Geospatial Analysis of Stroke Mortality & Hospitalization:
An Overview Using Health Outcome Data

ESRI Health Conference, Denver

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Virginia Network for Geospatial Health Research

Steve Sedlock

Ken Studer, PhD

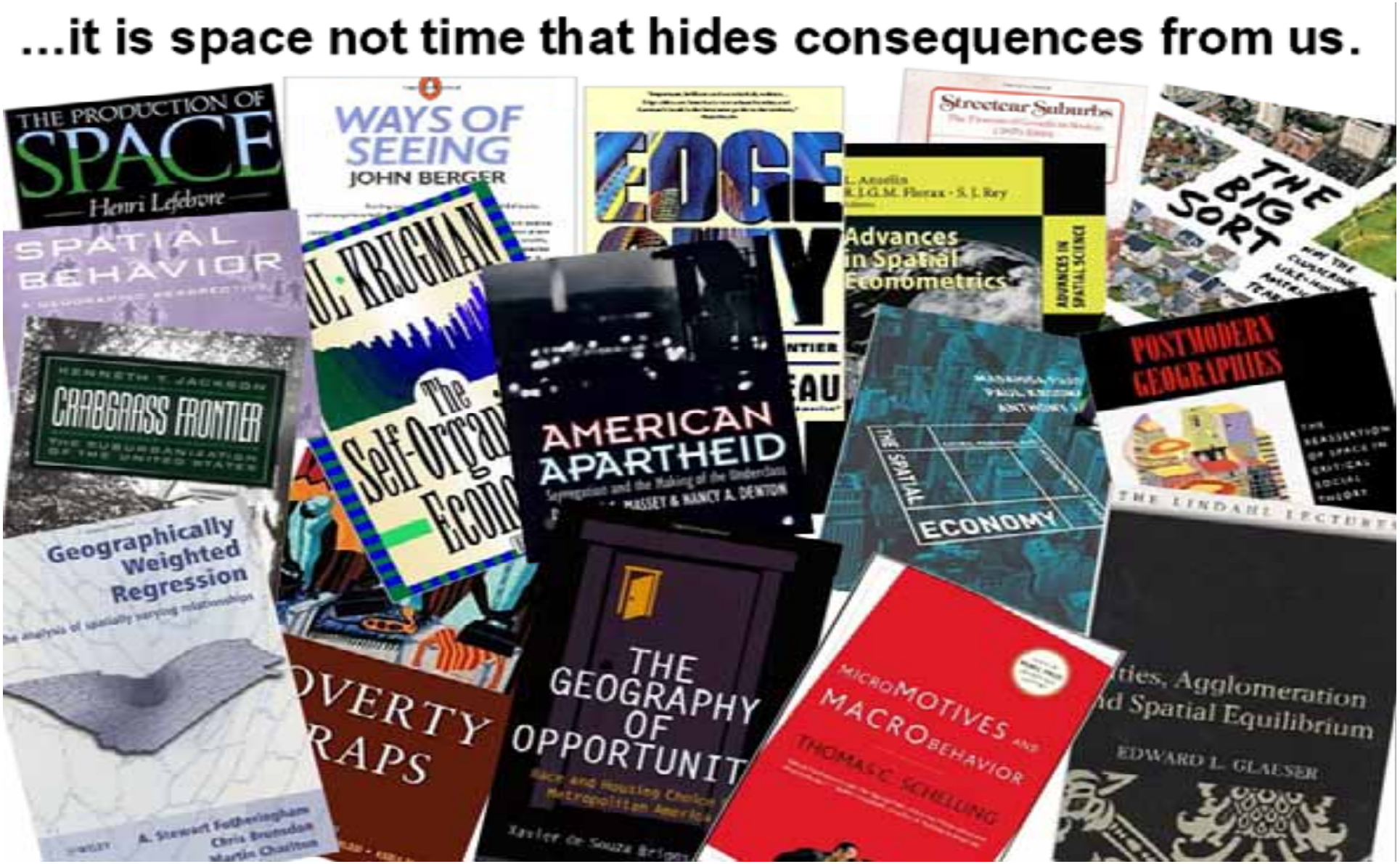
Rexford Anson-Dwamena

VANGHR

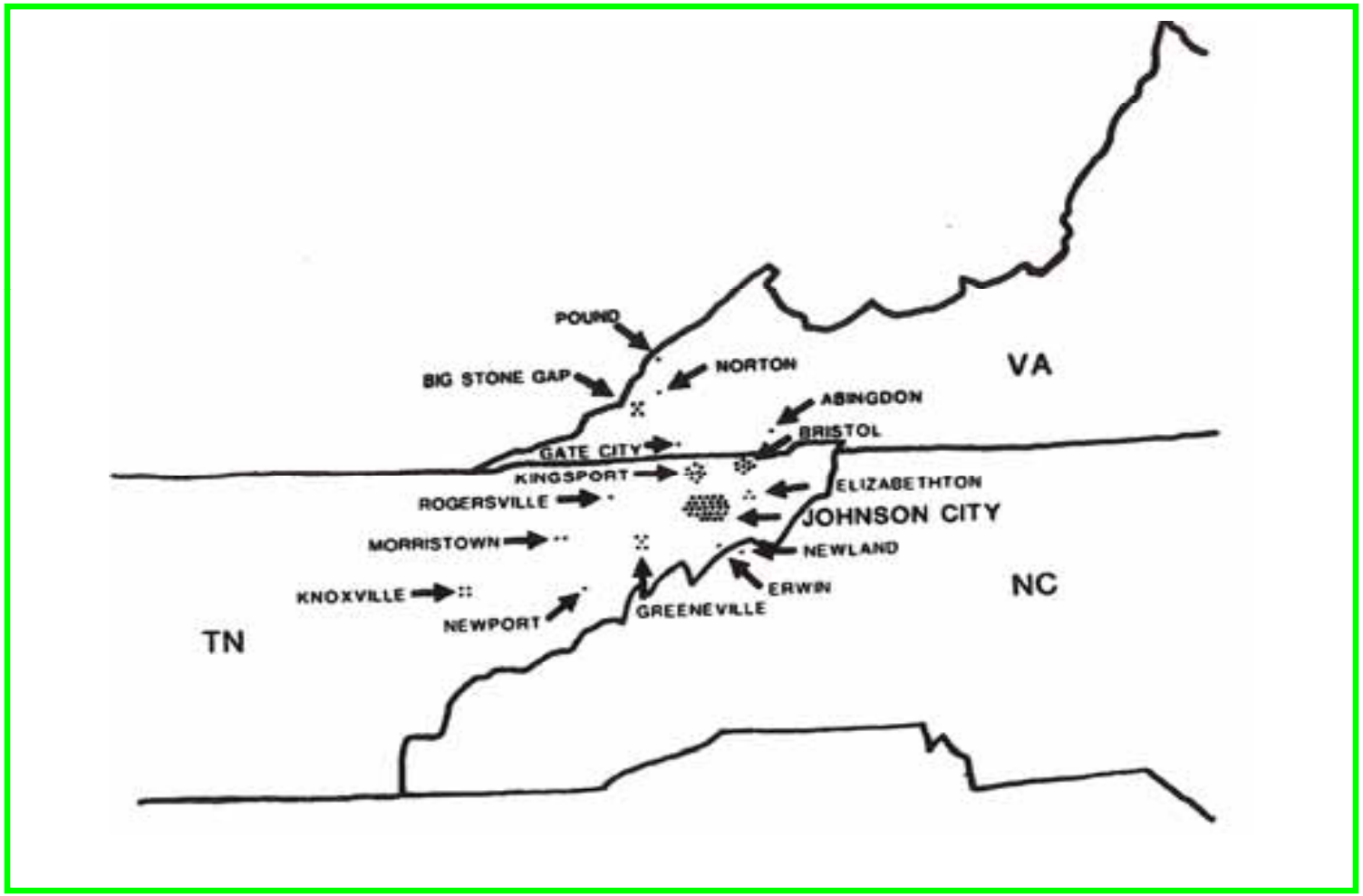
Changing the view on public health

Place Matters

…it is space not time that hides consequences from us.



Abraham Verghese: Urbs in Rure



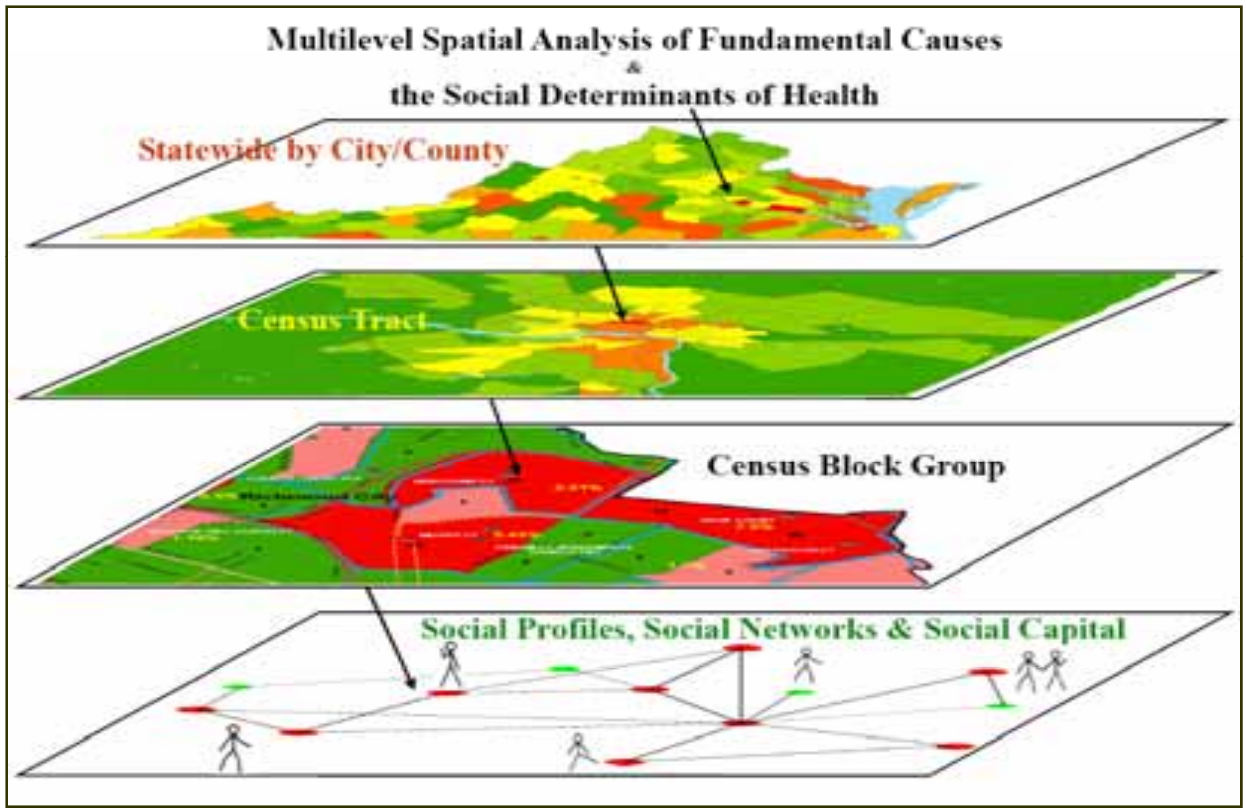
Verghese, A., S. Berk, and F. Sarubbi. 1989. Urbs in Rure: HIV infections in rural Tennessee. Journal of Infectious Diseases 160(6): 1051-1055.

Types of Spatial Analysis

1. **Traditional GIS**
   A. Query and display
   B. Buffering
   C. Overlay

2. **Spatial Statistics**
   A. Hot spot analysis
   B. Spatial pattern analysis
   C. Spatial Regression

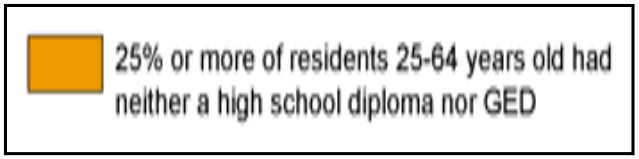
Multilevel Spatial Analysis: Social Determinants of Health & Neighborhood Effects

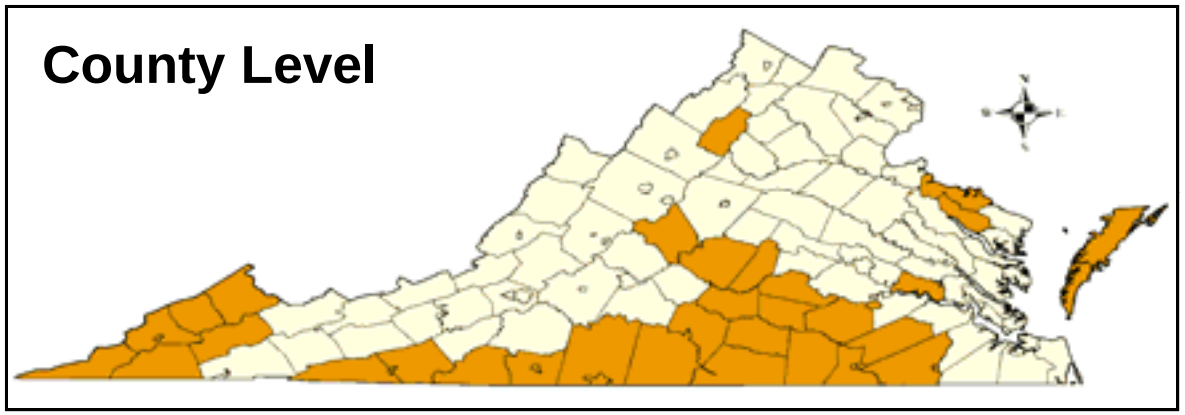


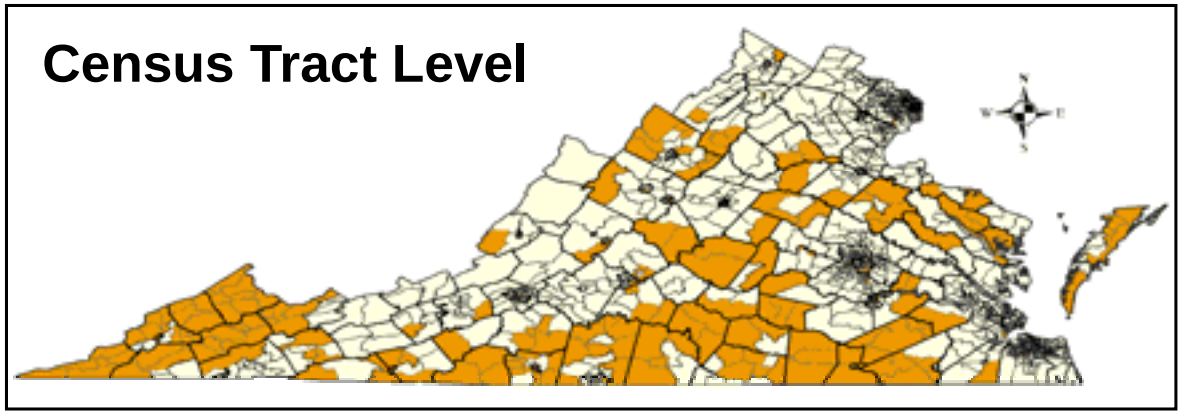
From: After To: Beside

Aggregation

Low Education in Virginia



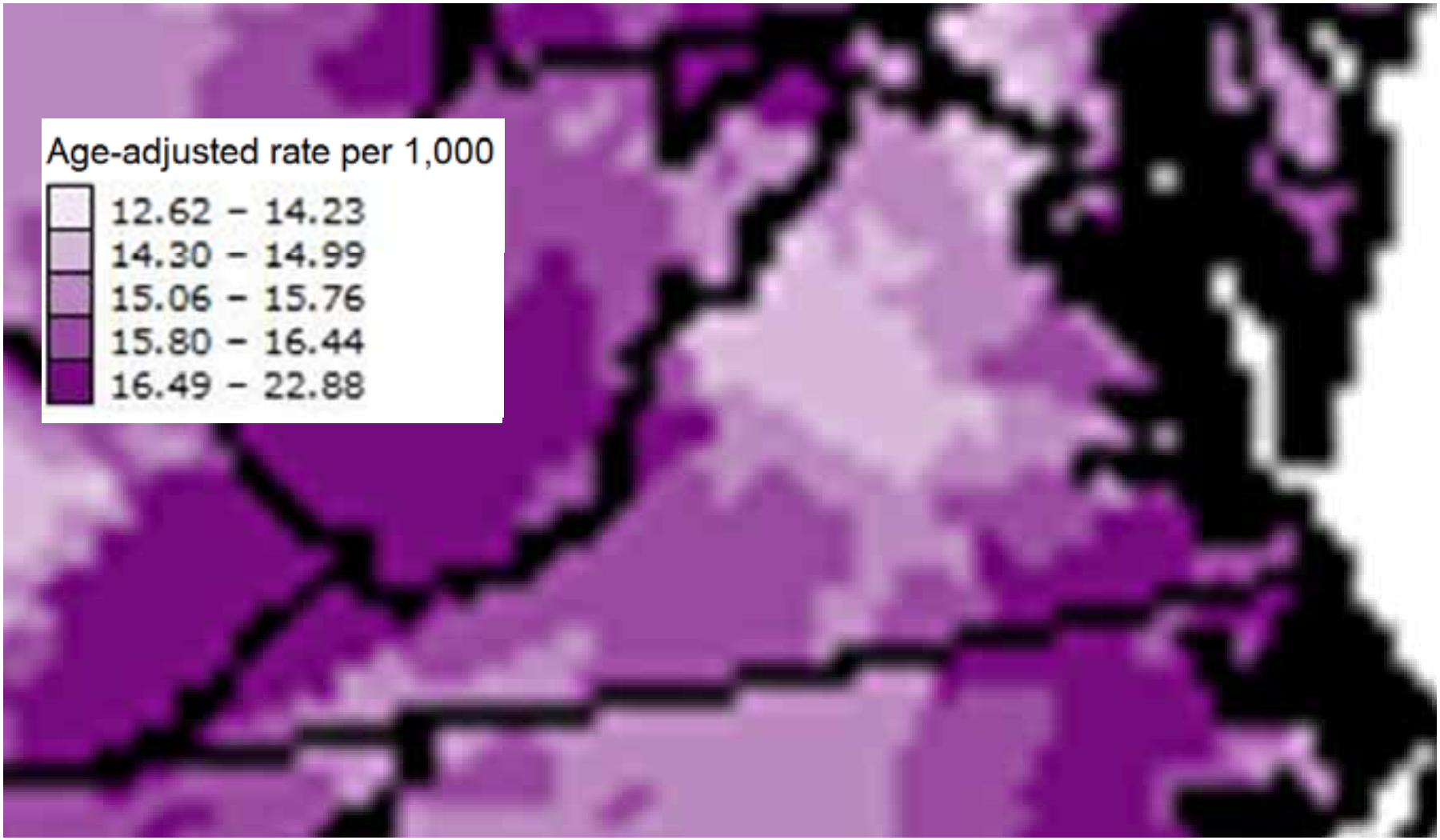




Source: United States Department of Agriculture: Economic Research Service, 2004 County Typologies; Census 2000, SF3-PCT25.

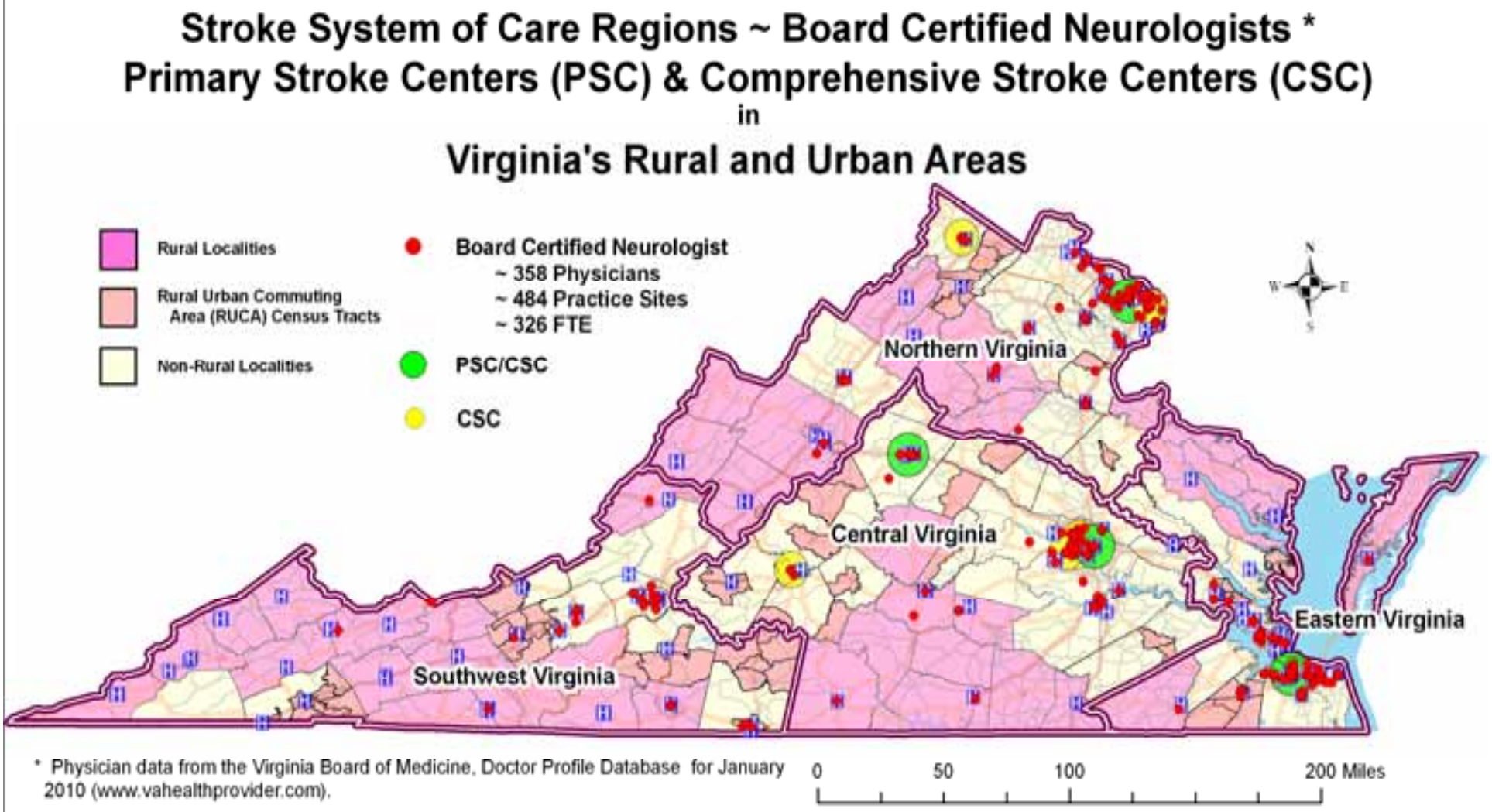
US ~ Stroke Hospitalization Rates

Pop Ages 65+, Medicare Beneficiaries, 2000-2006



Source: http://apps.nccd.cdc.gov/giscvh2/Results.aspx

Distribution of Health Care Providers



HotSpot Analysis & Scan Statistics

Examining Spatial Patterns

- Hot Spot Analysis Getis Ord Gi*
  - Used to identify clusters of features with values significantly higher or lower than the overall study area mean
  - Z score is calculated
    - **High Z = hot spot (surrounded by other high Z)**
    - **Low z = cold spot (surrounded by other low Z**)

ESRI, "Understanding Spatial Statistics in ArcGIS." Transcript, 2006

Virginia

Hot Spot Analysis ~ Relative Risk

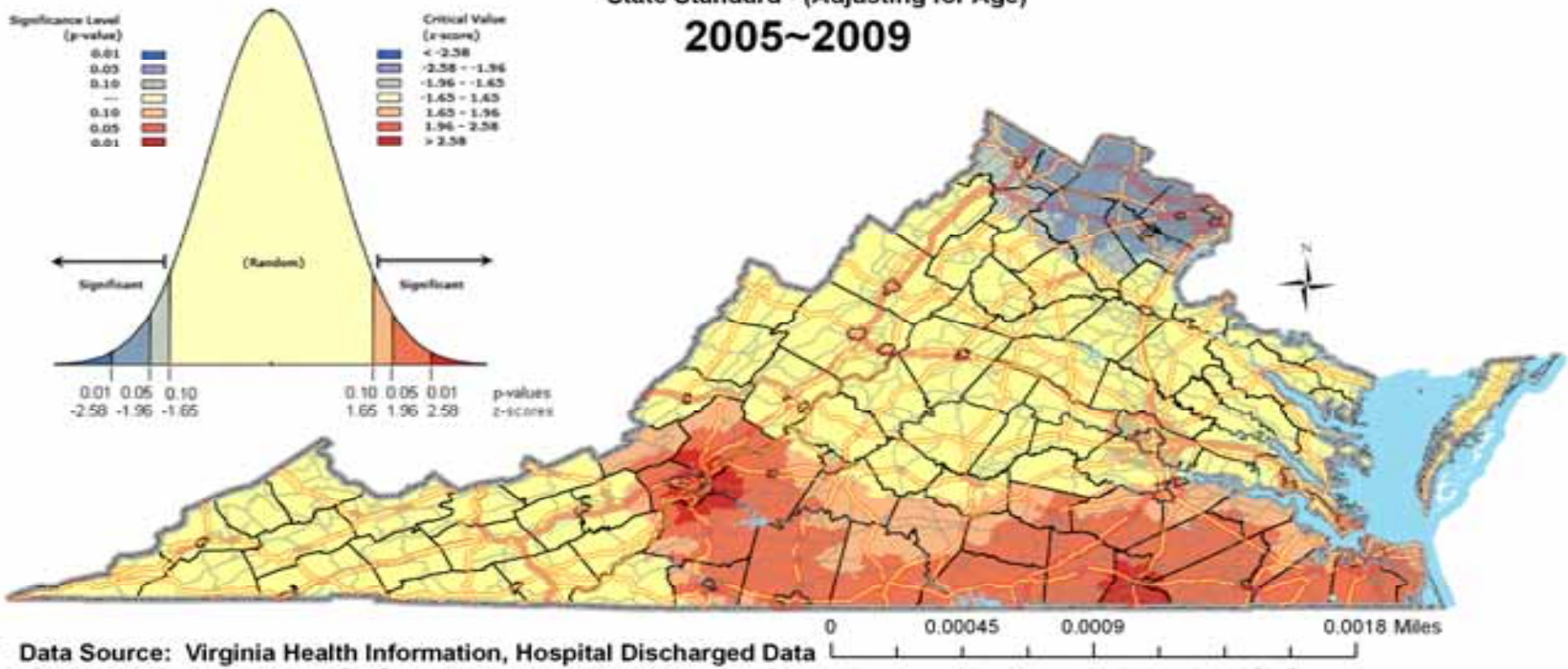
Arterial Ischemic Stroke (AIS)

Hospitalization (Primary Diagnosis) Discharged Data

Ages 35 Years & Over by ZIP Code

State Standard - (Adjusting for Age)

2005~2009



* Data Source: Virginia Health Information, Hospital Discharged Data

2005-2009 Analysis based on SatScan (v9.0, 2009) clustering algorithms developed by Martin Kulldorf for NCI. Data represent Stroke Discharged Data which have been age-adjusted Viginia Standard Population. Relative Risks take into account SatScan adjustments based on distribution within contiguious area.

Virginia

Hot Spot Analysis ~ Average Distance Travelled

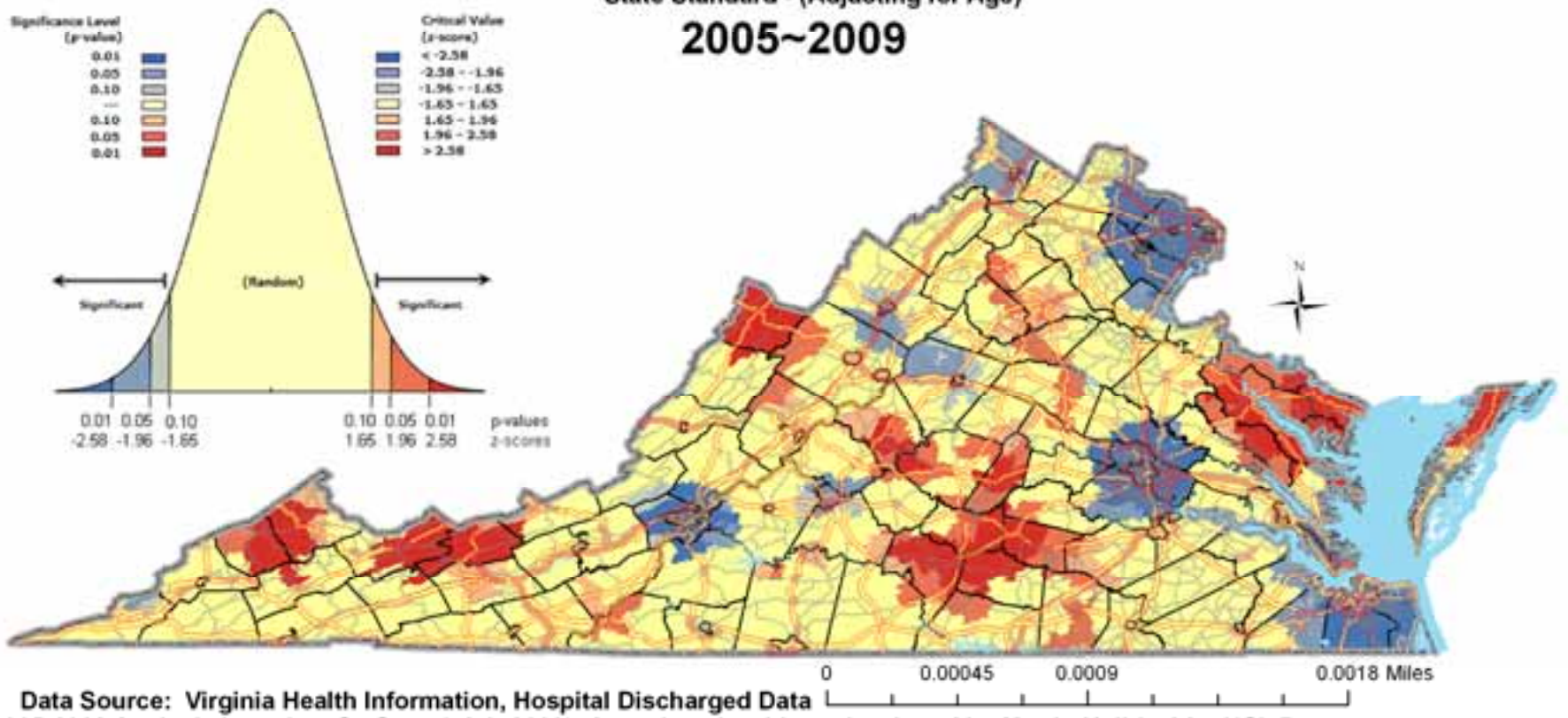
Arterial Ischemic Stroke (AIS)

Hospitalization (Primary Diagnosis) Discharged Data

Ages 35 Years & Over by ZIP Code

State Standard - (Adjusting for Age)

2005~2009



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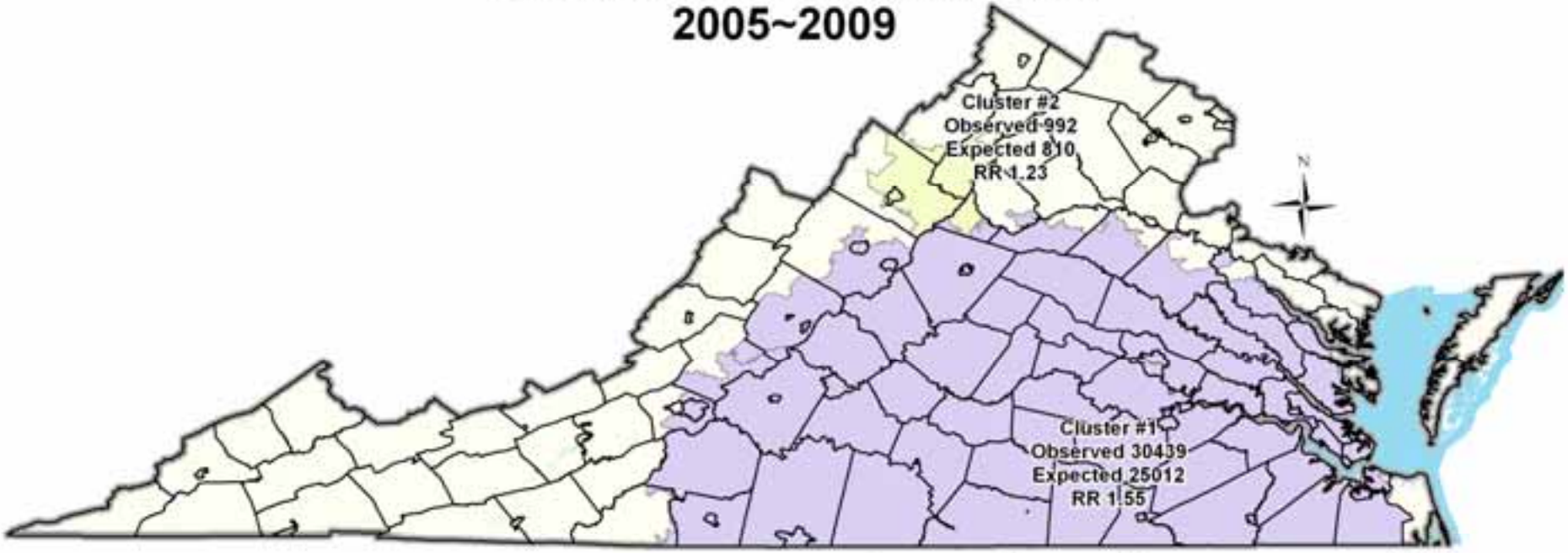
Virginia

Arterial Ischemic Stroke (AIS) ~ 35 Years & Over

Hospitalization (Primary Diagnosis) Discharge Data *

SaTScan Cluster Analysis (Global)

2005~2009



* Data Source: Virginia Health Information, Hospital Discharge Data 2005-2009. Analysis based on SatScan (v9.0, 2009) clustering algorithms developed by Martin Kulldorf for NCI. Data represent Primary Diagnosis Stroke Discharges for ICD-9 Codes, 433.01, 433.11, 433.21, 433.31, 433.81, 433.91, 434.01, 434.11, 434.91, and 436. Data have been age-adjusted, to Viginia State Standard Population. Relative Risk Ratios take into account SatScan adjustments based on Poisson distributions within contiguious area.

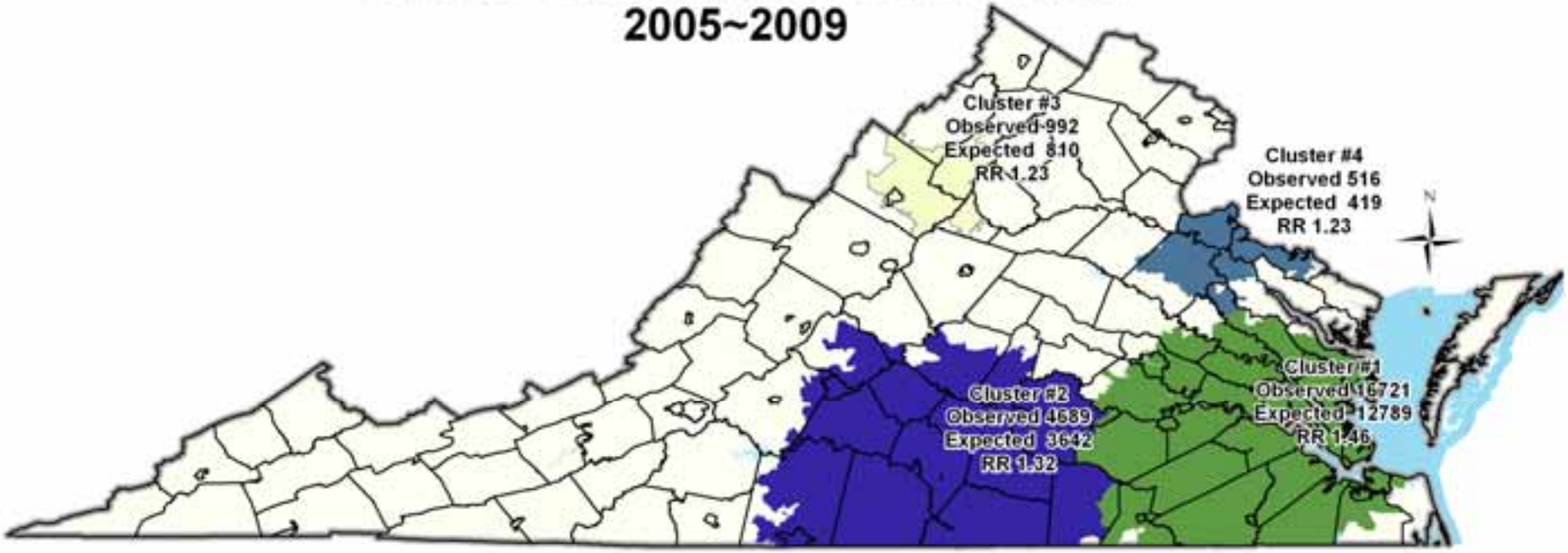
Virginia

Arterial Ischemic Stroke (AIS) ~ 35 Years & Over

Hospitalization (Primary Diagnosis) Discharge Data *

SaTScan Cluster Analysis (50 Miles Radius)

2005~2009



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Virginia

Arterial Ischemic Stroke (AIS) ~ 35 Years & Over

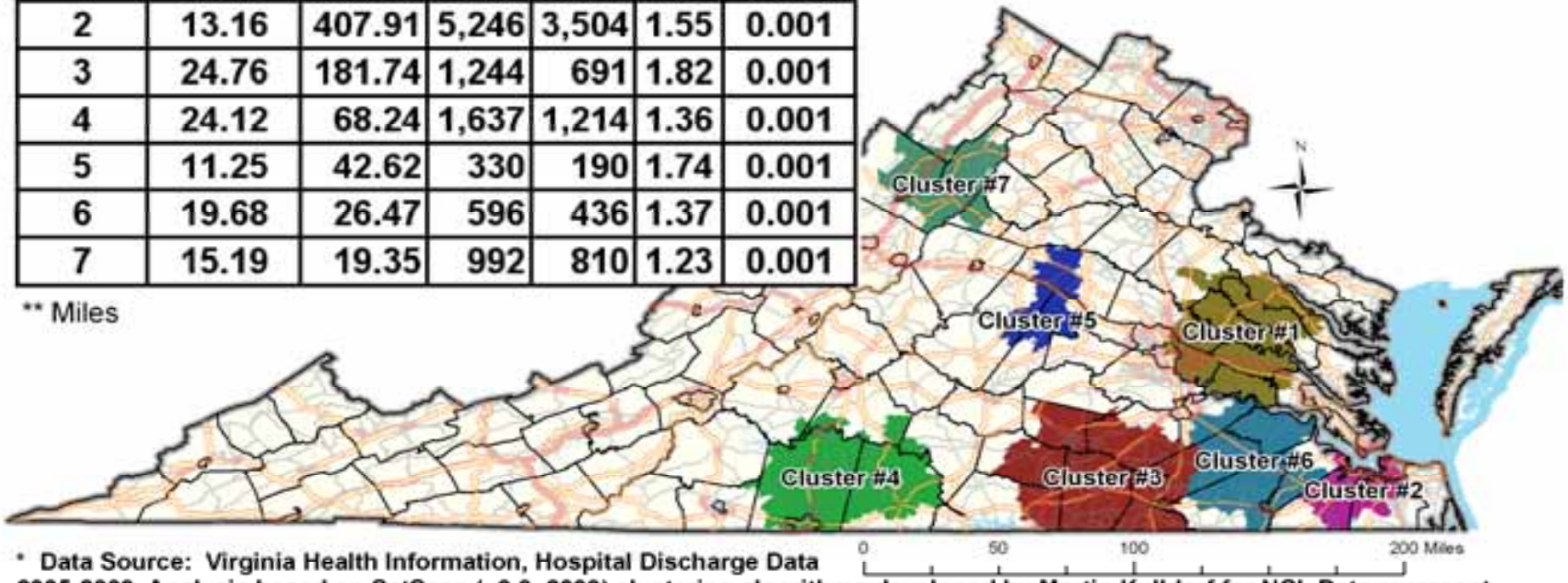
Hospitalization (Primary Diagnosis) Discharge Data *

SaTScan Cluster Analysis (25 Miles Radius)

2005~2009

Cluster	Radius**	LLR	Obs.	Exp.	RR	P value
1	22.64	450.88	3,464	2,013	1.77	0.001
2	13.16	407.91	5,246	3,504	1.55	0.001
3	24.76	181.74	1,244	691	1.82	0.001
4	24.12	68.24	1,637	1,214	1.36	0.001
5	11.25	42.62	330	190	1.74	0.001
6	19.68	26.47	596	436	1.37	0.001
7	15.19	19.35	992	810	1.23	0.001

** Miles



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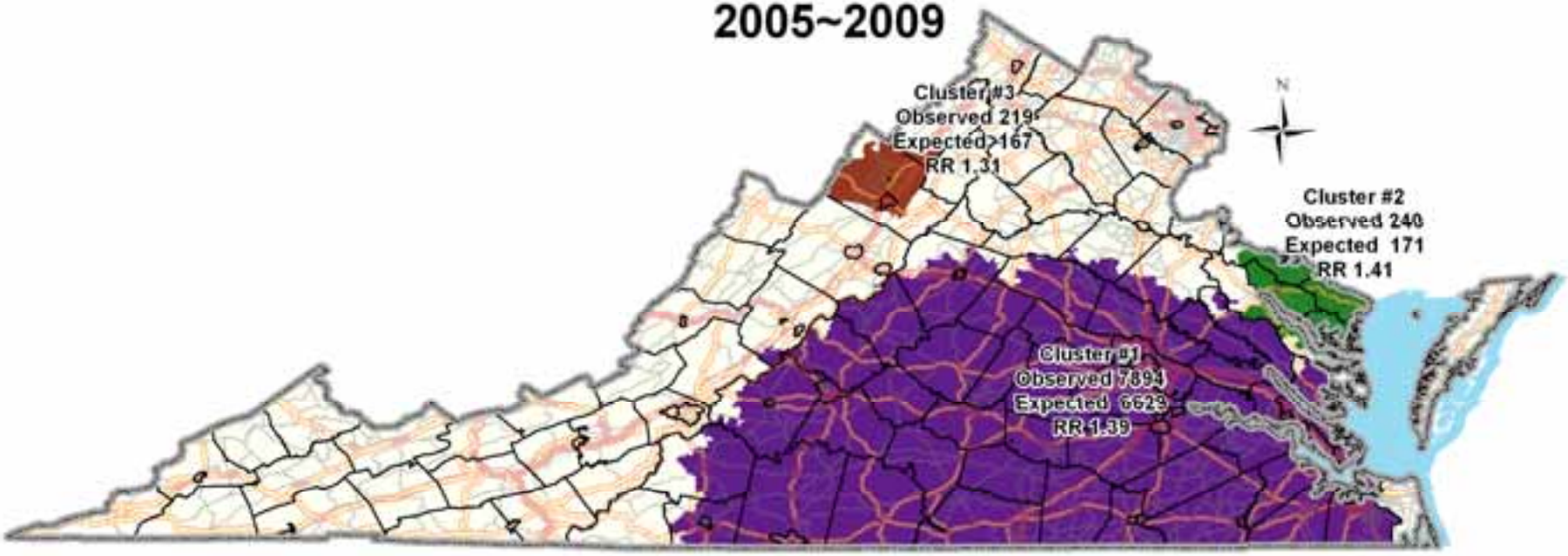
Virginia

Stroke Mortality ~ Indirect Standardization for Ages 35 Years & Over

SaTScan Cluster Analysis (Global)

2005~2009



* Data Source: Vital Record Database 2005-2009.

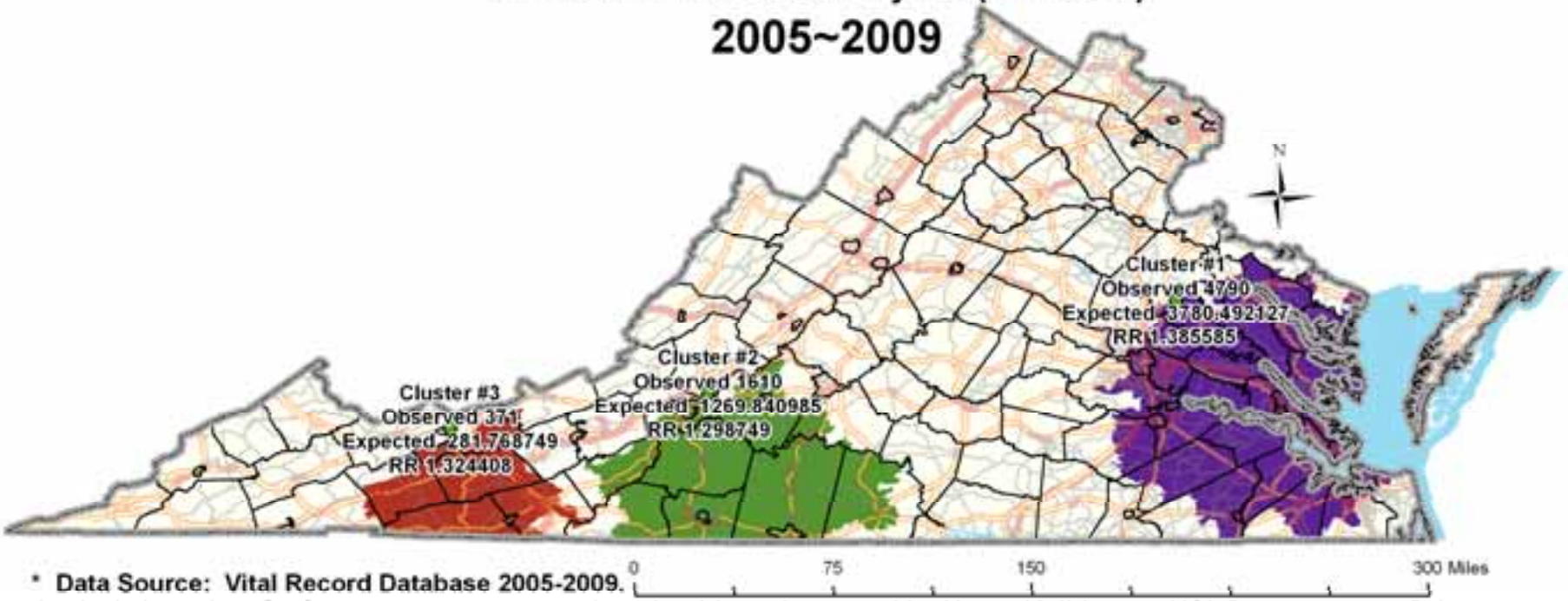
Analysis based on SatScan (v9.0, 2009) clustering algorithms developed by Martin Kulldorf for NCI. Data represent Primary Diagnosis Stroke Discharges for ICD-10 Codes, I60 ~ I69. Data have been age-adjusted, to Viginia State Standard Population. Relative Risk Ratios take into account SatScan adjustments based on Poisson distributions within contiguious area.

Virginia

Stroke Mortality ~ Indirect Standardization for Ages 35 Years & Over

SaTScan Cluster Analysis (50 Miles)

2005~2009



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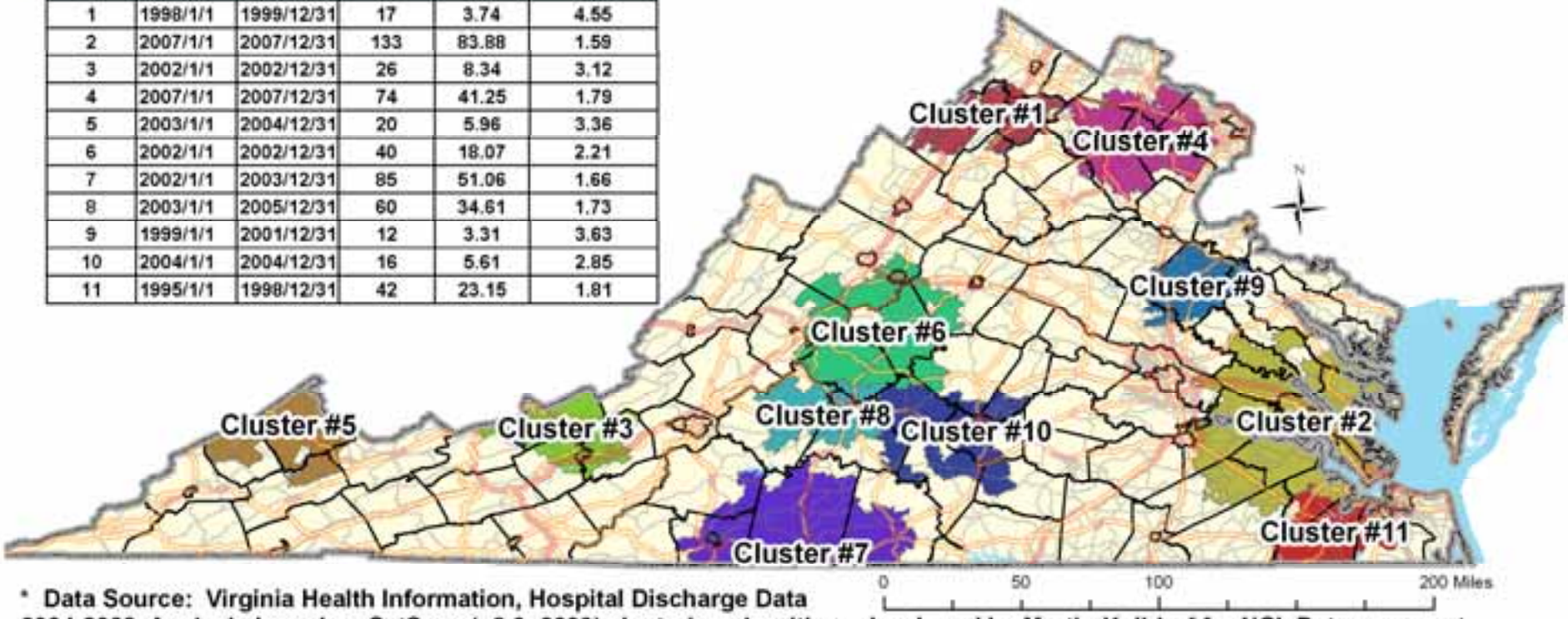
Virginia

Stroke Related Recurrent Admission ~ 35 Years & Over
Based on 2008 AIS Admissions Cohort

Hospitalization Discharge Data *
Space-Time Permutation Analysis ~ Retrospective

1994~2007

Cluster #	Start Date	End Date	Observed	Expected	RR
1	1998/1/1	1999/12/31	17	3.74	4.55
2	2007/1/1	2007/12/31	133	83.88	1.59
3	2002/1/1	2002/12/31	26	8.34	3.12
4	2007/1/1	2007/12/31	74	41.25	1.79
5	2003/1/1	2004/12/31	20	5.96	3.36
6	2002/1/1	2002/12/31	40	18.07	2.21
7	2002/1/1	2003/12/31	85	51.06	1.66
8	2003/1/1	2005/12/31	60	34.61	1.73
9	1999/1/1	2001/12/31	12	3.31	3.63
10	2004/1/1	2004/12/31	16	5.61	2.85
11	1995/1/1	1998/12/31	42	23.15	1.81



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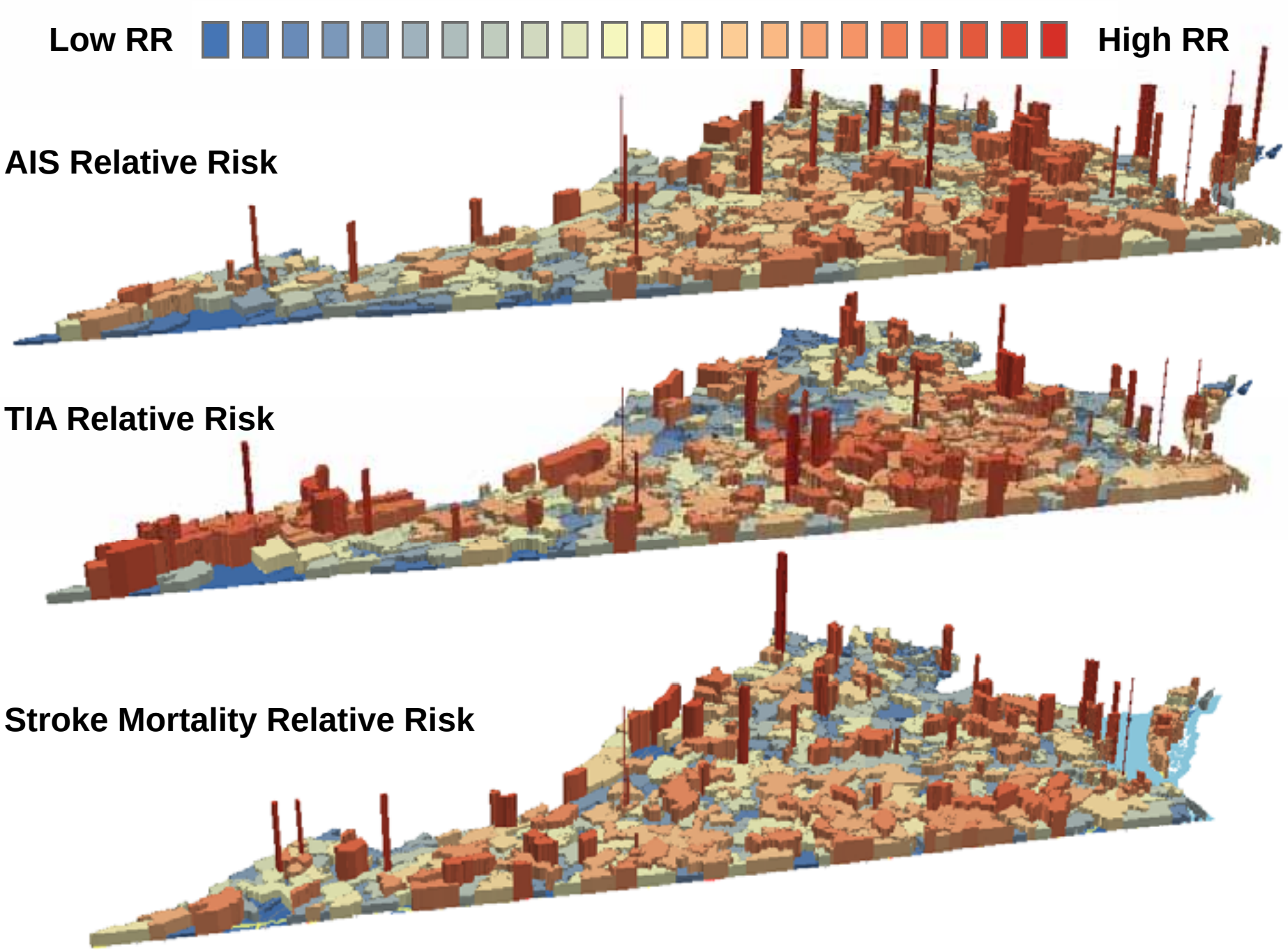
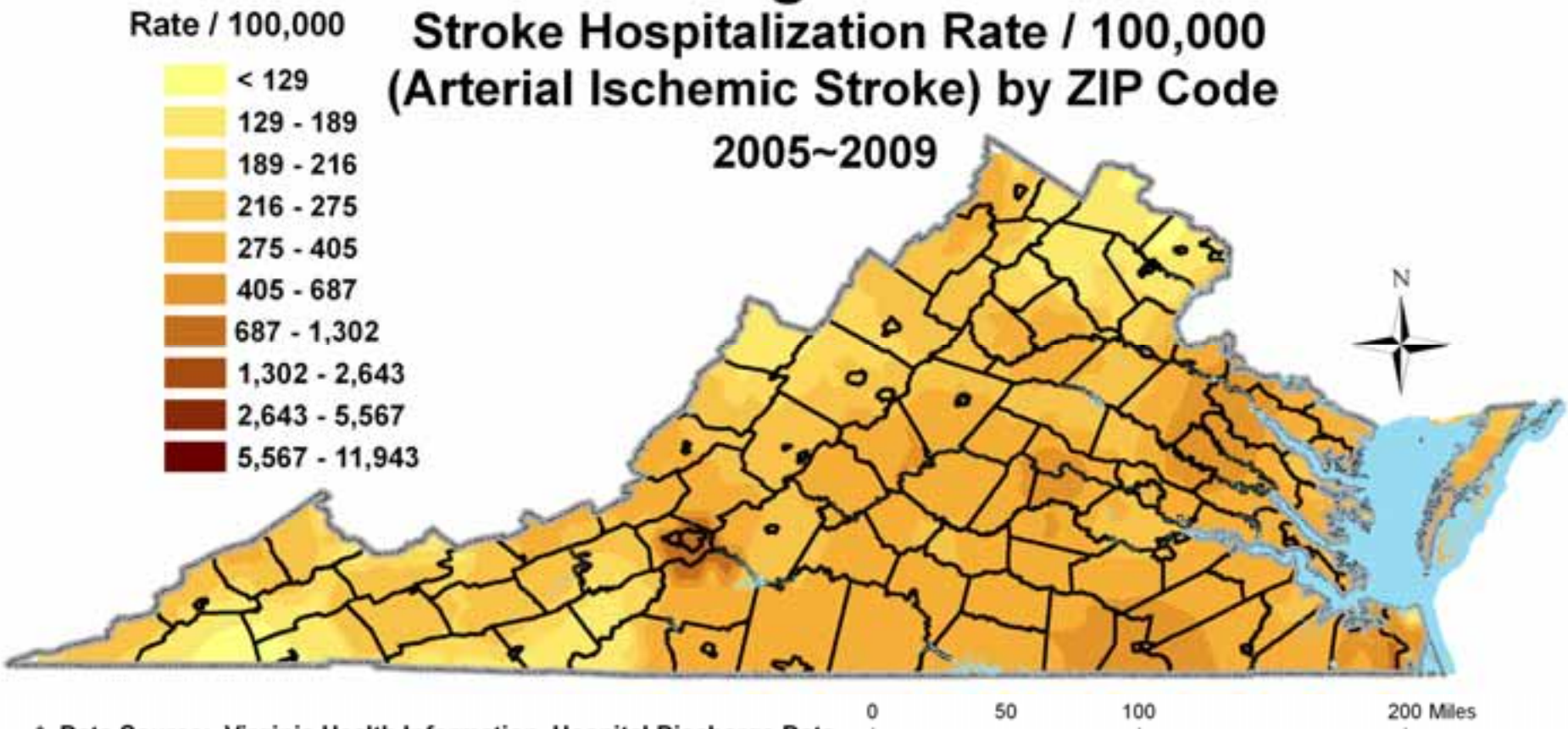

Low RR
High RR
AIS Relative Risk
TIA Relative Risk
Stroke Mortality Relative Risk

Virginia

Stroke Hospitalization Rate / 100,000 (Arterial Ischemic Stroke) by ZIP Code 2005~2009



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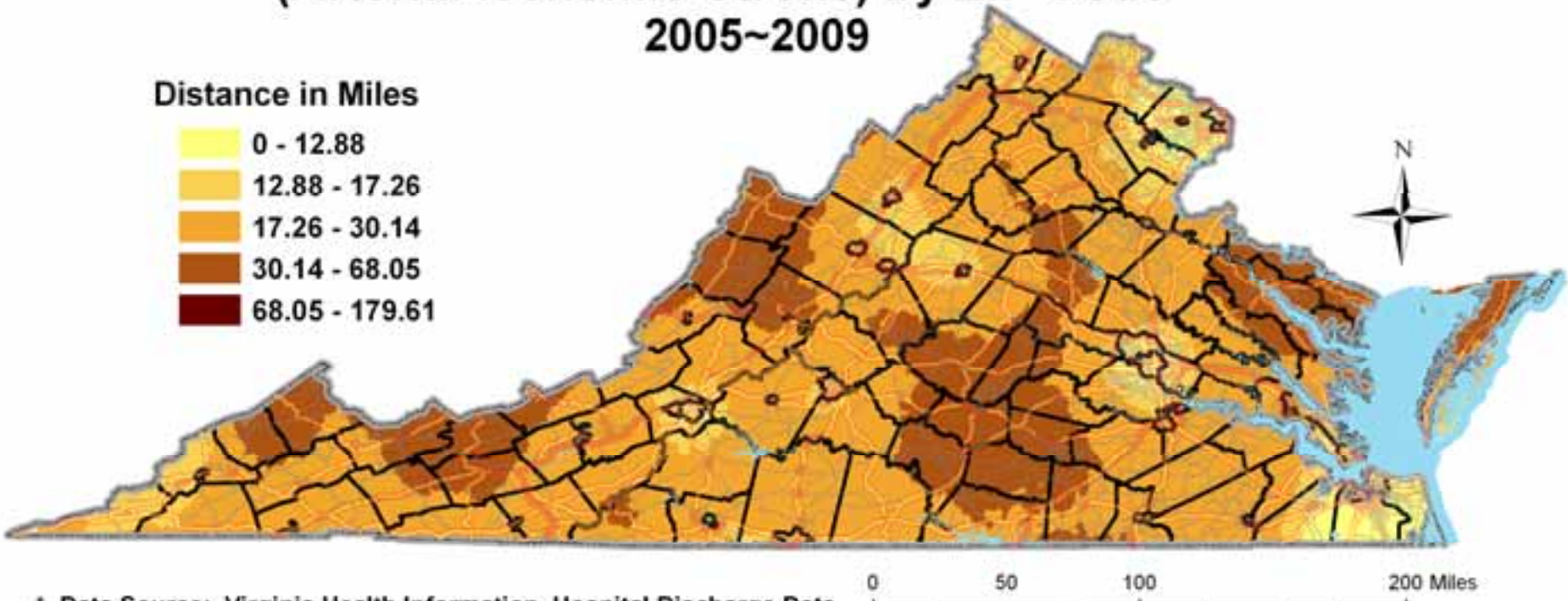
Virginia

Kriging Analysis

Average Distance Travelled for Stroke Hospitalization (Arterial Ischemic Stroke) by ZIP Code

2005~2009



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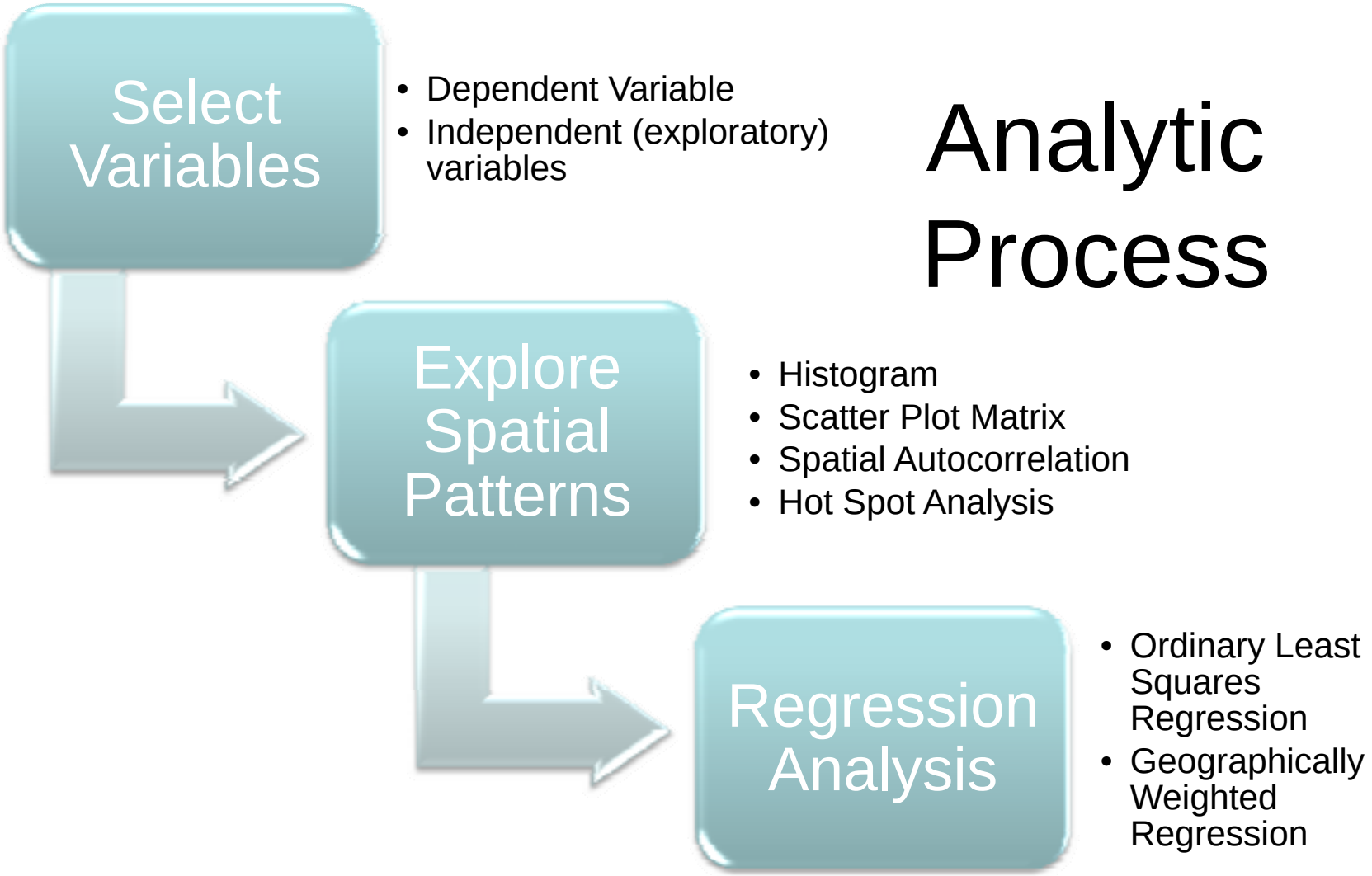
Spatial Analysis

Regression

Analytic Process



- Dependent Variable
- Independent (exploratory) variables

- Histogram
- Scatter Plot Matrix
- Spatial Autocorrelation
- Hot Spot Analysis

- Ordinary Least Squares Regression
- Geographically Weighted Regression

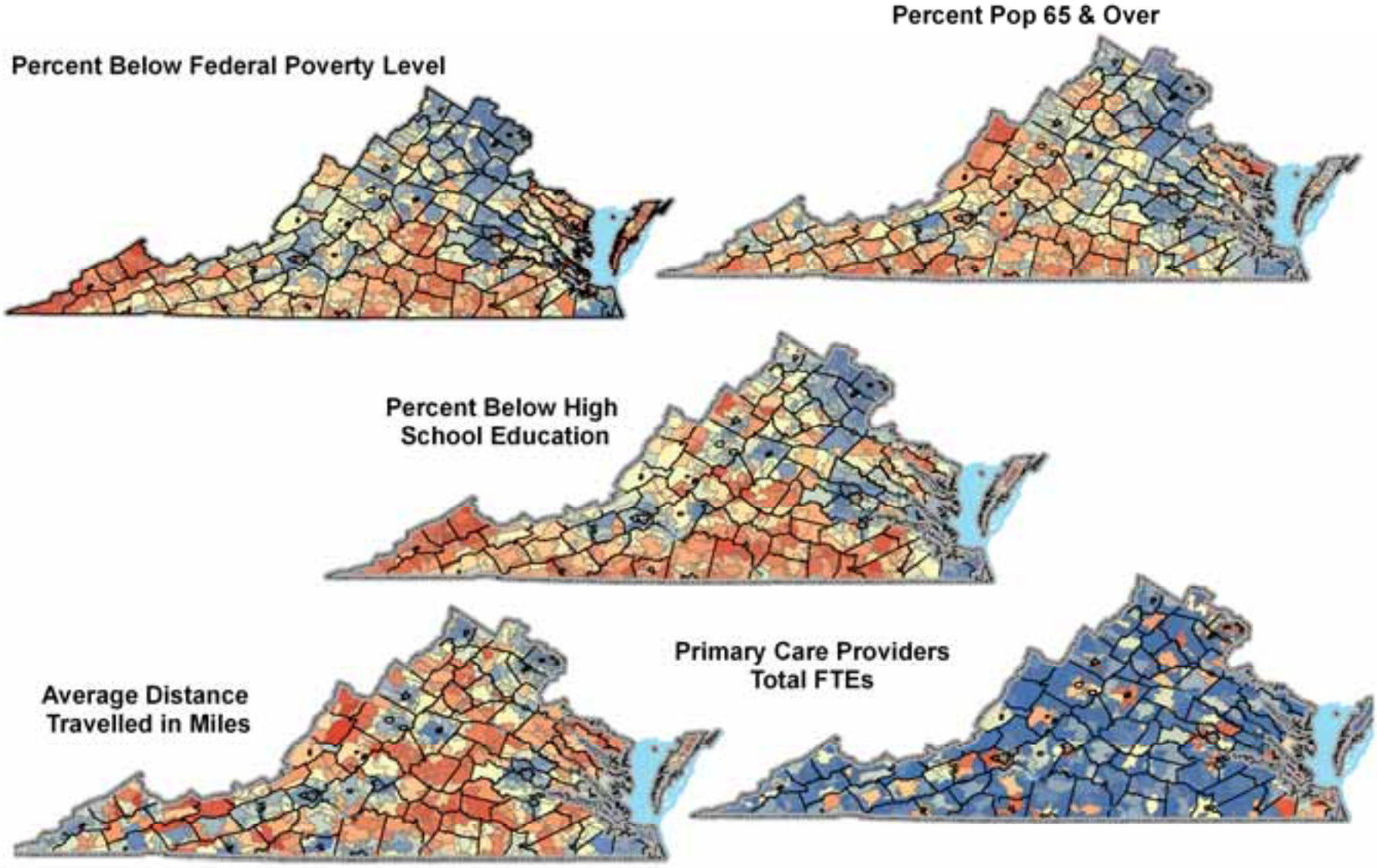
Ordinary Least Squares Regression (OLS)

- Global regression technique
- Single equation to represent overall relationship between variables
- OLS will indicate spatially significant explanatory variables
- Remove non-significant variables, explore other explanatory variables
- Run several iterations of OLS

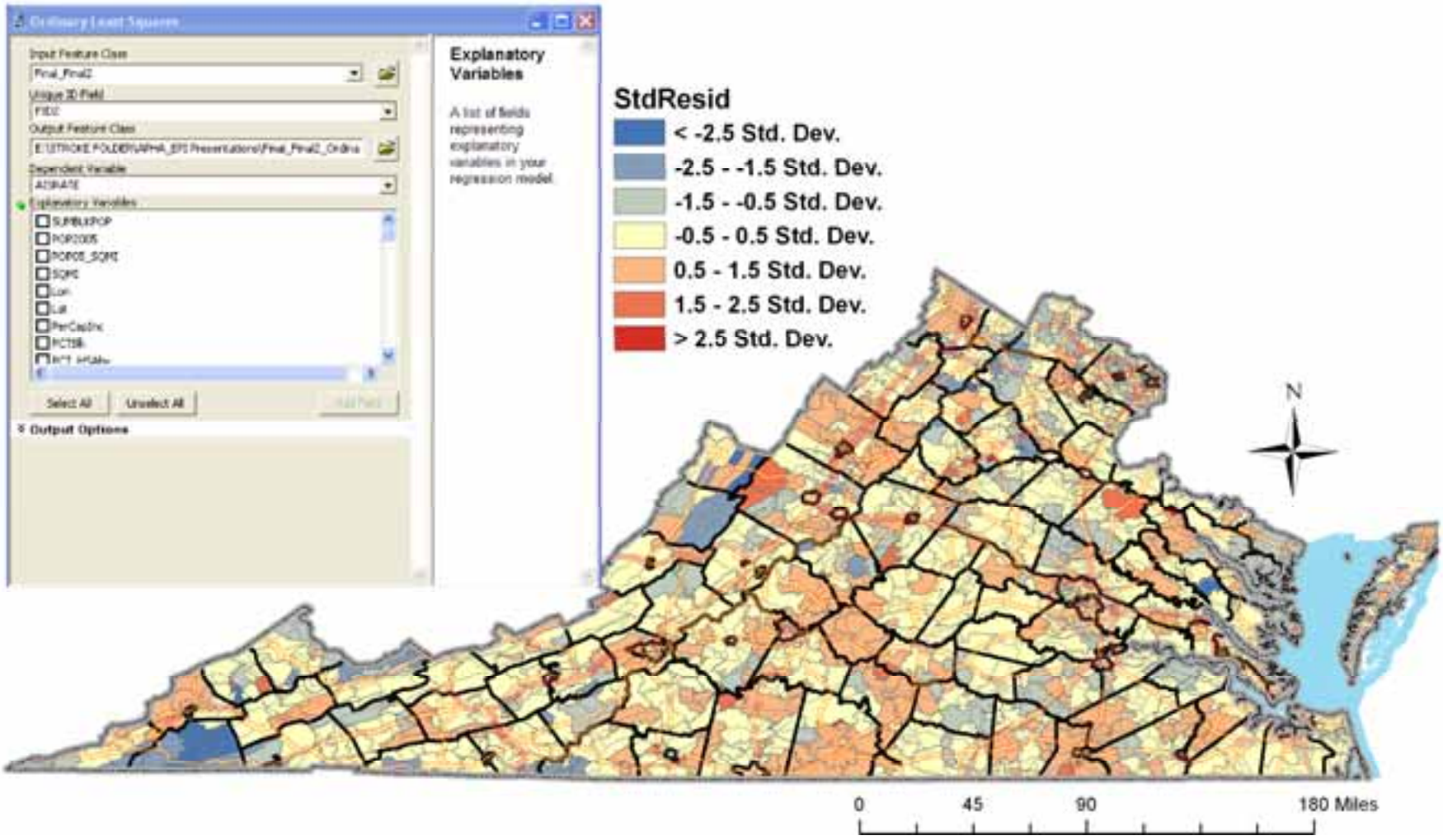
Ordinary Least Squares Regression (OLS)

- Six (6) diagnostic indicators
  - Coefficients have the expected sign
  - Check for redundancy (VIF>7.5)
  - Coefficients are statistical significance
  - Residual are normally distributed
  - AIC & Adjusted R-Squared values
  - Relationships across the area do not vary significantly

Selecting Variables for Spatial Regression.....??????



Using OLS to test hypotheses



Spatial Autocorrelation

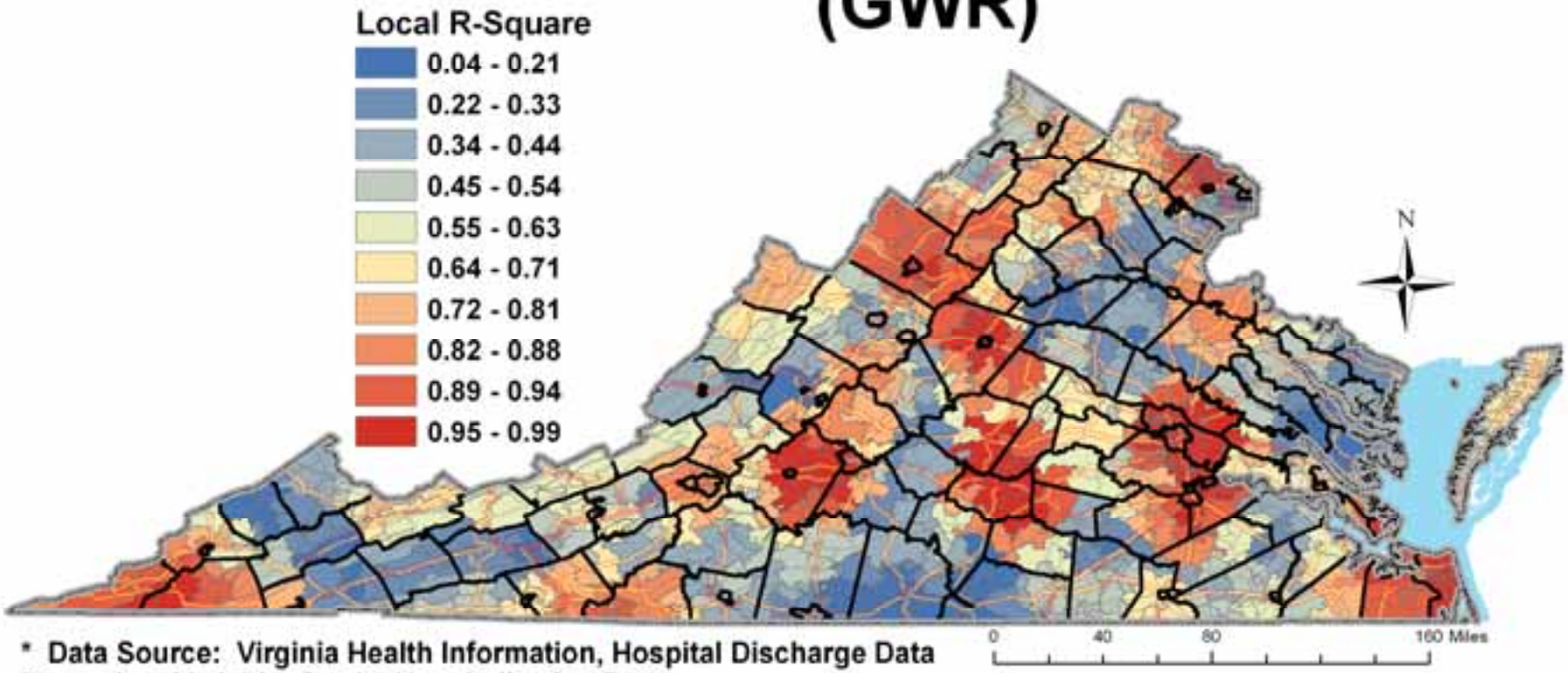
Virginia

Exploring Spatial Variation

Stroke Hospitalization Rate ~ 2005-2009

Geographically Weighted Regression

(GWR)



* Data Source: Virginia Health Information, Hospital Discharge Data

Dependent Variable: Stroke Hospitalization Rate

Independent Variables: PctPoverty, Pct 65 & Over, Average Distance to Care, PCP FTEs, Length of Stay

Spatial Autocorrelation

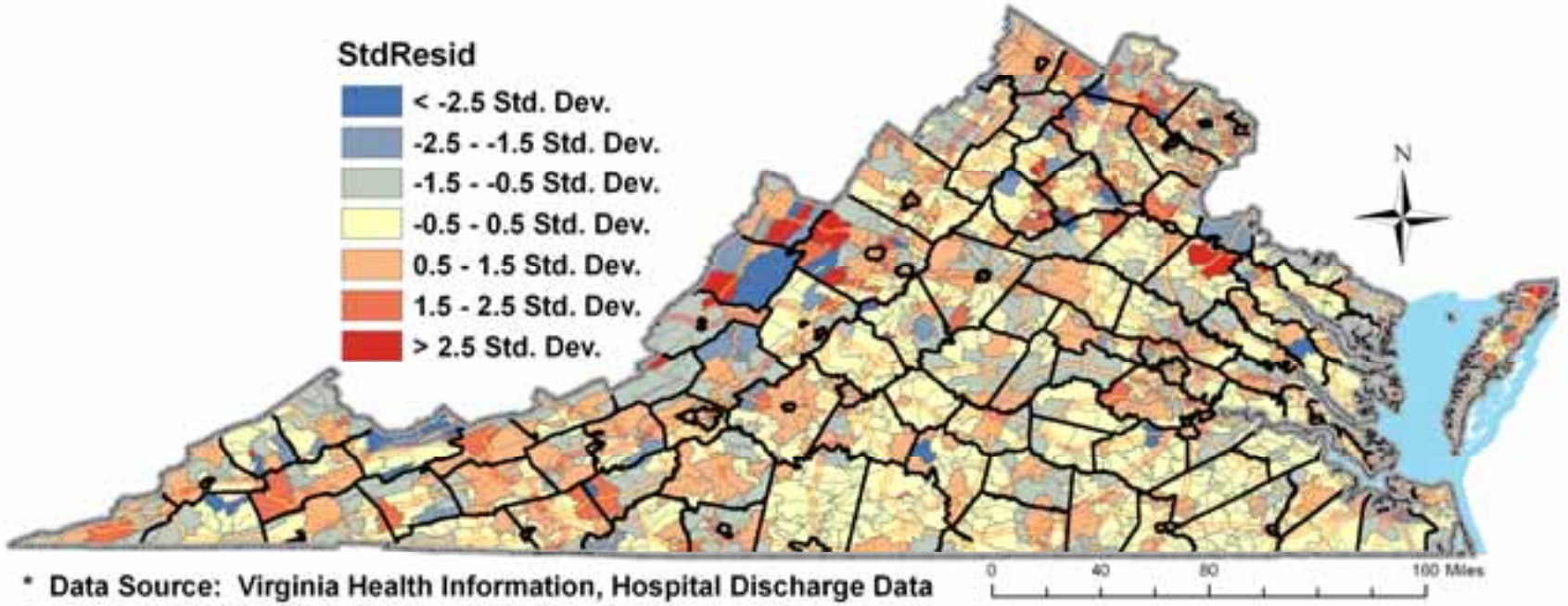
Virginia

Exploring Spatial Variation

Stroke Hospitalization Rate ~ 2005-2009

Geographically Weighted Regression

(GWR Residual)



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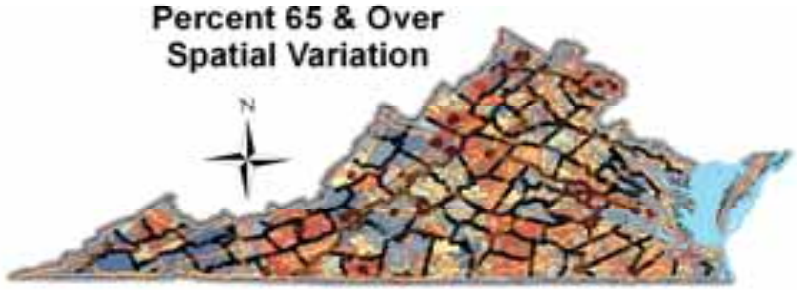
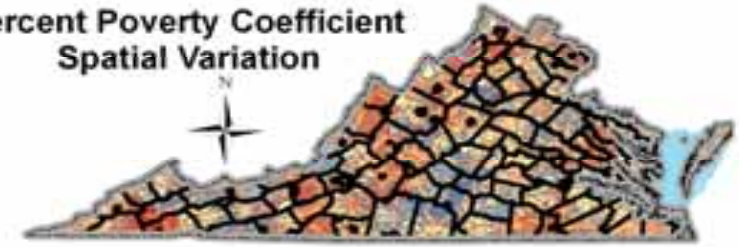
Percent 65 & Over
Spatial Variation



Average Distance Coefficient
Spatial Variation

Modeled Relationship Across the Study Area

Percent Poverty Coefficient
Spatial Variation



Average Length of Stay Cooefficient
Spatial Variation

Total Primary Care Providers Total FTEs Coefficient
Spatial Variation

Contact Information:

- Steve Sedlock
  ssedlock@vnghr.org

Virginia Network for Geospatial Health Research, Inc.
PO Box 15818
Richmond, VA 23227
804.264.3325