<td>−38.65 (−59.42 to −17.88)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>&gt;4 vs 0</td>
<td>−45.91 (−64.09 to −27.73)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Metropolitan county classification</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hospitals with oncology services (each additional hospital)</td>
<td>−1.87 (−3.11 to −0.63)</td>
<td>.003</td>
</tr>
<tr>
<td>White population (each additional percentage)</td>
<td>1.51 (1.12 to 1.90)</td>
<td>.001</td>
</tr>
<tr>
<td>Melanoma incidence (each additional case per 100,000 people)</td>
<td>2.33 (1.60 to 3.07)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Population with health insurance (each additional percentage)</td>
<td>1.52 (0.24 to 2.81)</td>
<td>.02</td>
</tr>
</tbody>
</table>

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**STATISTICAL ANALYSIS**

Univariate associations between the predictor variables and melanoma mortality were tested using the t test for categorical predictors and simple linear regressions for continuous predictors. The predictor variables were dermatologist density, melanoma incidence, metropolitan county status, health professional shortage area classification, primary care physician density, percentage of the population older than 65 years, percentage of the population older than 25 years with a high school diploma or equivalent, number of hospitals with oncology services, percentage of non-Hispanic white population, percentage of health-insured population, median household income, and unemployment rate. The outcome variables were normally distributed.

Multivariate regression models were built using backward stepwise selection with a univariate P < .15 for inclusion into the models. Variance inflation factors were used to assess for interactions among variables. Statistical significance for the final model was determined at P < .05. The reference group in all analyses was derived from the age-adjusted means of counties with 0 dermatologists and nonmetropolitan county status but not classified as an area of health professional shortage. Statistical analysis was performed using Stata statistical software, version 9.2 (StataCorp). Dermatologist density categories were mapped using the mapping software ArcGIS, version 9.2 (Environmental Systems Research Institute Inc).
Primary care physician density, percentage of population older than 65 years, health professional shortage area classification, percentage of population older than 25 years with a high school diploma or equivalent, median household income, and unemployment rate were parameters not associated with melanoma mortality rate.

There are 0 dermatologists per 100,000 people in a large portion of the country (Figure). Greater densities of dermatologists were noted along the Pacific Coast, throughout the state of Hawaii, and in clusters along the East Coast and the Midwest. Significantly fewer dermatologists are in the central United States relative to the rest of the country.

COMMENT

In 2000, Roetzheim et al23 found that people with limited access to care were more likely to receive a late-stage melanoma diagnosis. More recent studies24,25 have illustrated that diagnosis by a dermatologist is associated with an earlier stage of melanoma compared with detection by a nondermatologist. Our analysis demonstrated that the presence of 0.001 to 1 dermatologist per 100,000 people is associated with a lower melanoma mortality rate by more than one-third compared with counties that lack dermatologists. We believe that this reflects that access to a dermatologist allows for an accurate and earlier diagnosis of melanoma, more appropriate therapy, or a combination of these factors. Our analysis makes the assumption that patients receive relevant health services, such as screening skin examinations, melanoma preventive education, and treatment in the county where the diagnosis was made.

The lowest melanoma mortality rate was observed in counties with 1.001 to 2 dermatologists per 100,000 people. However, increasing dermatologist density beyond this level did not further improve mortality rates, suggesting a plateau effect with increasing physician supply. Areas with a dermatologist density higher than 2 may represent academic centers, where dermatologists have educational and research responsibilities in addition to clinical practice. Alternatively, this plateau may not reflect access to physicians but instead may represent the limitations of our current therapeutics. Similar plateau effects have been described when relating physician density and health outcomes in the fields of urology and neonatology.6,7

No statistically significant differences in melanoma mortality rates were observed when comparing a dermatologist density of 1.001 to 2 dermatologists to counties with higher densities. Our analysis suggests that increasing the number of dermatologists in counties with existing physicians is unlikely to significantly alter melanoma mortality because having 2 dermatologists is not statistically significant from having 4 dermatologists when considering mortality rates. The most notable finding in our analysis demonstrates that having a single dermatologist compared with a county with 0 dermatologists reduces the mortality rate by nearly 35%. Thus, the placement of dermatologists in counties currently lacking physicians may be the most optimal approach to combating the increasing incidence of melanoma in the United States.26 Developing incentives to attract dermatologists to underserved counties may allow us to meet this need. For example, dermatology residency positions or student loan repayments could be tied to a contract of service in an area that lacked physicians.

Other factors associated with reduction in melanoma mortality rates are the presence of hospitals with oncology departments and metropolitan county status. Metropolitan county status is associated with a 30.27% reduction in melanoma mortality that cannot be accounted for by socioeconomic factors, including difference in educational level, age, income, or employment. In other re-

![Figure. Mean dermatologist density among US counties, 2002-2006.](image-url)
force. We have demonstrated that the geographic variability of dermatologist workforces in the United States could result in a population-level decrease in the incidence of melanoma. We speculate that this is due to the availability of dermatologists, who are associated with a lower melanoma mortality rate compared with counties where dermatologists are lacking. The presence of dermatologists is associated with the incidence of melanoma, and the incidence of melanoma is greater than 0 dermatologists are associated with no melanoma mortality. However, counties with a greater incidence of melanoma are associated with no dermatologist density. Our findings suggest that dermatologist density may serve as a proxy for specialty factors, such as hypertension, diabetes mellitus, stroke, or heart disease.

Physician supply may be correlated with cancer outcomes by serving as a proxy for overall health care resources. Previous studies have demonstrated associations between higher numbers of primary care physicians and lower all-cause mortality, cancer mortality, and cardiovascular mortality rates. Our analysis did not find a relationship between primary care physician density and melanoma mortality. Our findings suggest that dermatologist density, which may serve as a proxy for specialists, may be a more suitable proxy for melanoma mortality than primary care physicians.

The limitations of this analysis include the exclusion of 669 counties due to their rural county status. These counties were excluded because limited mortality data were reported from these areas and there were few rural counties (<5%) with any dermatologists. We hypothesize that inclusion of rural counties, where the incidence of melanoma is low, would skew the analysis because the findings may imply that 0 dermatologists are associated with no melanoma mortality. However, counties with the incidence of melanoma is greater than 0 would have heightened the association we observed between dermatologist density and improved melanoma mortality.

The incidence data used in our analysis did not account for severity of disease at the time of diagnosis. We hypothesized that greater dermatologist density allows for disease detection at an earlier stage. Other reports have made use of the SEER database, which accounts for severity of disease at presentation; however, the merged data set used in our analysis does not reflect extent of disease at presentation. Lastly, in our analysis, no distinction was made between dermatologists engaged in clinical activities full time vs part time or in the way to account for dermatologic services provided by physician assistants, nurse practitioners, and other health care professionals.

In conclusion, our analysis found that within a given county, the presence of a dermatologist is associated with a lower melanoma mortality rate compared with counties that lacked a dermatologist. We speculate that efforts to recruit dermatologists to counties currently lacking such specialists could result in a population-level reduction in melanoma mortality.

Our analysis uses melanoma mortality to highlight the consequence of a maldistributed dermatologist workforce. We have demonstrated that the geographic variation in melanoma mortality is associated with the density of dermatologists. Given the nature of this field, it is unclear whether dermatologist density affects prevention, diagnosis, treatment, or some combination of the aforementioned. Further studies are needed using staging information to highlight whether dermatologist density is associated with earlier diagnosis of melanoma or improved treatment.

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Author Contributions: All authors had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.

Study concept and design: Savina Aneja, Sanjay Aneja, and Bordeaux. Acquisition of the data: Savina Aneja, Sanjay Aneja, and Bordeaux. Analysis and interpretation of the data: Savina Aneja, Sanjay Aneja, and Bordeaux. Drafting of the manuscript: Savina Aneja. Critical revision of the manuscript for important intellectual content: Sanjay Aneja and Bordeaux. Statistical analysis: Savina Aneja and Sanjay Aneja. Administrative, technical, or material support: Savina Aneja. Study supervision: Bordeaux.

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Online-Only Material: Visit www.archdermatol.com to listen to an author podcast about this article.

REFERENCES

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World Records in Dermatology

Many of us enjoy reading about the great feats and accomplishments that can be found in the Guinness World Records and on its official Web site. This famous encyclopedic reference covers the whole range of human endeavors, listing the greatest and worst records of all time. A few of the amazing achievements in the field of dermatology are listed below:

1. Longest beard—living male. This record belongs to Sarwan Singh of Canada, whose beard measured 2.37 m (7 ft 9 in) on March 4, 2010.
2. Longest hair (female). Xie Qiuping of China has been growing her hair since 1973, from the age of 13 years. On May 8, 2004, her hair measured 5.627 m (18 ft 5.54 in).
3. Most tattooed senior citizen (female). Isobel Varley, age 72 years, of the United Kingdom had 93% of her body covered with tattoos as of April 25, 2009.
4. Longest fingernails (female)—ever. Lee Redmond of the United States holds this record. Her nails measured a total length of 8.65 m (28 ft 4.5 in) on February 23, 2008. She started growing her nails in 1979 but unfortunately lost them in an automobile accident in early 2009.
5. First use of smallpox as a biological weapon. This incident occurred on June 24, 1763, in the aftermath of the French and Indian War during Pontiac’s War, an uprising by Native American tribes that were dissatisfied with British policies. During the siege of Fort Pitt, Pennsylvania, Captain Simon Ecuyer, the commander of the British fort, gave 2 Delaware tribal emissaries 2 blankets and a handkerchief that had been exposed to smallpox. Guinness World Records claims that epidemics followed, killing more than 50% of the affected tribes. Historians debate whether the blankets were effective in spreading the disease, since smallpox outbreaks were already widespread from other sources of the infection.2
6. Oldest disease. Earlier editions of Guinness World Records listed leprosy as the oldest disease, dating back to Egypt 1350 BCE. This record is no longer cited. Tuberculosis is now considered to be among the oldest of human diseases. Recently, evidence of tuberculosis was found in a 500,000-year-old fossil hominin skull from Turkey.3 The bone lesions were consistent with a diagnosis of Leptomenigitis tuberculosa.

World records in dermatology can be amusing and entertaining. They can also inspire us. Take, for example, the following:

Largest skin cancer screening (multiple locations). This event was organized by the Brazilian Society of Dermatology on December 5, 2009. It involved 34,435 participants at 170 different locations across Brazil. Honorable mention goes to the American Academy of Dermatology and the 457 dermatologists who screened 10,339 people for skin cancer on May 6, 2006.

These skin cancer screening programs are the kind of world records that deserve our recognition. They are among the most notable and noteworthy of accomplishments.

Lenard J. Hoenig, MD

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