MULTILEVEL MODELING OF MELANOMA INCIDENCE USING COMBINED NPCR AND SEER DATA

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The SES Paper

- Association of Cutaneous Malignant Melanoma Incidence with Area-based Socioeconomic Indicators —United States, 2004–2006

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The SES Paper

• An individual’s socioeconomic status (SES) is known to be one of the most powerful predictors of health.

• Measures / proxy indicators of SES include income, education, occupation, place of residence, and race.
Research Goal

• To provide a detailed description of cutaneous melanoma incidence and stage of disease in relationship to area-based socioeconomic measures including poverty level, education, income, and unemployment in the United States.
Data Types and Sources

- **Cancer Incidence by County/Race/Ethnicity**
  - United States Cancer Statistics = NPCR + SEER
  - 2004-2006, aged 15+ years
  - 121,253 NHW cases reported from 44 registries

- **SES by County/Race/Ethnicity**
  - Education and poverty status from 2000 US Census

- **SES by County**
  - Income and unemployment from 2000 US Census

- **County-Level Urbanicity/Rurality**
  - Metropolitan, suburban, and rural, using the U.S. Department of Agriculture’s 2003 urban/rural continuum codes
County-Level SES by Race/Ethnicity

- Poverty status
- % of the county population below the federal poverty level:
  - < 10%
  - 10-19.9%
  - ≥ 20%
Poverty Status
US Census 2000
NHW

US Counties
% with incomes below FPG
<10
10-<20
20+
County-Level SES by Race/Ethnicity

- High school education
- % of the county population who reported a high school education (among persons aged 25+)
  - < 75%
  - 75-% < 85%
  - 85% +
County-Level SES

• Median household income
  < $35,000
  $35,000-49,999
  $50,000 +
Median HH Income
US Census 2000

US Counties
Median Household Income
- <35,000
- 35,000-49,999
- 50,000+
- 50,000+
County-Level SES

• Unemployment
  < 5%
  5-10%
  >10%
County-Level Measures of Rural-Urban Status

• U.S. Department of Agriculture’s urban/rural continuum codes (2003):
  Metropolitan: (RUCC 1-3)
  Urban: non-metropolitan counties with urban populations (RUCC 4-7)
  Rural (RUCC 8-9)
Statistical Methods

• **Multilevel Modeling**
  - Poisson multilevel mixed models using SAS PROC GLIMMIX (V9.2) were fitted to model the incidence of cutaneous melanoma
  - Separate models for early and late stage
    - CS derived SEER Summary Stage 2000 variable
      - Localized
      - Regional / Distant
  - Data had a hierarchical multilevel structure:
    - Sex by age group by county “analysis cells”
      - Age groups 15-34, 35-64, 65+
    - Analysis cells were nested within counties
    - Counties were nested within states.
Multilevel Modeling

State of residence at the time of diagnosis was included as a random effect in the models.

Conditional on the state random effect rates and the fixed effects at the county and cell levels, the observed cancer case counts were assumed to be independent Poisson variables.

Offset was log of expected cases, which was calculated using age- and sex-specific rates for all states combined – this accounts for potential confounding by age and sex.

Covariance parameter was included to address spatial autocorrelation.
Results - Early Stage Melanoma SES Model

Incidence Density Ratio

- 10-<20 vs. <10
- 20+ vs. <10
- 75-<85 vs <75
- 85+ vs <75
- 35,000-49,999 vs <35,000
- 50,000+ vs <35,000
- 5-10 vs >10
- <5 vs >10
- Metropolitan vs urban
- Rural vs urban

% with > High School Education

% below Poverty Level

Median Household Income

% Unemployed Urban-Rural Status
Early Stage Melanoma BLUP Rates Ages 15+, SES Model

Rates by State

BLUP Rates

- 9.3 - 21.8
- 21.9 - 23.0
- 23.1 - 25.4
- 25.5 - 26.7
- 26.8 - 39.4
- p<0.05
Late Stage Melanoma
Age-Adjusted Rates
Ages 15+

Rates by State
Late Stage Rate

- 2.5 - 2.8
- 2.9 - 3.5
- 3.6 - 4.4
- 4.5 - 5.5
- 5.6 - 8.4
Results - Late Stage Melanoma SES Model

Incidence Density Ratio

<table>
<thead>
<tr>
<th>Category</th>
<th>Comparison</th>
<th>Incidence Density Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent Below Poverty Level</td>
<td>10-20 vs. &lt;10</td>
<td>0.00</td>
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<tr>
<td></td>
<td>20+ vs. &lt;10</td>
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<tr>
<td>75-&lt;85 vs &lt;75</td>
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<td>2.00</td>
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<tr>
<td>85+ vs &lt;75</td>
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<tr>
<td>% with &gt; High School Education</td>
<td>35,000-49,999 vs &lt;35,000</td>
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<td></td>
<td>50,000+ vs &lt;35,000</td>
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<tr>
<td>Median Household Income % Unemployed</td>
<td>5-10 vs &gt;10</td>
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<td></td>
<td>&lt;5 vs &gt;10</td>
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<tr>
<td>Urban-Rural Status % Unemployed</td>
<td>Metropolitan vs urban</td>
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<td></td>
<td>Rural vs urban</td>
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</tbody>
</table>
Late Stage Melanoma
BLUP Rates
Ages 15+, SES Model

Rates by State
BLUP Rates

- 3.4
- 3.5 - 3.6
- 3.7 - 4.0
- 4.1 - 4.2
- 4.3 - 4.5
- p<0.05
The UV Paper

• Association of Cutaneous Melanoma Incidence with Ultraviolet Exposure

• Authors:
  – Thomas B Richards, Christopher J Johnson, Zaria Tatalovich, Myles Cockburn, Melody J. Eide, Kevin A Henry, Sue-Min Lai, Sai S Cherala, Youjie Huang, Umed A Ajani
Research Goal

• To quantify the association of solar UV exposure with melanoma incidence in U.S. non-Hispanic whites.
Data Types and Sources

- **Cancer Incidence by County**
  - United States Cancer Statistics = NPCR + SEER
  - 2004-2006, aged 15+ years
  - 120,037 NHW cases reported from 42 registries

- **SES by County**
- **County-Level Urbanicity/Rurality**
- **AVGLO as Proxy for UV**
- **Health Insurance – SAHIE**
- **Physician Density**
AVGLO as Proxy for UV

- **AVverage daily total GLObal solar radiation**
  - Data from 200+ measurement stations, part of the National Solar Radiation Database (NSRAD)
  - Modeled using data from 1961-1990
  - Zaria Tatalovich, John P. Wilson, and Myles Cockburn
    - “A Comparison of Thiessen Polygon, Kriging, and Spline Models of Potential UV Exposure”
  - Mean county measure for contiguous US
  - Unit = watt hours per square meter (Wh/m²)
  - Categories:
    - “Lower UV Counties” 3011.7 to 4079.8 Wh/m² (779 counties)
    - “Middle UV Counties” 4079.9 to 4492.2 Wh/m² (920 counties)
    - “Higher UV Counties” 4492.3 to 5722.5 Wh/m² (713 counties)
Mean AVGLO Tertile

US Counties
Mean AVGLO Tertile
- Lower Tertile
- Middle Tertile
- Upper Tertile
Results - Early Stage Melanoma UV Model

Incidence Density Ratio

- Female 15-34
- Female 35-64
- Female 65+
- Male 15-34
- Male 35-64
- Male 65+

Comparisons:
- Middle vs. Lower
- Upper vs. Lower

Circles indicate significant differences in incidence density ratio.
Early Stage Melanoma BLUP Rates
Ages 15+, UV Model

Rates by State
BLUP Rates
- 13.6 - 21.9
- 22.0 - 23.1
- 23.2 - 25.5
- 25.6 - 26.7
- 26.8 - 44.1
- <0.05
Late Stage Melanoma
BLUP Rates
Ages 15+, UV Model

Rates by State
BLUP Rates
- 3.5 - 3.4
- 3.5 - 3.6
- 3.7 - 4.0
- 4.1 - 4.2
- 4.3 - 4.5
- <0.05
Discussion

• Relationship of SES and UV to incidence differs by stage.
• Differences in state random effects by stage may be due to greater state differences in (under-) reporting of early stage versus late stage melanoma.
• Additional studies are needed to evaluate if artificial sources of UV exposure or other factors might be equalizing the risk between higher and lower solar UV counties among younger adults.
• AVGLO
  – The action spectrum of ultraviolet radiation mainly responsible for melanoma induction is unknown, but evidence suggests it could be UVA, which has a different geographic distribution than UVB.
Limitations

• Variation in completeness of reporting
• Not all states could be included
  – Hawaii
• County-based ecologic study
  – Individual-level SES and UV exposure not available
  – Tanning bed use not available
• Geographic distribution of ethnicities and ancestries among non-Hispanic whites was not evaluated
Collaborators

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The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention or the National Cancer Institute.