A BRIEF ORIGINAL CONTRIBUTION

Declining Effect of Latitude on Melanoma Mortality Rates in the United States

A Preliminary Study

John A. H. Lee

The gradient of mortality from melanoma of the skin with latitude among US whites was estimated from the slopes of semilogarithmic models fitted to the state-specific mortality rates and the latitudes of the states’ capital cities. The upward gradient of mortality from north to south for malignant melanoma of the skin has been decreasing since 1950-1959, when data first became available, through 1960-1969, 1970-1979, and 1988-1992. By the early years of the 21st century, rates of melanoma mortality in the contiguous United States are expected to be unaffected by latitude. For the country as a whole, melanoma mortality rates have been rising for many years. This rise has become progressively slower, such that national rates have been projected to stabilize in the near future. While increasing geographic mobility has probably played a role in reducing the latitude effect, melanoma mortality rates may have reached levels at which increased exposure of US whites to sunlight has little incremental effect. Am J Epidemiol 1997;146:413-17.

geography; melanoma; mortality; sunlight; time; whites

There have been reports from Scandinavia, Australia, and the United States (1–4) that the rise in melanoma incidence and mortality is slowing. The stabilization of melanoma mortality rates over time is more rapid in younger age groups (1–4), suggesting birth cohort effects. It has been found in the United States that both the increase in melanoma mortality rates and the effect of latitude are successively smaller the more recent the year of birth (5). The similarity of the age patterns in the rate trends and the effect of latitude hint that both findings might reflect common changes.

In commentary on the most recent US melanoma data reported by state, the Centers for Disease Control and Prevention said, “For whites, the age-adjusted death rates by state ranged from 2.2 to 5.0 per 100,000 (1988–1992) for males and [from] 0.8 to 2.3 for females. Most states that are in the two highest death rate quartiles are not in the lower US latitudes where sun exposure is generally more intense” (6, p. 343). This report, and the similarity between the effects of age on the geographic distribution and the time trend of melanoma, suggested that the latitude gradient for melanoma in the United States might indeed be declining, and prompted an examination of the mortality data by state over time.

The geographic variations in melanoma mortality rates and in solar radiation have been used to develop dose-response relationships for use in predicting changes in death rates consequent upon changes in the stratospheric ozone layer (7). Should the latitude effect on death rates be changing with time, this would complicate such efforts.

MATERIALS AND METHODS

Melanoma death rates for the United States, adjusted to the US 1970 age distribution, were obtained by state for the years 1950–1959, 1960–1969, 1970–1979 (8), and (the series not being continuous) 1988–1992 (6). Latitudes were taken as those of each state’s capital city. The white populations of Alaska and Hawaii are small, and these states are distant from the contiguous United States; thus, these states were excluded from this preliminary study.

Latitude gradients for the four periods were characterized by coefficients from linear regressions fitted to the natural logarithms of state-specific melanoma mortality rates and their latitudes. Similar gradients were
also estimated using the mean mortality rate for each state as the independent variable rather than the latitude. The rates of change in the state-specific mortality rates per calendar year were characterized by coefficients from linear regression models fitted to the sets of four rates and their midpoint dates (1955, 1965, 1975, and 1990). Linear regression models for males and females were fitted to the state-specific rates of change with time and the latitude of each state.

### RESULTS

For the separate time periods, the gradient of melanoma mortality rates with latitude was at a maximum in 1950–1959, and it has been steadily decreasing (table 1, figures 1 and 2). Table 2 shows the percentage change in the melanoma death rate for 1° of travel south at the latitude of Washington, DC, for each period. The effect of latitude is generally smaller in


<table>
<thead>
<tr>
<th>Period</th>
<th>Coefficient*</th>
<th>95% confidence interval</th>
<th>P value</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Men</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1950–1959</td>
<td>-0.03928</td>
<td>-0.05024 to -0.02832</td>
<td>&lt;0.001</td>
<td>0.53090</td>
</tr>
<tr>
<td>1960–1969</td>
<td>-0.03726</td>
<td>-0.04677 to -0.02774</td>
<td>&lt;0.001</td>
<td>0.57440</td>
</tr>
<tr>
<td>1970–1979</td>
<td>-0.02575</td>
<td>-0.03624 to -0.01525</td>
<td>&lt;0.001</td>
<td>0.34620</td>
</tr>
<tr>
<td>1988–1992</td>
<td>-0.01432</td>
<td>-0.02339 to -0.00526</td>
<td>&lt;0.005</td>
<td>0.18130</td>
</tr>
<tr>
<td>Women</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1950–1959</td>
<td>-0.03878</td>
<td>-0.05283 to -0.02074</td>
<td>&lt;0.001</td>
<td>0.31770</td>
</tr>
<tr>
<td>1960–1969</td>
<td>-0.02980</td>
<td>-0.03853 to -0.02107</td>
<td>&lt;0.001</td>
<td>0.50780</td>
</tr>
<tr>
<td>1970–1979</td>
<td>-0.02278</td>
<td>-0.03216 to -0.01341</td>
<td>&lt;0.001</td>
<td>0.34200</td>
</tr>
<tr>
<td>1988–1992</td>
<td>-0.00883</td>
<td>-0.01924 to 0.00159</td>
<td>&lt;0.100</td>
<td>0.05950</td>
</tr>
</tbody>
</table>

* Coefficient from a linear regression model fitted to the log melanoma rates for each state. The coefficients are negative because latitudes decline towards the Equator.

**FIGURE 1.** Age-adjusted rates of death from malignant melanoma per 100,000 population, by latitude, in the 48 contiguous states of the United States during the periods 1950–1959, 1960–1969, 1970–1979, and 1988–1992. (Data were obtained from the Centers for Disease Control and Prevention (6) and the National Cancer Institute (8).)
females than in males, and in the 1988–1992 data, the gradient for females includes zero in its confidence interval. Projection of fitted trend lines for the gradients takes the female latitude gradient to zero in the year 2002 and the male gradient to zero in the year 2010 (figure 2).

Linear regression models were fitted to the logarithms of the age-adjusted death rates for each of the 48 contiguous states over time for the four periods 1950–1959, 1960–1969, 1970–1979, and 1988–1992. The coefficients of these—the relative increases in death rates over 1 year—are shown in figure 3. The further the state from the Equator, the greater the relative increase over the 42-year period. The increases in death rates over time were smaller in females than in males, but the effects of latitude were closely similar for the two sexes. These changes correspond to an average increase in melanoma mortality of 3 percent per year in males and 2 percent per year in females for US whites between 1950–1959 and 1988–1992. This is comparable to the values derived from the national data taken as a unit. The association between latitude and rate of change in the melanoma death rate was found in each of the intervals between time periods.

To test whether change in something other than latitude was important, we constructed models relating state-specific changes in melanoma mortality rates to the mean state-specific death rates for the whole period. The mortality rates in the states where the mean of these was high still rose more slowly than did the corresponding rates in the states with low mortality rates, but the relation was weaker than when latitude was used as the independent variable.

**TABLE 2.** Estimated period-specific melanoma death rates at the latitude of Washington, DC, and period-specific changes per degree of latitude

<table>
<thead>
<tr>
<th>Period</th>
<th>Death rate per 100,000 population at latitude of Washington, DC (from models)</th>
<th>% change in death rate per degree of latitude at that latitude (from models)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Men</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1950–1959</td>
<td>1.28</td>
<td>3.93</td>
</tr>
<tr>
<td>1960–1969</td>
<td>1.78</td>
<td>3.73</td>
</tr>
<tr>
<td>1970–1979</td>
<td>2.32</td>
<td>2.57</td>
</tr>
<tr>
<td>1988–1992</td>
<td>3.38</td>
<td>1.43</td>
</tr>
<tr>
<td><strong>Women</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1950–1959</td>
<td>0.99</td>
<td>3.68</td>
</tr>
<tr>
<td>1960–1969</td>
<td>1.24</td>
<td>2.98</td>
</tr>
<tr>
<td>1970–1979</td>
<td>1.47</td>
<td>2.28</td>
</tr>
<tr>
<td>1988–1992</td>
<td>1.70</td>
<td>0.88</td>
</tr>
</tbody>
</table>

**DISCUSSION**

Melanoma incidence and mortality have been increasing in white populations for many years, but at an increasingly slow pace. An actual decrease in the United States by the second decade of the next century has been projected (1, 2). As we reported above, in the US white population, the influence of latitude of residence on death rates—highest in the South, lowest in the North—was greatest during the period 1950–1959, and it has been steadily decreasing since. The two effects, or perhaps two aspects of the same process, will mean that melanoma death rates will be geographically uniform and stable or declining by the early years of the 21st century.

Broad social changes may have influenced the melanoma epidemic across the entire country. For exam-
ple, the increased use of sunscreen preparations has perhaps slowed the rise in rates nationwide. Birth-cohort analyses and studies of migrants suggest that a large proportion of the damage leading to melanoma is incurred in childhood and early adult life. The average age of diagnosis is between 50 and 60 years, so population movements will blur the geographic distribution of the disease (9). As the geographic mobility of the population increases, so will latitude gradients be reduced. Only a few people who are very sensitive to the sun will intentionally move north, but movement unrelated to a causative factor will still reduce geographic differences in the ensuing disease. However, in spite of increasing opportunities for people to move during their latent periods (10, 11), substantial geographic variations continue to exist for a number of other cancers. Place of birth is recorded on death certificates. Since childhood exposures are so important in the genesis of melanoma of the skin, the construction of area-specific birth cohorts for the study of melanoma mortality would be feasible and worthwhile.

Outdoor work does little to increase the risk of melanoma. The study by Goodman et al. (12) is a recent example from a large body of literature. Armstrong (13) suggested that there is a wide band of exposures wherein the melanoma mortality rate does not increase with increasing exposure. While it is possible that the trend toward stability in national death rates and the trend toward geographic homogeneity are due to separate and unrelated changes in a complex society, the possibility should be considered that the observed geographic and temporal stabilization indicates that rates in the population have reached a level at which the dose-response curve is nearly flat and variations in sun exposure have little effect.

These analyses suggest opportunities for further research. The models (e.g., see figure 3) are derived from age-adjusted rates, are sex-specific, and take latitude into account. The state-specific deviations for males and females are significantly correlated, suggesting that more refined geographic analysis would be helpful. This association persists even when the states of Arizona and New Mexico, which have low death rates for their latitude (probably because of their high proportions of Hispanic residents), are excluded. Geographic variations in melanoma mortality rates are not likely to exactly follow state boundaries. Counties are probably too small individually, but they could reasonably be regrouped in light of the data. The results reported here are derived from data published for discrete time periods. Cohort studies of the effects of time and space, using methods pioneered by Burbank (14), would be useful.

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