Geospatial Analysis of Lung Cancer Incidence & Mortality Rate

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Office of Health Equity & Virginia Cancer Registry
Virginia Department of Health
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Analysis on Lung Cancer Incidence Rate Around High Way and Superfund Sites

What is Superfund?
Thousands of contaminated sites exist nationally due to hazardous waste being dumped, left out in the open, or otherwise improperly managed. These sites include manufacturing facilities, processing plants, landfills and mining sites.

In the late 1970s, toxic waste dumps such as Love Canal and Valley of the Drums received national attention when the public learned about the risks to human health and the environment posed by contaminated sites.

What is Superfund?
The National Priorities List (NPL) is the priority list of hazardous waste sites in the United States eligible for long-term remedial investigation and remedial action (cleanup) financed under the federal Superfund program.

Of the 40,000 federal Superfund sites across the country, approximately 1,600 are on the NPL. The vast majority are shorter-term cleanups that are not listed on the NPL.
Data Used

1. Cancer Data
   - Lung cancer 2009-2018 from Virginia Cancer Registry
   - Age 35 and above
   - VA residents
   - No name, SSN, DOB, or address provided
   - Consolidated SS2000, Derived SS2000 and SS2018
   - State specific data, smoke, alcohol etc. included

2. Social economic and EPA data
   Locality data on Population density, EPA environmental, Walkability, income inequality, education, job participation, access to health care, access to employment, food access, etc.
Virginia
Lung Cancer * Rate per 100,000 Population
Hot Spot Analysis at Census Tract
Overlaid with EPA Superfund Site**
2009 - 2019

Hotspot Analysis Of Lung Cancer
- Cold Spot - 99% Confidence
- Cold Spot - 95% Confidence
- Cold Spot - 90% Confidence
- Not Significant
- Hot Spot - 90% Confidence
- Hot Spot - 95% Confidence
- Hot Spot - 99% Confidence

EPANational Priorities List (NPL) Sites

** NPL is the priority list of hazardous waste sites in the United States eligible for long-term remedial investigation and remedial action (cleanup) financed under the federal Superfund program.
GeoDA – Spatial Pattern-Lung cancer Mortality Rate
GeoDA – Spatial Pattern-Lung cancer Late Stage Rate

Moran's I 0.494 (isolates in weights are removed)

LISA Cluster Map: Queen_StagingRate, I_Rate (999 perm)
- Not Significant (1074)
- High-High (257)
- Low-Low (451)
- Low-High (51)
- High-Low (19)
Map of Lung Cancer Mortality Crude Rate and Rate of Lung Cancer Diagnosed At Late Stage, VA 2009-2018

LISA Cluster Map: Queen_DeathRate, I_Mortality (999 perm)
- Not Significant (1061)
- High-High (255)
- Low-Low (462)
- Low-High (54)
- High-Low (16)
Virginina
Geographical Location of Lung Cancer * Clusters
Using SaTScan to Detect Geographic Targets for Lung Cancer
2009 - 2019

Cluster 1
Radius: 71.2
LLR: 202.1
P Value: 0.000001
Observed: 14,300
Expected: 12,318
Relative Risk: 1.22

Cluster 2
Radius: 51.7
LLR: 61.9
P Value: 0.000001
Observed: 3,737
Expected: 3,117
Relative Risk: 1.21

Cluster 3
Radius: 4.4
LLR: 61.8
P Value: 0.000001
Observed: 576
Expected: 349
Relative Risk: 1.66

Cluster 4
Radius: 48.3
LLR: 14.6
P Value: 0.00009
Observed: 1,900
Expected: 1,677
Relative Risk: 1.14

* Data Source: Virginia Department of Health, Cancer Registry Incidence Data, 2009-2019,
Virginia
Geographical Location of Lung Cancer * Clusters
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Overlaid with EPA Superfund Site**
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- Expected: 349
- Relative Risk: 1.66

Cluster 4
- Radius: 48.3
- LLR: 14.6
- P Value: 0.0009
- Observed: 1,900
- Expected: 1,677
- Relative Risk: 1.14

** NPL is the priority list of hazardous waste sites in the United States eligible for long-term remedial investigation and remedial action (cleanup) financed under the federal Superfund program.
Residential Proximity to EPA SuperFund Sites & Lung Cancer Incidence in Virginia, per 100,000 Population

- Up to One and Half Miles: 133.44
- Between One-Half and Two Miles: 126.44
- Above 2 Miles: 118.77
Residential Proximity to EPA SuperFund Sites & Lung Cancer Mortality in Virginia, per 100,000 Population

- Up to One and Half Miles: 91.08
- Between One-Half and Two Miles: 84.19
- Above 2 Miles: 80.84
Cluster #1 and Half Mile Proximity to NPL * Sites Federal Poverty Level (1 FPL) by Race

Cluster #1

- All: 13.6
- White: 8.9
- Black: 20.2

0.5 Mile Proximity to NPL

- All: 26.4
- White: 15.2
- Black: 35.1

Legend:
- Cluster # 1
- 0.5 Mile Proximity to NPL
Segment Profile of Pop. residing One & half miles from Superfund Sites

- White Alone 54.9%, Black Alone 33.3%, Asian Alone 3.7%, Other Race 8.1%
- Per Capita Income $28,090 (US - $31,950)
- Median household income is $55,097 in the area, compared to $58,100 for all U.S.
- Currently, 50.7% of the 74,417 housing units in the area are owner occupied; 41.7%, renter occupied; and 7.6% are vacant
- 30.8% of household has a net worth less than $15,000
Residential & Lung Cancer Crude Incidence Rate (per 100,000) Proximity From Virginia Highway By Distance

<table>
<thead>
<tr>
<th>Distance</th>
<th>Incidence Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 25 Meters</td>
<td>143.5</td>
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<tr>
<td>25 to 49 Meters</td>
<td>137.5</td>
</tr>
<tr>
<td>50 to 100 Meters</td>
<td>133.5</td>
</tr>
<tr>
<td>101 to 500 Meters</td>
<td>124.5</td>
</tr>
<tr>
<td>Above 500 Meters</td>
<td>121.3</td>
</tr>
</tbody>
</table>
Hampton Roads Metropolis
Lung Cancer Relative Risk
Optimal Cluster Reporting Sizes within Cluster # 1
2009 - 2019

Cluster 1

Relative Risk
- 0.30 - 0.90
- 0.91 - 1.09
- 1.10 - 1.28
- 1.29 - 1.59
- 1.60 - 3.20

0 - 40 Miles
0.5 Miles Proximity from Superfund Sites in Cluster #1

- Relative Risk = 1.44
- Current median household income is $44,333 in the area, compared to $58,100 for all U.S. households.
- Current per capita income is $22,002 in the area, compared to the U.S. per capita income of $31,950.
- Currently, 35.2% of the 4,878 housing units in the area are owner occupied; 54.1%, renter occupied
Lung Cancer Data Modeling

Neighborhood Effect
Virginia
Health Opportunity Index (HOI)
by Census Tract *

* Health opportunity Index (HOI) – The HOI is a composite measure comprising 4 components that reflect a broad array of social determinants of health. The 4 components include: 1. Consumer Opportunity Profile 2. Economic Opportunity Profile 3. Wellness Disparity Profile 4. Community Environmental Profile (Note: the 4 components were derived from 13 initial indices)

The HOI was developed to assist the public, businesses, policy makers, communities, healthcare organizations and public health professionals in identifying key social and economic factors (also known as social determinants of health) that affect the health outcomes of the residents of Virginia communities. The set of factors chosen to be included within the HOI was designed to capture the processes by which “opportunities to be healthy” emerge; upon determination of the community HOI score it can suggest where specific interventions may aid in developing a healthy community. Not only does the HOI assist in identifying such areas, it can facilitate a positive attitude toward change within the local community.
Healthy People 2020: Five Elements of SDOH
Health Opportunity Index
### Lung Cancer Data Modeling
Ordinary Least Square Diagnostics

<table>
<thead>
<tr>
<th>Variables</th>
<th>Coefficient [a]</th>
<th>Standard Error</th>
<th>Probability</th>
<th>Robust Probability</th>
<th>VIF [c]</th>
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<tbody>
<tr>
<td>Intercept</td>
<td>504.0</td>
<td>21.1</td>
<td>0.000000*</td>
<td>0.000000*</td>
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<tr>
<td>Access to Healthcare</td>
<td>-26.6</td>
<td>8.7</td>
<td>0.002323*</td>
<td>0.002931*</td>
<td>1.13</td>
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<tr>
<td>Access to Employment</td>
<td>81.0</td>
<td>35.4</td>
<td>0.022290*</td>
<td>0.0634920</td>
<td>1.90</td>
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<tr>
<td>Affordability</td>
<td>-66.3</td>
<td>12.8</td>
<td>0.000000*</td>
<td>0.000579*</td>
<td>2.71</td>
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<tr>
<td>EPA Environmental</td>
<td>-18.8</td>
<td>10.9</td>
<td>0.0850210</td>
<td>0.1203670</td>
<td>1.39</td>
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<tr>
<td>Population Churning</td>
<td>30.2</td>
<td>10.5</td>
<td>0.003989*</td>
<td>0.042989*</td>
<td>1.59</td>
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<tr>
<td>Education</td>
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<td>24.8</td>
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<td>0.000000*</td>
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<td>Food Access</td>
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<td>14.3</td>
<td>0.6097600</td>
<td>0.6711010</td>
<td>1.11</td>
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<tr>
<td>Income Inequality</td>
<td>-69.5</td>
<td>15.0</td>
<td>0.000006*</td>
<td>0.000193*</td>
<td>1.70</td>
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<tr>
<td>Job Participation</td>
<td>-143.6</td>
<td>14.2</td>
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<td>0.000000*</td>
<td>2.34</td>
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<tr>
<td>Population Density</td>
<td>-151.2</td>
<td>20.8</td>
<td>0.000000*</td>
<td>0.000001*</td>
<td>1.84</td>
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<td>Segregation</td>
<td>-18.2</td>
<td>5.9</td>
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<td>0.002444*</td>
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<tr>
<td>Material Deprivation</td>
<td>-19.4</td>
<td>12.8</td>
<td>0.1304530</td>
<td>0.2067550</td>
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<tr>
<td>Walkability</td>
<td>66.5</td>
<td>14.3</td>
<td>0.000005*</td>
<td>0.000018*</td>
<td>2.29</td>
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</tbody>
</table>
Histogram of Standardized Residuals

Stan. Residuals

Ols Diagnostics

Input Features: Hotspot_PolyRate_Select
- Number of Observations: 1856
- Multiple R-Squared [d]: 0.486691
- Joint F-Statistic [e]: 134.344609
- Joint Wald Statistic [e]: 1598.242960
- Koenker (BP) Statistic [f]: 236.263055
- Jarque-Bera Statistic [g]: 128.274835

Dependent Variable: RATE
- Akaike's Information Criterion (AICc) [d]: 19280.427279
- Adjusted R-Squared [d]: 0.483068
- Prob(>F), (13,1842) degrees of freedom: 0.000000*
- Prob(>chi-squared), (13) degrees of freedom: 0.000000*
- Prob(>chi-squared), (2) degrees of freedom: 0.000000*
Geographically Weighted Regression (GWR) – Standard Residual Residual

<table>
<thead>
<tr>
<th>VARNAME</th>
<th>VARIABLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neighbors</td>
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</tr>
<tr>
<td>Residual Squares</td>
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</tr>
<tr>
<td>Effective Number</td>
<td>83.03</td>
</tr>
<tr>
<td>Sigma</td>
<td>0.12</td>
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<tr>
<td>AICc</td>
<td>94.79</td>
</tr>
<tr>
<td>R2</td>
<td>0.89</td>
</tr>
<tr>
<td>R2 Adjusted</td>
<td>0.64</td>
</tr>
<tr>
<td>Dependent</td>
<td>Lung Cancer Rate per 100,000</td>
</tr>
<tr>
<td>Explanatory</td>
<td>Income Inequality</td>
</tr>
<tr>
<td>Explanatory</td>
<td>Job Participation</td>
</tr>
<tr>
<td>Explanatory</td>
<td>Townson Material Deprivation</td>
</tr>
<tr>
<td>Explanatory</td>
<td>Affordability</td>
</tr>
</tbody>
</table>
Virginia
Income Inequality Coefficient Surface
Geographically Weighted Regression Local Parameter Variation
Lung Cancer Spatial Regression

Data Source: Virginia Department of Health, Cancer Registry
Virginia
Job Participation Coefficient Surface
Geographically Weighted Regression Local Parameter Variation
Lung Cancer Spatial Regression

Data Source: Virginia Department of Health, Cancer Registry
Virginia
Material Deprivation (Townsend Index) Coefficient Surface

Geographically Weighted Regression Local Parameter Variation
Lung Cancer Spatial Regression

Data Source: Virginia Department of Health, Cancer Registry
Conclusion

• This study presents suggestive evidence of an association between proximity to superfund/Highway and lung cancer (More evidence is needed)

• Living in low-socioeconomic status (SES) areas was associated with higher total, lung cancer incidence, and higher total cancer mortality.

• After accounting for individual age and Race living in lower-SES areas remained associated with higher lung cancer incidence, and higher total cancer mortality.
Contact Information

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