RELATIONSHIPS BETWEEN CONSUMER HEALTH SPENDING AND MORTALITY ACROSS CENTRAL APPALACHIA

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Morehead State University

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Historical Background: Central Appalachia

- High levels of deprivation
- High levels of mortality rates
- Especially in eastern KY & WV
Research Questions

- In what ways are deprivation & poor mortality rates reflected in consumer spending on health & education?
- What is the relationship among deprivation, mortality rates, and consumer spending on Health?
Data – for 2008

- Aggregated by county
- ESRI Demographic Update
  - Social & demographic variables
  - From Census ACS & CPS
- CDC Seerstat
  - Mortality rates

- Variables
  - Demography
  - Income
  - Household structure
  - Employment
  - Educational attainment
  - Marital patterns
  - Consumer spending
    - Health & education
ESRI Consumer Spending 2008

- **Sources**
  - Consumer Expenditure Surveys from BLS
  - ESRI's Community Tapestry segmentation system.
  - A conditional probability model

- **Consumer spending**
  - Total expenditure - aggregate amount spent by all households in an area
  - Average amount spent per household
  - Per capita spending
Mortality Variables - 2005

- All causes
- Diseases of Heart
- All Cancers
- Chronic Obstructive Pulmonary Disease
Study Area

Appalachian Cities
- Over 50,000

Non-Appalachian Cities
- Over 250,000

- Northern Appalachia
- Central Appalachia
- Southern Appalachia
Average Household Size

- **2.6 - 4.7**
- **2.6 - 2.5**
- **2.5**
- **2.4**
- **0.0 - 2.3**
Average Household Size LISA Cluster Map

Household Size LISA
- Not Significant
- High-High
- High-Low
- Low-High
- Low-Low

Miles
0 50 100
Median Housing Value

- $320,861.01 - $497,576.00
- $215,329.01 - $320,861.00
- $151,127.01 - $215,329.00
- $105,827.01 - $151,127.00
- $35,837.00 - $105,827.00
- $151,127.00 - $215,329.00

Map showing the distribution of median housing values across different regions.
% of People 25+ with Less Than 9th Grade Education

% < 9th Grade Education
- 12.6% - 30%
- 10.1% - 12.5%
- 7.6% - 10%
- 5.2% - 7.5%
- 1.2% - 5.1%
- 0% - 1%
Diversity Index LISA Cluster Map

Diversity Index LISA

- Not Significant
- High-High
- Low-High
- Low-Low

Map showing various regions colored in red, blue, and gray to indicate different clusters and significance levels.
Consumer Spending

- Total Expenditures
- Health Care Spending (% of Total Spending)
- Health Care Spending per Household
- Health Insurance Spending (% of Total)
- Health Insurance Spending per household
- Medical Care Spending (% of Total Spending)
- Medical Care Spending per household
- Hospital Spending (% of Total Spending)
- Hospital Spending per Household
- Education Spending (% of Total Spending)
- Education Spending per household
Total Expenditures

- $2,000,000,000.01 - $51,244,244,742.00
- $900,000,000.01 - $2,000,000,000.00
- $460,000,000.01 - $900,000,000.00
- $249,682,104.01 - $460,000,000.00
- $36,484,823.00 - $249,682,104.00
- $36,484,823.00 - $249,682,104.00

Illinois:
- $460,000,000.01 - $900,000,000.00

Map showing the distribution of total expenditures across different regions with a scale from 0 to 100 miles.
<table>
<thead>
<tr>
<th>Total Per Capita Spending</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$24,000.01 - $60,766.31</td>
<td>Highest</td>
</tr>
<tr>
<td>$20,000.01 - $24,000.00</td>
<td>Very High</td>
</tr>
<tr>
<td>$18,800.01 - $20,000.00</td>
<td>High</td>
</tr>
<tr>
<td>$16,968.70 - $18,800.00</td>
<td>Medium High</td>
</tr>
<tr>
<td>$0.00 - $16,968.69</td>
<td>Lowest</td>
</tr>
</tbody>
</table>

**Total Expenditures (per capita)**

![Map showing total expenditures per capita across different regions.](image)
Total Expenditures per Capita LISA Cluster Map

**Per Capita Spending**
- Not Significant
- High-High
- Low-High
- Low-Low
Education Spending (% of Total Spending)

<table>
<thead>
<tr>
<th>% Education Spending</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.2% - 3%</td>
</tr>
<tr>
<td>2% - 2.1%</td>
</tr>
<tr>
<td>1.8% - 1.9%</td>
</tr>
<tr>
<td>1.6% - 1.7%</td>
</tr>
<tr>
<td>1.3% - 1.5%</td>
</tr>
</tbody>
</table>

Illinois: 2% - 2.1%
Education Spending as a % of Total LISA Cluster Map

- Not Significant
- High-High
- High-Low
- Low-High
- Low-Low

Map showing various regions colored in shades of red and blue indicating different levels of education spending.
College Tuition Spending (% of Total Household Spending)

% College Tuition
- 1.6% - 2.1%
- 1.4% - 1.5%
- 1.2% - 1.3%
- 1% - 1.1%
- 0.7% - 0.9%

Illinois: 1.4% - 1.5%
Health Spending as % of Total LISA Cluster Map

Health Spending %
- Not Significant
- High-High
- High-Low
- Low-High
- Low-Low

Map showing clusters of high and low health spending percentages across different regions.
Health Care Spending per capita

Health Care Spending

- $12,500.01 - $1,042,589.50
- $9,000.01 - $12,500.00
- $6,000.01 - $9,000.00
- $3,036.14 - $6,000.00
- $204.41 - $3,036.13

Illinois

$9,000.01 - $12,500.00

$6,000.01 - $9,000.00

$3,036.14 - $6,000.00

$204.41 - $3,036.13
Health Insurance Spending

[Map showing health insurance spending across different states, with color coding for different spending ranges:]

- **$63,500,000.01 - $1,353,166,484.00**
- **$27,500,000.01 - $63,500,000.00**
- **$15,000,000.01 - $27,500,000.00**
- **$8,503,145.01 - $15,000,000.00**
- **$1,284,490.00 - $8,503,145.00**
- **$1,284,490.00 - $8,503,145.00**
Health Insurance Spending (% of Total Expenditures)

% Health Insurance Spending
- 3.6% - 3.8%
- 3.4% - 3.5%
- 3.1% - 3.3%
- 2.9% - 3%
- 2.6% - 2.8%

Illinois: 3.4% - 3.5%
<table>
<thead>
<tr>
<th>State</th>
<th>% Hospital Services</th>
</tr>
</thead>
<tbody>
<tr>
<td>Illinois</td>
<td>0.55% - 0.58%</td>
</tr>
<tr>
<td></td>
<td>0.58% - 0.62%</td>
</tr>
<tr>
<td></td>
<td>0.3% - 0.43%</td>
</tr>
<tr>
<td></td>
<td>0.44% - 0.5%</td>
</tr>
<tr>
<td></td>
<td>0.51% - 0.54%</td>
</tr>
<tr>
<td></td>
<td>0.54% - 0.57%</td>
</tr>
</tbody>
</table>

The map shows the distribution of hospital spending as a percentage of total spending across various states, with different shades indicating the range of spending percentages.
Hospital Spending per Household

Hospital Services (per capita)
- $10,000.01 - $675,855.50
- $7,000.01 - $10,000.00
- $4,500.01 - $7,000.00
- $2,398.47 - $4,500.00
- $170.76 - $2,398.46

Map showing hospital spending per capita across various states, with different shades indicating different spending ranges.
Major Causes of Death

- Total
- Diseases of Heart
- Total Cancers
- COPD
Mortality Rates for All Causes Across Central

Total Mortality
- 1050.1 - 1345.6
- 1000.1 - 1050.0
- 950.1 - 1000.0
- 887.3 - 950.0
- 0.0 - 887.2

Miles
LISA Cluster Map of Total Mortality

<table>
<thead>
<tr>
<th>Total Mortality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not Significant</td>
</tr>
<tr>
<td>High-High</td>
</tr>
<tr>
<td>High-Low</td>
</tr>
<tr>
<td>Low-Low</td>
</tr>
<tr>
<td>Low-High</td>
</tr>
<tr>
<td>Low-Low</td>
</tr>
</tbody>
</table>

Map showing clusters of total mortality with various color codes for different levels of significance.
Mortality Due to Diseases of Heart

Total Heart Mortality

- 450.1 - 525.0
- 375.1 - 450.0
- 300.1 - 375.0
- 225.1 - 300.0
- 150.6 - 225.0

Miles

0 50 100
Mortality Due to Cancer

Total Cancer Mortality
- 281 - 320
- 241 - 280
- 201 - 240
- 161 - 200
- 134 - 160
Mortality Due to COPD

Total COPD Mortality

- 120.1 - 150.0
- 90.1 - 120.0
- 60.1 - 90.0
- 30.1 - 60.0
- 11.2 - 30.0
## ESDA: Moran’s I (vs. Total Mortality)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Moran’s I</th>
<th>Bivariate Moran’s I</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Mortality</td>
<td>0.2544</td>
<td>*** N/A</td>
</tr>
<tr>
<td>Health Spending (PH)</td>
<td>0.3819</td>
<td>*** 0.2528 ***</td>
</tr>
<tr>
<td>Education Spending (PH)</td>
<td>0.3349</td>
<td>*** -0.3306 ***</td>
</tr>
<tr>
<td>Population Density</td>
<td>0.4016</td>
<td>*** -0.2647 ***</td>
</tr>
<tr>
<td>Median Household Income</td>
<td>0.6082</td>
<td>*** -0.3224 ***</td>
</tr>
<tr>
<td>Educational Attainment</td>
<td>0.4189</td>
<td>*** -0.2553 ***</td>
</tr>
<tr>
<td>% Employed in Health Care</td>
<td>0.2312</td>
<td>*** 0.1255 ***</td>
</tr>
<tr>
<td>Unemployment Rate</td>
<td>0.3474</td>
<td>*** 0.2962 ***</td>
</tr>
</tbody>
</table>
ESDA: Summary of Results

- As ______ increases mortality increases
  - Health spending as % of household spending
  - % employed in health care
  - Unemployment

- As ______ increases mortality decreases
  - Education spending as % of household spending
  - Population density
  - Median Household income
  - Educational attainment
ESDA: Consistent Spatial Patterns

- High deprivation
  - Eastern Kentucky
  - West Virginia
  - Coastal North Carolina
  - Coastal southeastern Virginia

- Low Deprivation
  - All along eastern edge of Appalachia
  - Pennsylvania & northeastern study area
## OLS Model: Total Mortality

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Observations:</td>
<td>597</td>
<td>Number of Variables:</td>
<td>10</td>
</tr>
<tr>
<td>Degrees of Freedom:</td>
<td>587</td>
<td>Akaike's Information Criterion (AIC):</td>
<td>7106.958</td>
</tr>
<tr>
<td>Multiple R-Squared:</td>
<td>0.388929</td>
<td>Adjusted R-Squared:</td>
<td>0.3796</td>
</tr>
</tbody>
</table>
## OLS Model: Total Mortality

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>StdError</th>
<th>t-Statistic</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>916.169299</td>
<td>83.752692</td>
<td>10.938983</td>
<td>0.000000</td>
</tr>
<tr>
<td>Health Spending as % of Total Spending</td>
<td>-5.292712</td>
<td>8.096655</td>
<td>-0.653691</td>
<td>0.513564</td>
</tr>
<tr>
<td>Educational Spending as % of Total Spending</td>
<td>93.157677</td>
<td>20.847958</td>
<td>4.468432</td>
<td>0.000012</td>
</tr>
<tr>
<td>Median Household Income</td>
<td>-0.003658</td>
<td>0.000633</td>
<td>-5.777821</td>
<td>0.000000</td>
</tr>
<tr>
<td>Mean Household Size</td>
<td>80.018813</td>
<td>30.055596</td>
<td>2.662360</td>
<td>0.007967</td>
</tr>
<tr>
<td>Diversity Index</td>
<td>0.473557</td>
<td>0.227736</td>
<td>2.079414</td>
<td>0.038000</td>
</tr>
<tr>
<td>% w/ High School Diploma</td>
<td>-2.726191</td>
<td>0.685269</td>
<td>-3.978280</td>
<td>0.000086</td>
</tr>
<tr>
<td>Unemployment Rate</td>
<td>14.253831</td>
<td>2.132368</td>
<td>6.684509</td>
<td>0.000000</td>
</tr>
</tbody>
</table>

Note: * p < 0.1, ** p < 0.01, *** p < 0.001
OLS Model Standard Residuals

OLS Standard Residuals

- < -2.5 Std. Dev.
- -2.5 - -1.5 Std. Dev.
- -1.5 - -0.5 Std. Dev.
- -0.5 - 0.5 Std. Dev.
- 0.5 - 1.5 Std. Dev.
- 1.5 - 2.5 Std. Dev.
- > 2.5 Std. Dev.

Miles
0 50 100
### OLS Model 1: Diagnostics for Spatial Dependence

<table>
<thead>
<tr>
<th>TEST</th>
<th>MI/DF</th>
<th>VALUE</th>
<th>PROB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moran's I (error)</td>
<td>0.086977</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Lagrange Multiplier (lag)</td>
<td>1</td>
<td>9.58570650</td>
<td>0.0019610</td>
</tr>
<tr>
<td>Robust LM (lag)</td>
<td>1</td>
<td>0.2699404</td>
<td>0.6033718</td>
</tr>
<tr>
<td>Lagrange Multiplier (error)</td>
<td>1</td>
<td>11.0669908</td>
<td>0.0008788</td>
</tr>
<tr>
<td>Robust LM (error)</td>
<td>1</td>
<td>1.75122470</td>
<td>0.1857228</td>
</tr>
<tr>
<td>Lagrange Multiplier (SARMA)</td>
<td>2</td>
<td>11.33693120</td>
<td>0.0034532</td>
</tr>
</tbody>
</table>
## Spatial Error Model Results

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>R-squared:</td>
<td>0.405444</td>
<td>R-squared (BUSE):</td>
<td>-</td>
</tr>
<tr>
<td>Sigma-square:</td>
<td>8149.206</td>
<td>Akaike info criterion:</td>
<td>7092.24</td>
</tr>
<tr>
<td>S.E of regression:</td>
<td>90.273</td>
<td>Schwarz criterion:</td>
<td>7127.38</td>
</tr>
</tbody>
</table>
### Spatial Error Model

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std.Error</th>
<th>z-value</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONSTANT</td>
<td>991.1399</td>
<td>89.72619</td>
<td>11.04627</td>
<td>0.0000000</td>
</tr>
<tr>
<td>HESPPRHS</td>
<td>-4.173309</td>
<td>8.347418</td>
<td>-0.4999521</td>
<td>0.6171088</td>
</tr>
<tr>
<td>EDSPPRCSP</td>
<td>107.1212</td>
<td>20.86821</td>
<td>5.133226</td>
<td>0.0000003</td>
</tr>
<tr>
<td>MEDHINCCY</td>
<td>-0.0036941</td>
<td>0.0006658</td>
<td>-5.548272</td>
<td>0.0000000</td>
</tr>
<tr>
<td>AVGHHSZ_CY</td>
<td>54.83352</td>
<td>31.79137</td>
<td>1.724793</td>
<td>0.0845647</td>
</tr>
<tr>
<td>DIVINDX_CY</td>
<td>0.5394198</td>
<td>0.2622922</td>
<td>2.056561</td>
<td>0.0397284</td>
</tr>
<tr>
<td>PRHIGHSCHD</td>
<td>-3.159786</td>
<td>0.7313682</td>
<td>-4.320377</td>
<td>0.0000156</td>
</tr>
<tr>
<td>UNEMPRATE</td>
<td>12.72366</td>
<td>2.213794</td>
<td>5.747444</td>
<td>0.0000000</td>
</tr>
<tr>
<td>LAMBDA</td>
<td>0.2200312</td>
<td>0.0585949</td>
<td>3.755123</td>
<td>0.0001733</td>
</tr>
</tbody>
</table>
### Comparison of OLS vs. Spatial Error Model

<table>
<thead>
<tr>
<th></th>
<th>OLS</th>
<th>Spatial Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adjusted R-Squared:</td>
<td>0.3796</td>
<td>R-squared: 0.405444</td>
</tr>
<tr>
<td>Akaike's Information Criterion (AIC):</td>
<td>7106.958</td>
<td>Akaike info criterion: 7092.24</td>
</tr>
</tbody>
</table>
## Comparison of OLS vs. Spatial Error Model

<table>
<thead>
<tr>
<th></th>
<th>OLS Coefficient</th>
<th>Spatial Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>916.169299 ***</td>
<td>991.1399 ***</td>
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<td>93.157677 ***</td>
<td>107.1212 ***</td>
</tr>
<tr>
<td>Median Household Income</td>
<td>-0.003658 ***</td>
<td>-0.0036941 ***</td>
</tr>
<tr>
<td>Mean Household Size</td>
<td>80.018813 **</td>
<td>54.83352 *</td>
</tr>
<tr>
<td>Diversity Index</td>
<td>0.473557 *</td>
<td>0.5394198 *</td>
</tr>
<tr>
<td>% w/ High School Diploma</td>
<td>-2.726191 ***</td>
<td>-3.159786 ***</td>
</tr>
<tr>
<td>Unemployment Rate</td>
<td>14.253831 ***</td>
<td>12.72366 ***</td>
</tr>
<tr>
<td>LAMBDA</td>
<td>n/a</td>
<td>0.2200312 ***</td>
</tr>
</tbody>
</table>
Mortality Rates for All Causes Across Central

Total Mortality

- 1050.1 - 1345.6
- 1000.1 - 1050.0
- 950.1 - 1000.0
- 887.3 - 950.0
- 0.0 - 887.2

Miles
Why not use GWR?

- Model specification problems (multicolinearity)
Regression: Summary of Results

- As ______ increases, mortality increases
  - Education spending
  - Unemployment
  - Mean Household Size
  - Diversity

- As ______ increases, mortality decreases
  - Health spending
  - Median Household income
  - Educational attainment
Regression: Consistent Spatial Patterns

- High deprivation
  - Eastern Kentucky
  - West Virginia
  - Coastal North Caroline
  - Coastal southeastern Virginia

- Low Deprivation
  - All along eastern edge of Appalachia
  - Pennsylvania & northeastern study area
Conflicts between ESDA & Regression Analyses

- Changes in the direction of effects of
  - Health Spending
  - Education Spending
Major Patterns: Deprivation, Mortality, & Consumer Spending

- High deprivation ->
  - Low total health care expenditures
  - Low *per capita* health care spending
  - High spending as % of total household spending
  - High spending as % of total spending

- Patterns replicated for
  - Health insurance spending
  - Hospital spending
Key relationships

- Well established
  - High deprivation -> high mortality

- New observations
  - High deprivation ->
    - High health spending as % of total household spending
    - Low total health spending
    - Low *per capita* spending
Major Regional Patterns

- Eastern Kentucky’s situation
  - Highest deprivation
  - Highest mortality rates
  - Highest health spending as % of total spending
  - Lowest total & *per capita* health spending

- West Virginia – better than eastern KY
  - Lower deprivation
  - Lower mortality rates
  - Higher total & *per capita* health spending
Results Summary

- High degree of geographical variability
- Less geographical clustering than expected
- Many meaningful patterns
  - Urban vs. rural
  - Deprivation, mortality, & health spending
  - Eastern Kentucky – low health spending fails
  - West Virginia – high health spending pays off
Thank You

The Kentucky Center for Geospatial Education, Research, & Outreach
kcgero.org

Institute for Regional Analysis and Public Policy (IRAPP)
Center of Excellence, MSU
A Kentucky Program of Distinction
http://irapp.morehead-st.edu