A Spatio-temporal Analysis of Obesity and Poverty in the United States

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The findings and conclusions in this presentation are those of the authors and do not necessarily represent the views of the Centers for Disease Control and Prevention.

Purpose of Presentation

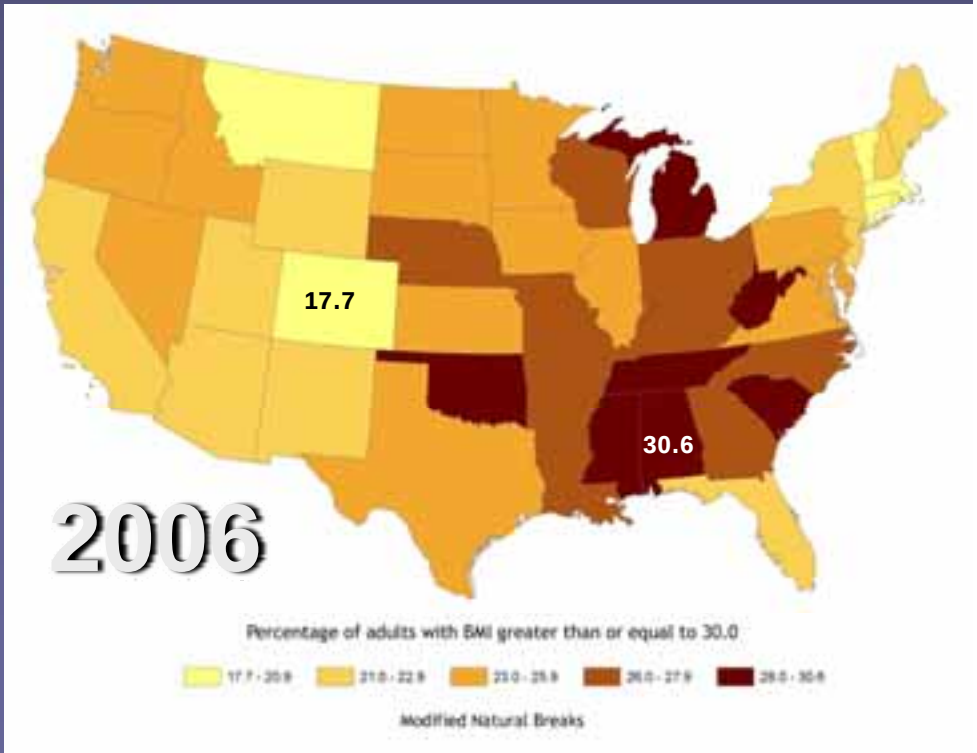
- Explore the spatio-temporal relationships between obesity and a key risk factor: poverty
- Illustrate Exploratory Spatial Data Analysis (ESDA) tools available in ArcGIS and GeoDa

Order of Presentation

- Obesity Prevalence and Trends
- Poverty as a Risk Factor for Obesity
- Poverty Prevalence and Trends
- Research Question
- Quantitative Methods and Results
- Discussion

Obesity* Prevalence

- Major public health concern
  - Poor nutrition and physical inactivity, which together were the second leading actual cause of death (after smoking) in 2000**
- In 2006, median state obesity prevalence*** = 24.7%
- BRFSS
  - State data
  - Self report
  - Non-institutionalized adults age 18+



*Body Mass Index => 30.0

**Mokdad et al, 2004. *JAMA* 291 (10): 1238-1245.
Mokdad et al, 2005. *JAMA* 293 (3): 293-294.

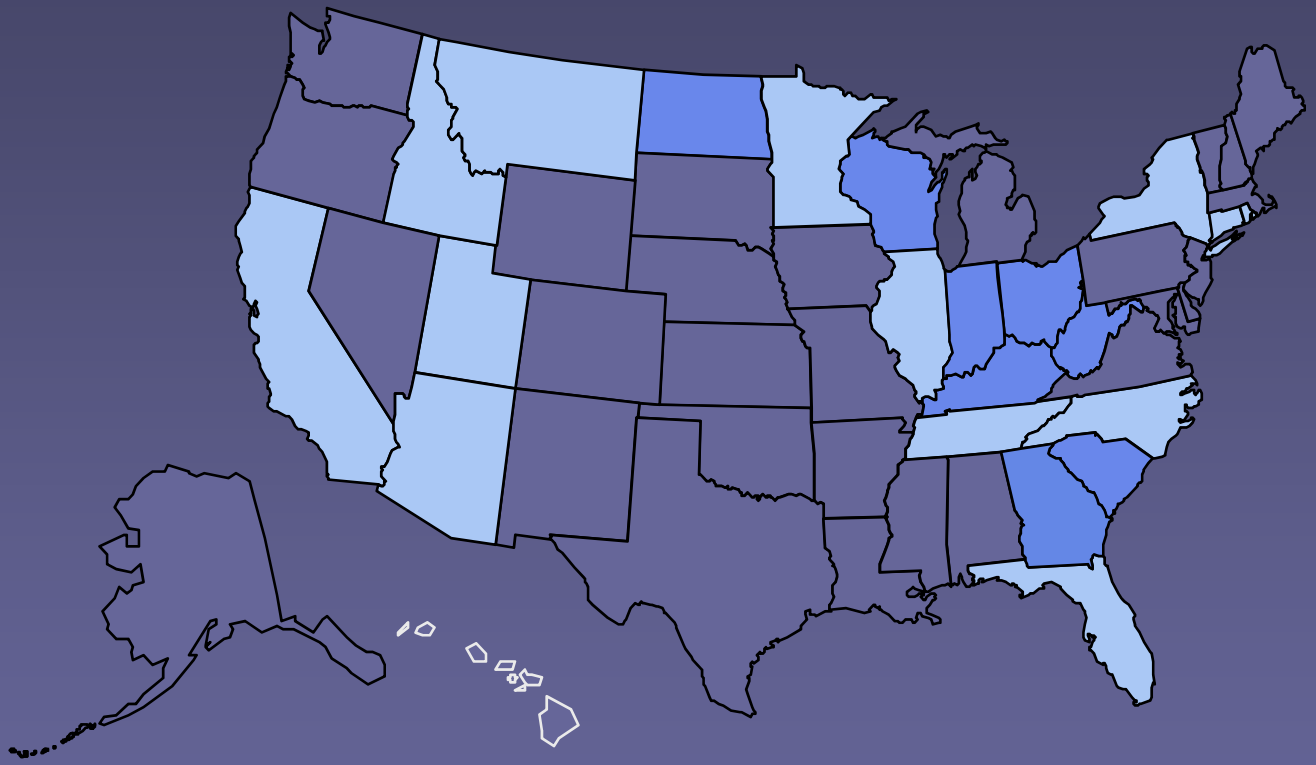
**Source: Behavioral Risk Factor Surveillance System

Obesity Trends

- 1996 median state obesity prevalence = 16.0
- 2001 median state obesity prevalence = 20.1
- 2006 median state obesity prevalence = 24.7
- In 10 years, an **8.7** percentage point increase; almost one percentage point increase *per year*
- Spatial patterns in obesity rates have been noted for some time…

Obesity Trends Among U.S. Adults

BRFSS, 1985



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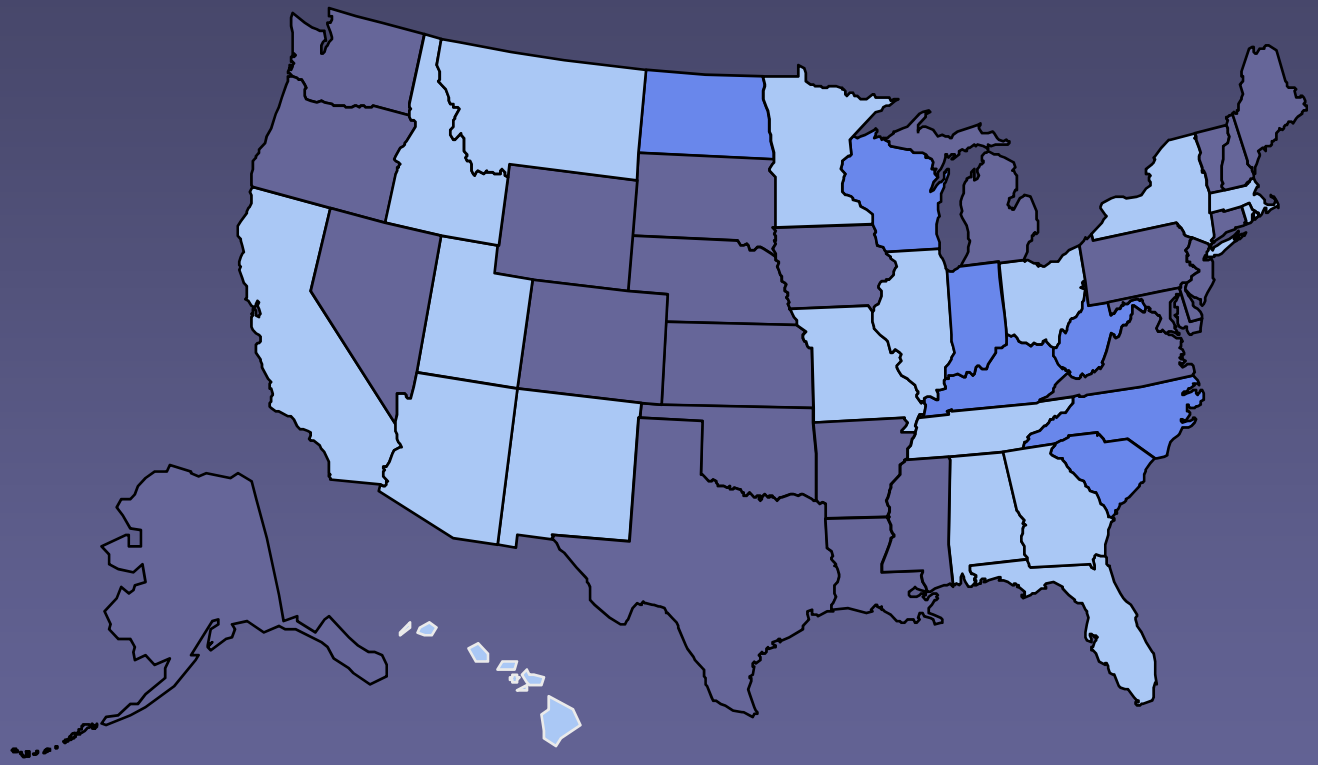
Source: Behavioral Risk Factor Surveillance System, CDC.

Obesity Trends Among U.S. Adults

BRFSS, 1986



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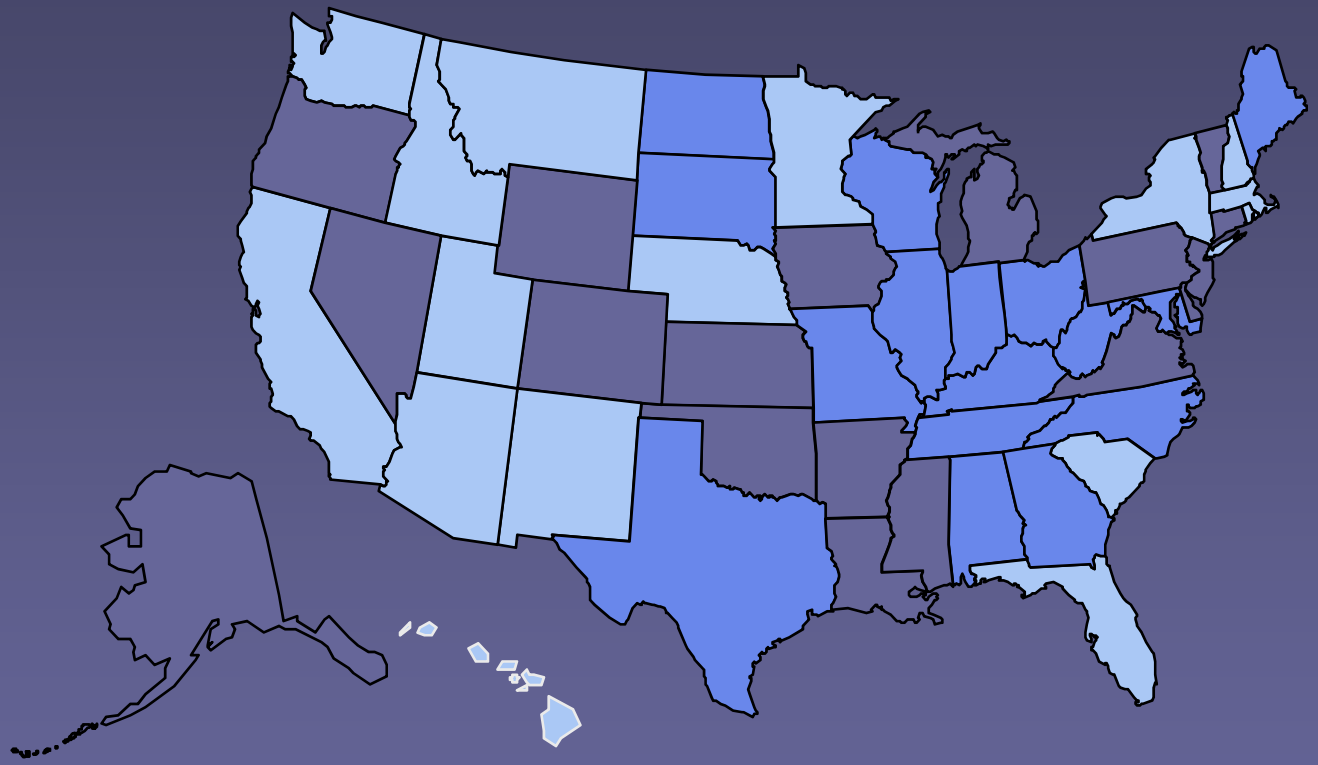
Source: Behavioral Risk Factor Surveillance System, CDC.

Obesity Trends Among U.S. Adults

BRFSS, 1987



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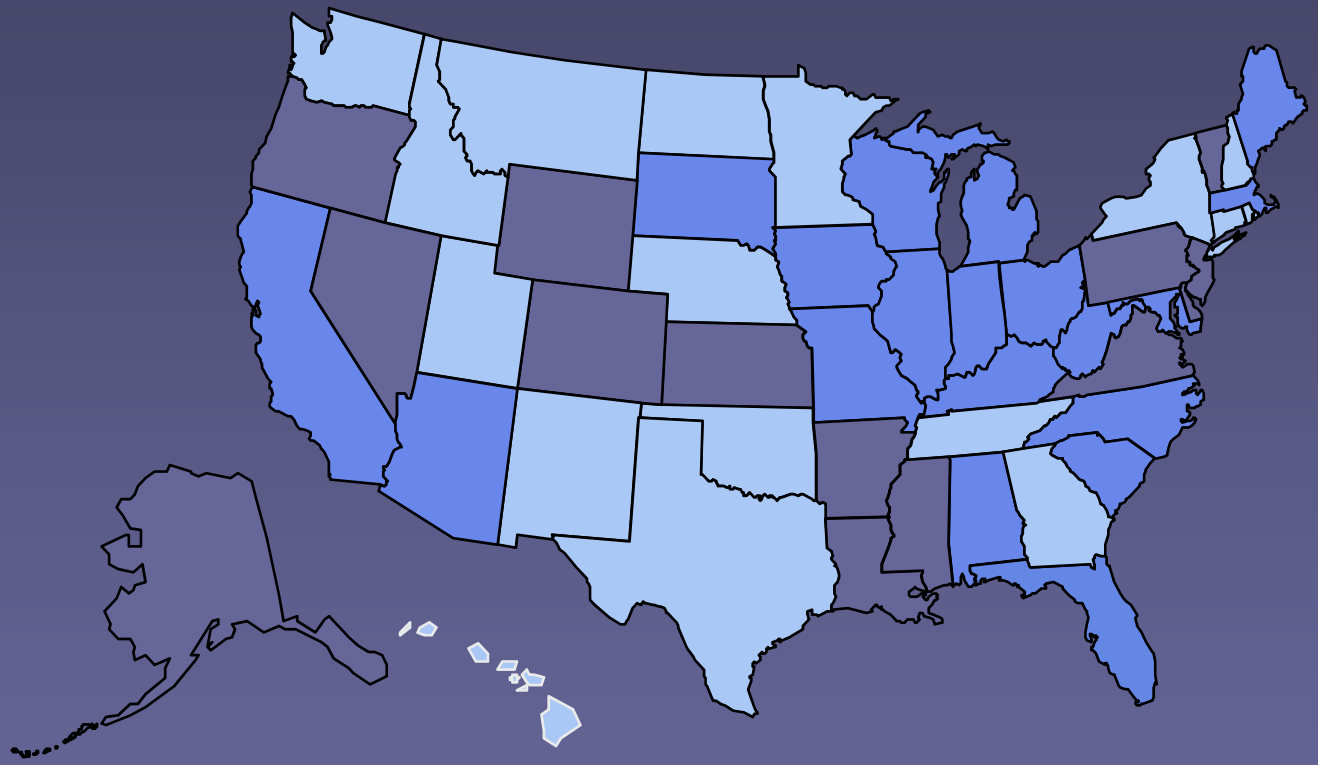
Source: Behavioral Risk Factor Surveillance System, CDC.

Obesity Trends Among U.S. Adults

BRFSS, 1988



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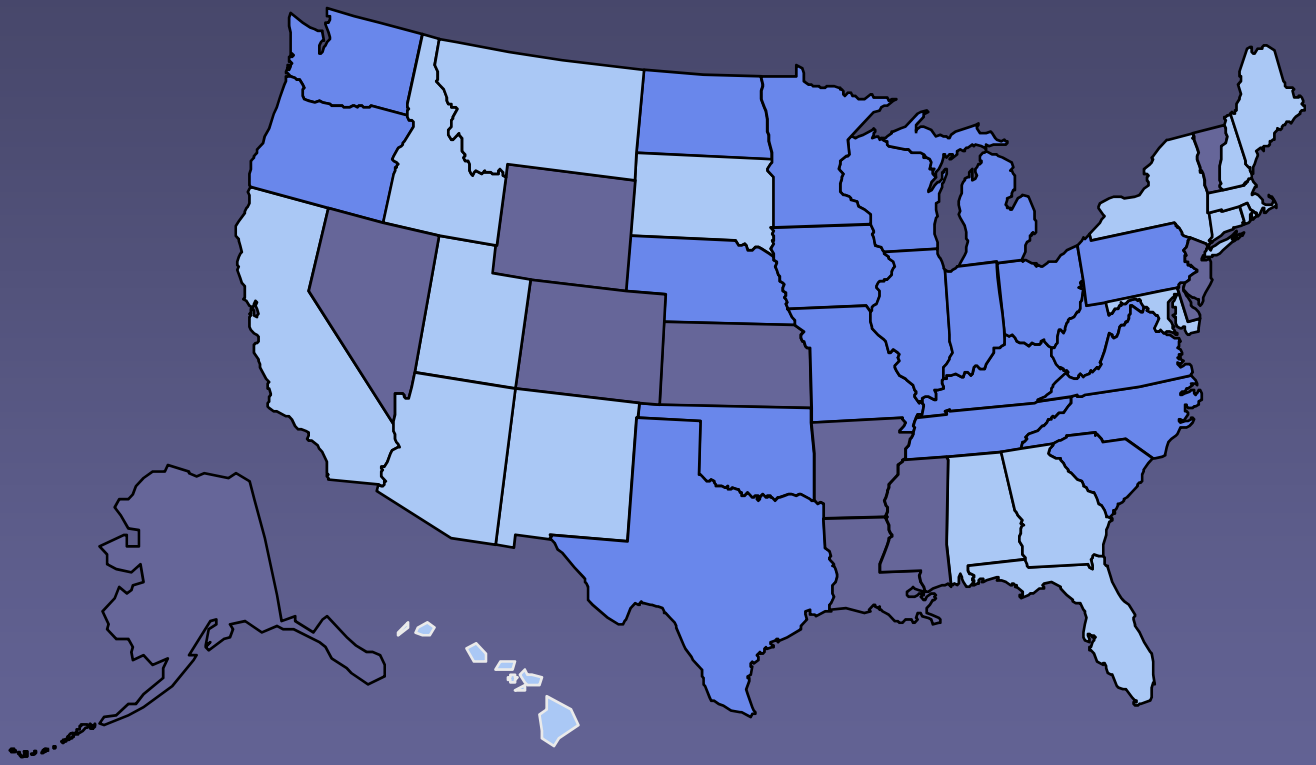
Source: Behavioral Risk Factor Surveillance System, CDC.

Obesity Trends Among U.S. Adults

BRFSS, 1989



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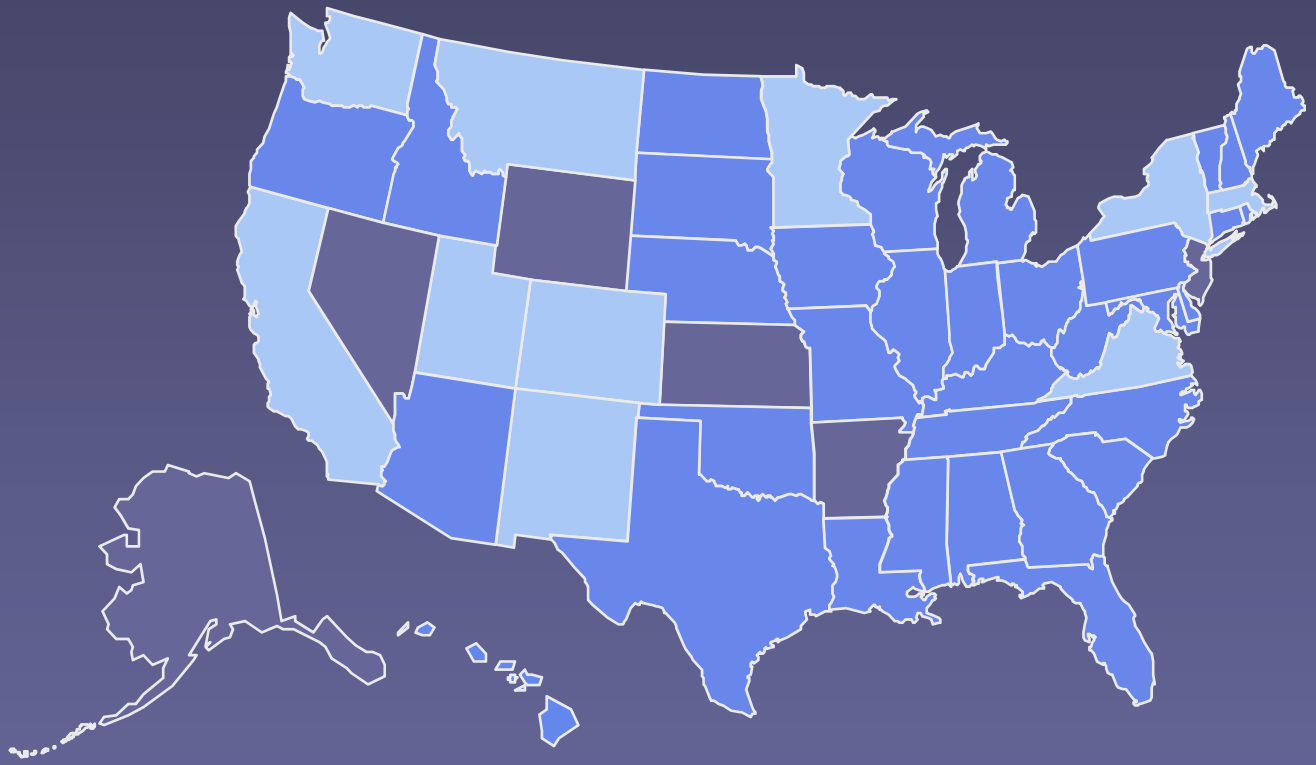
Source: Behavioral Risk Factor Surveillance System, CDC.

Obesity Trends Among U.S. Adults

BRFSS, 1990



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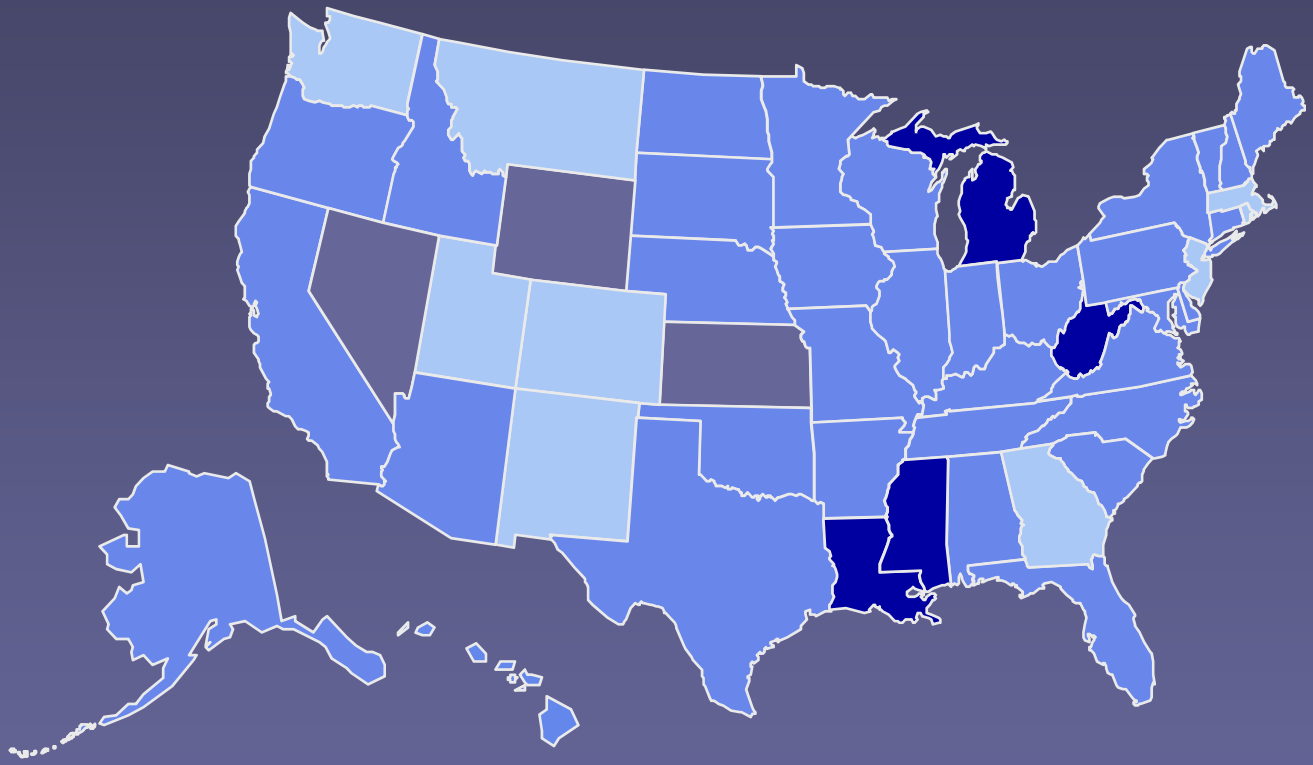
Obesity Trends Among U.S. Adults

BRFSS, 1991



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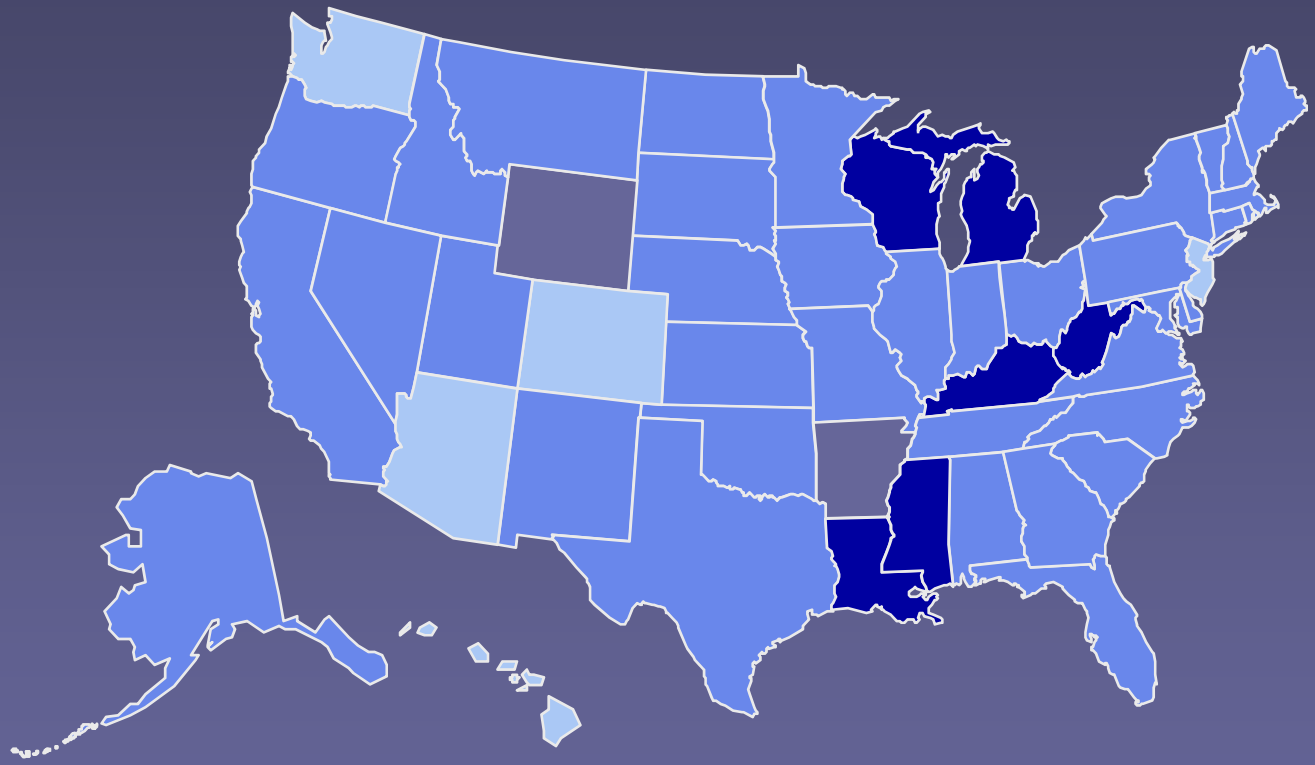
Obesity Trends Among U.S. Adults

BRFSS, 1992



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Obesity Trends Among U.S. Adults

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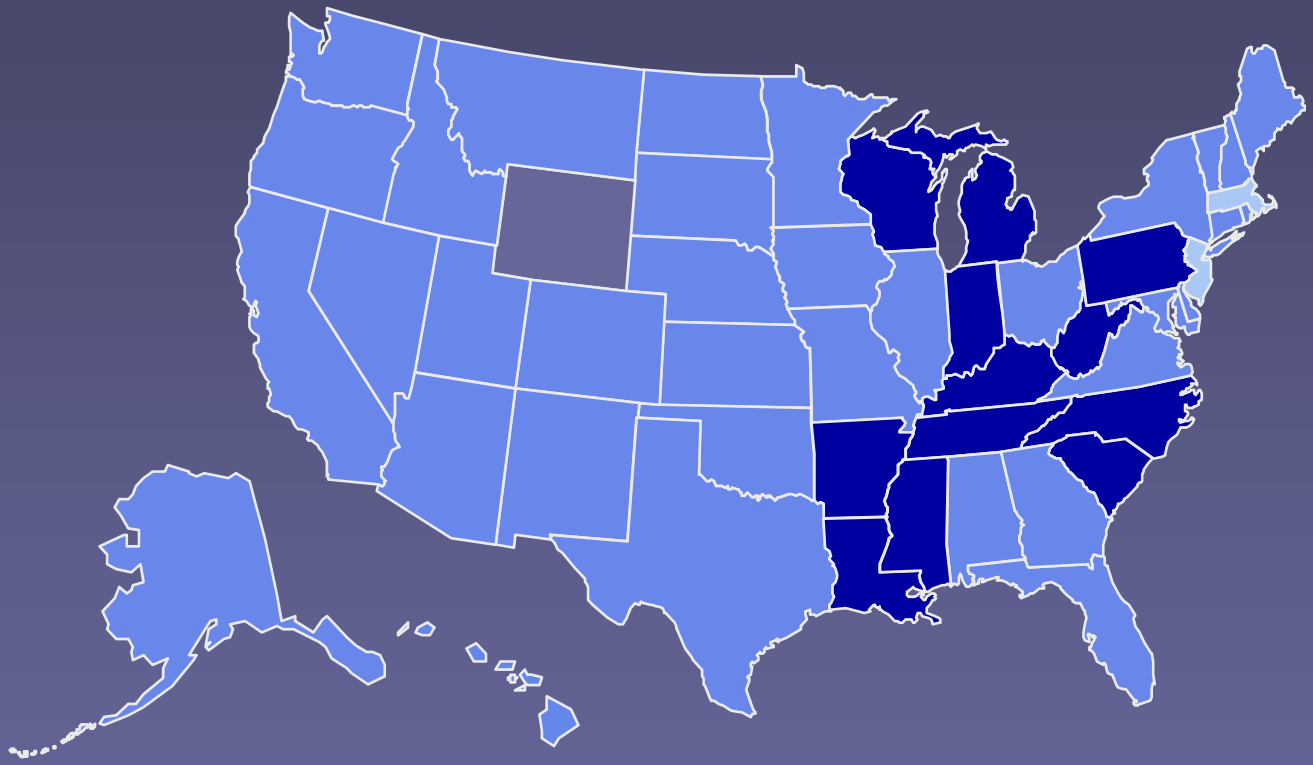

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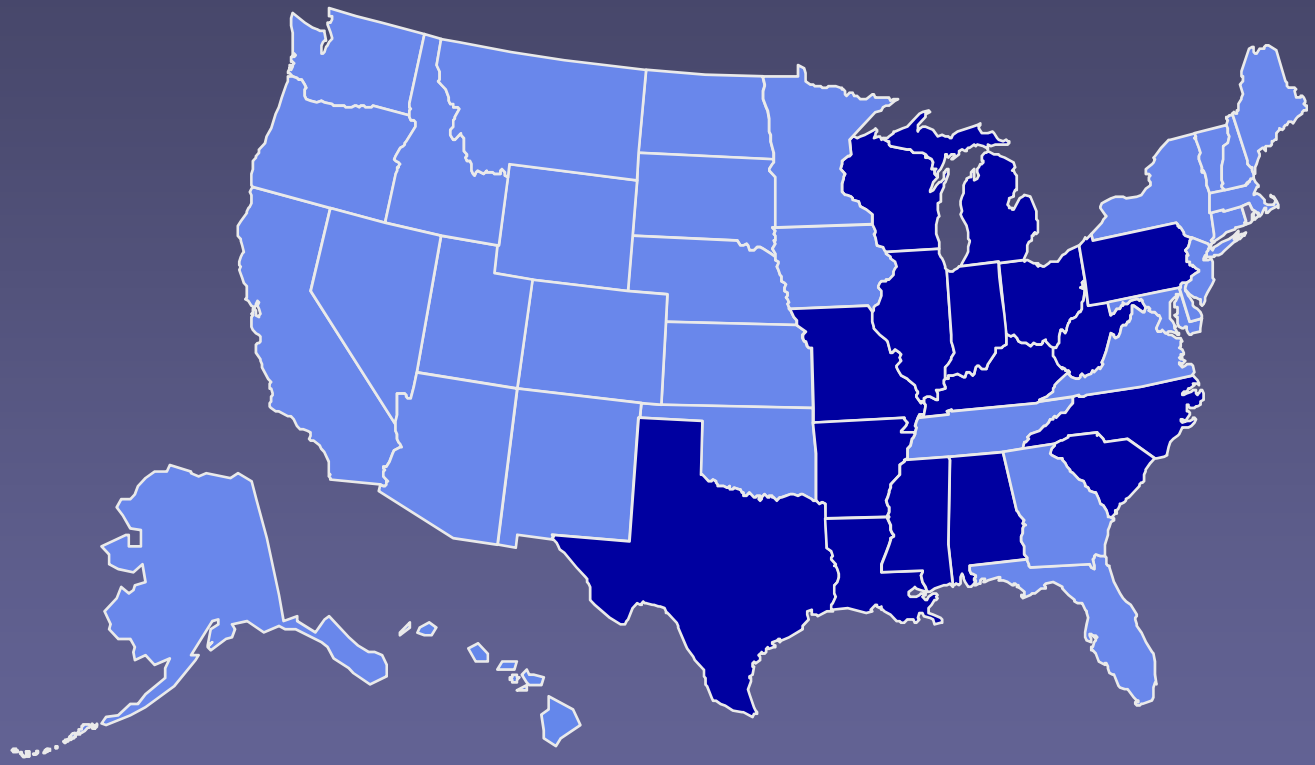
Source: Behavioral Risk Factor Surveillance System, CDC.

Obesity Trends Among U.S. Adults

BRFSS, 1994



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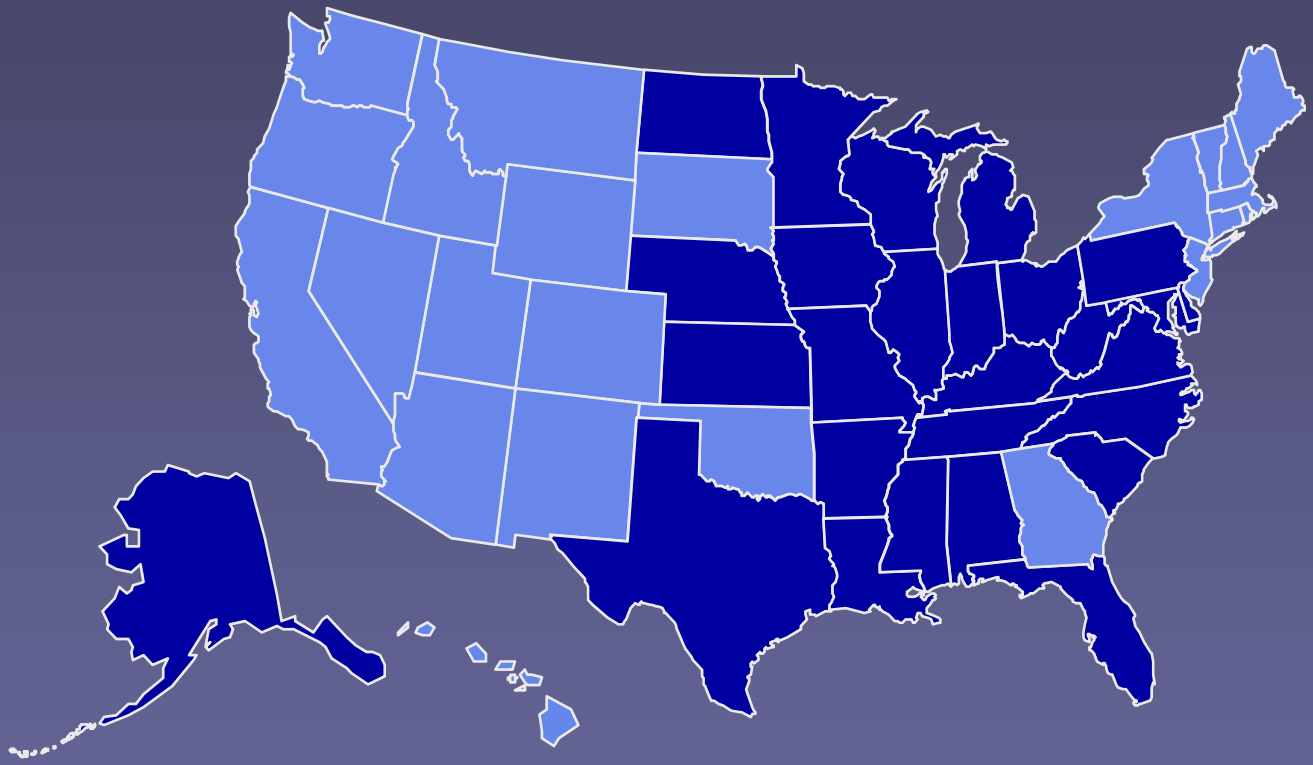
Source: Behavioral Risk Factor Surveillance System, CDC.

Obesity Trends Among U.S. Adults

BRFSS, 1995



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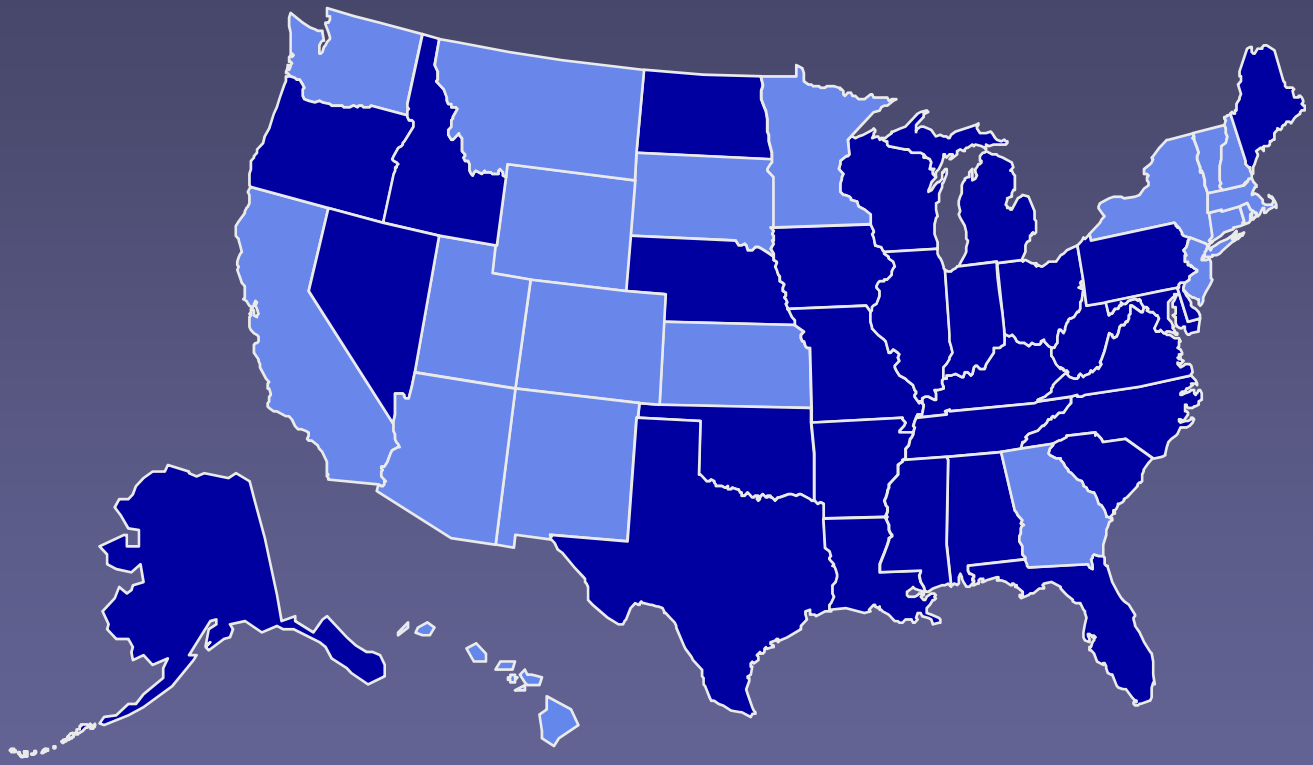
Source: Behavioral Risk Factor Surveillance System, CDC.

Obesity Trends Among U.S. Adults

BRFSS, 1996



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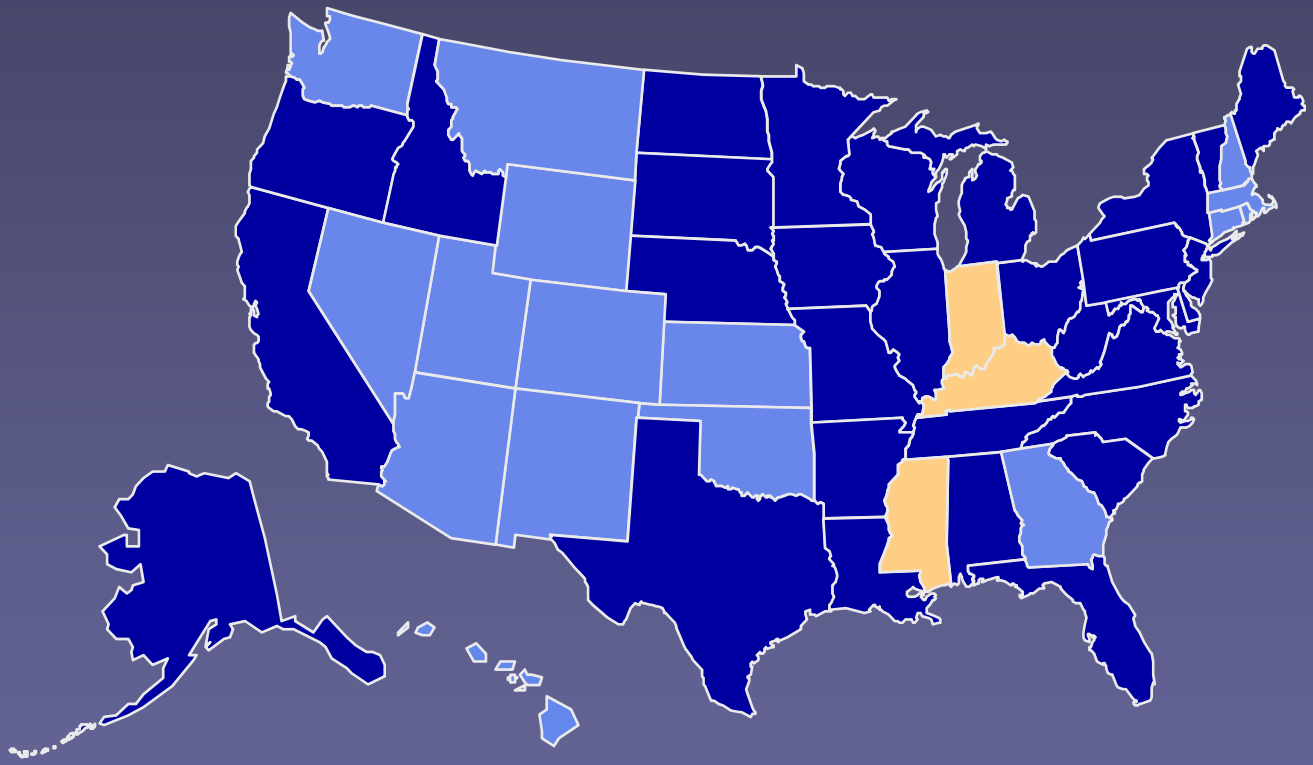
Source: Behavioral Risk Factor Surveillance System, CDC.

Obesity Trends Among U.S. Adults

BRFSS, 1997

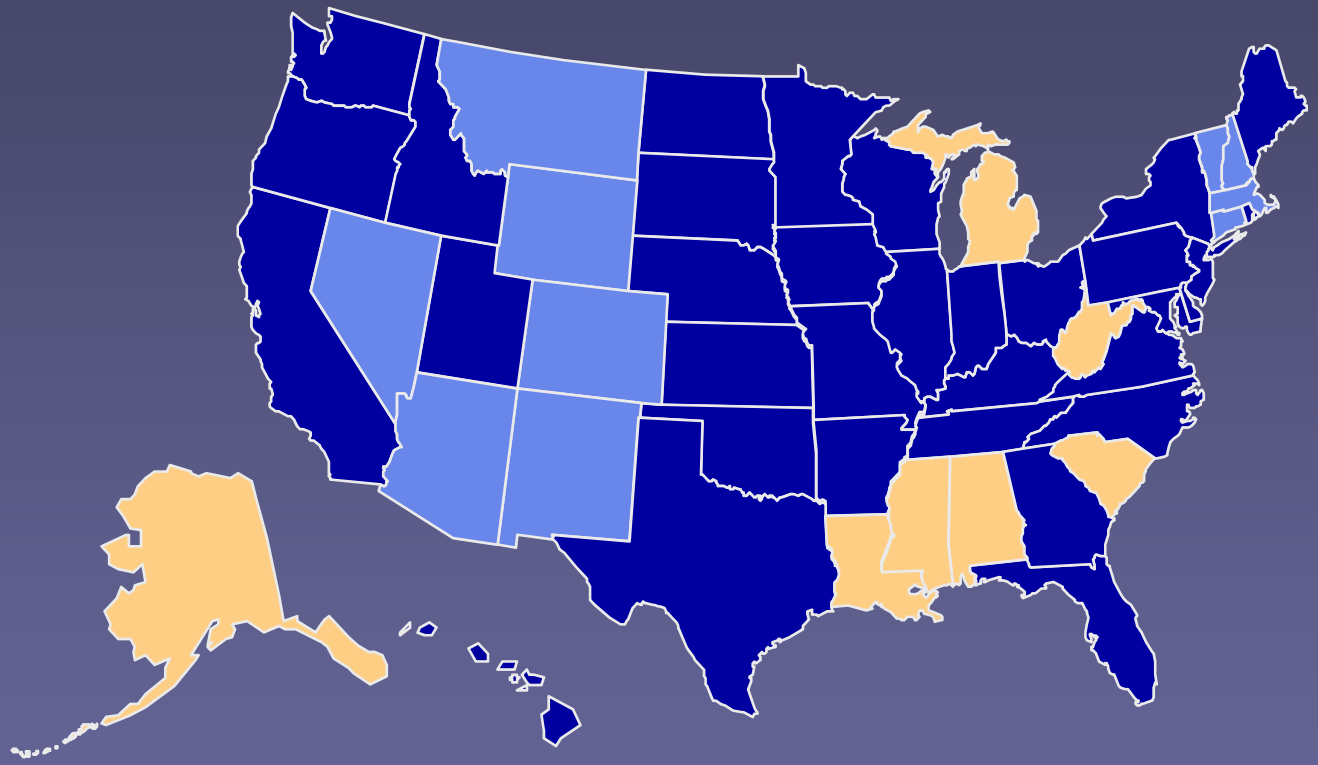


No Data | <10% | 10%–14% | 15%–19% | ≥20

Source: Behavioral Risk Factor Surveillance System, CDC.

Obesity Trends Among U.S. Adults

BRFSS, 1998



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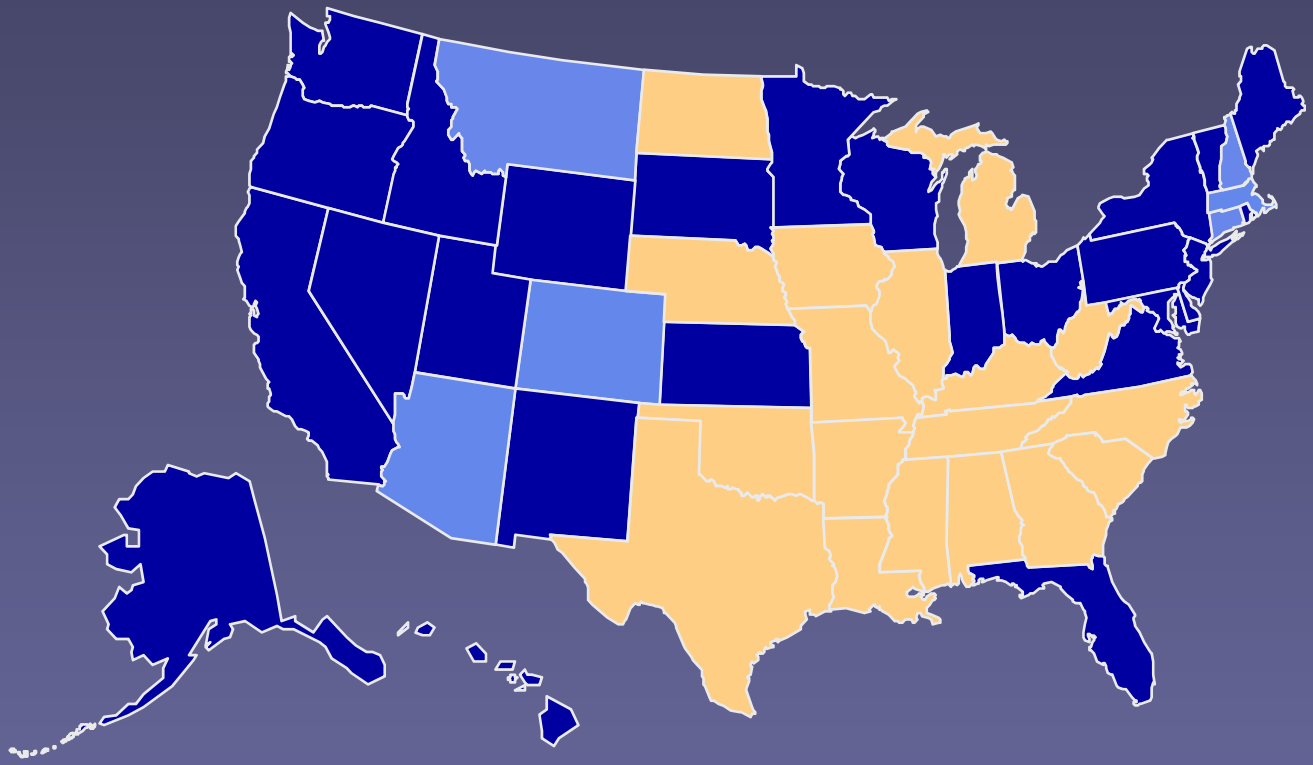
Source: Behavioral Risk Factor Surveillance System, CDC.

Obesity Trends Among U.S. Adults

BRFSS, 1999



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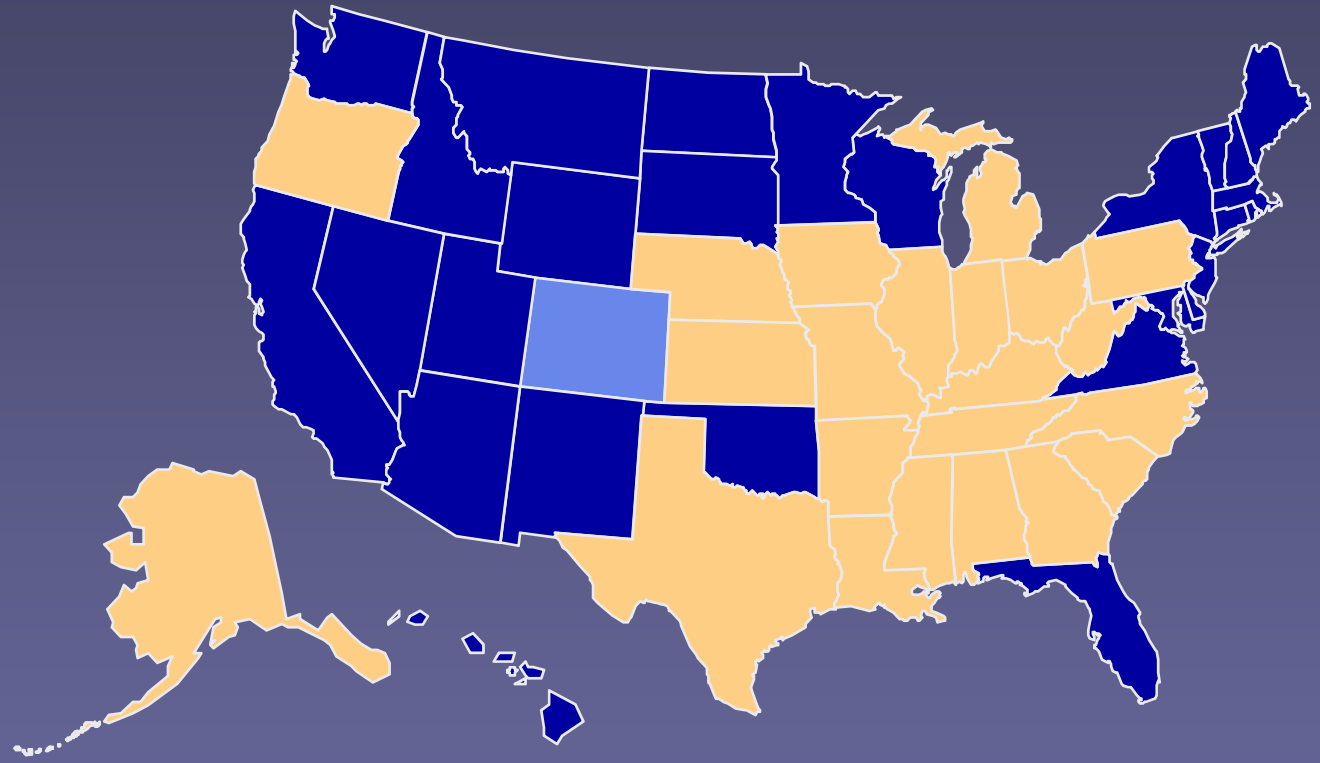
Source: Behavioral Risk Factor Surveillance System, CDC.

Obesity Trends Among U.S. Adults

BRFSS, 2000



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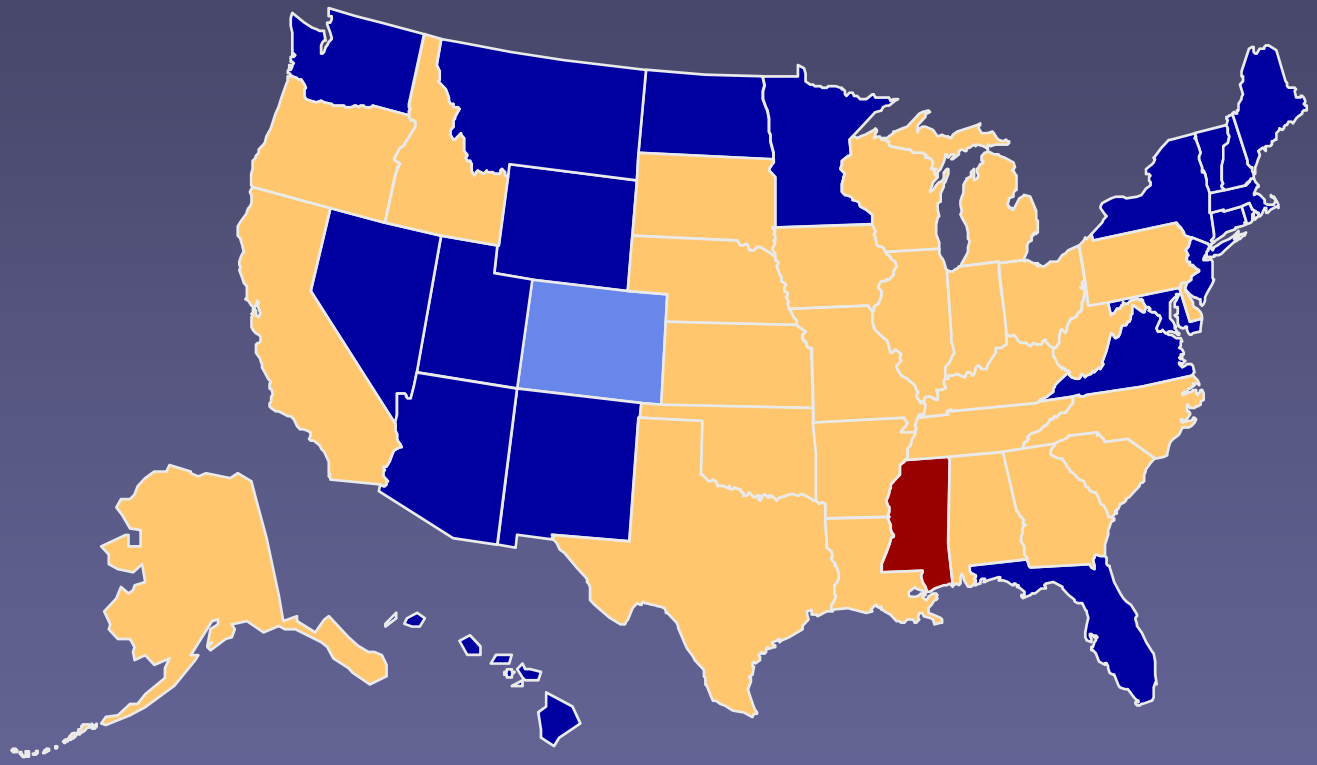
Source: Behavioral Risk Factor Surveillance System, CDC.

Obesity Trends Among U.S. Adults

BRFSS, 2001

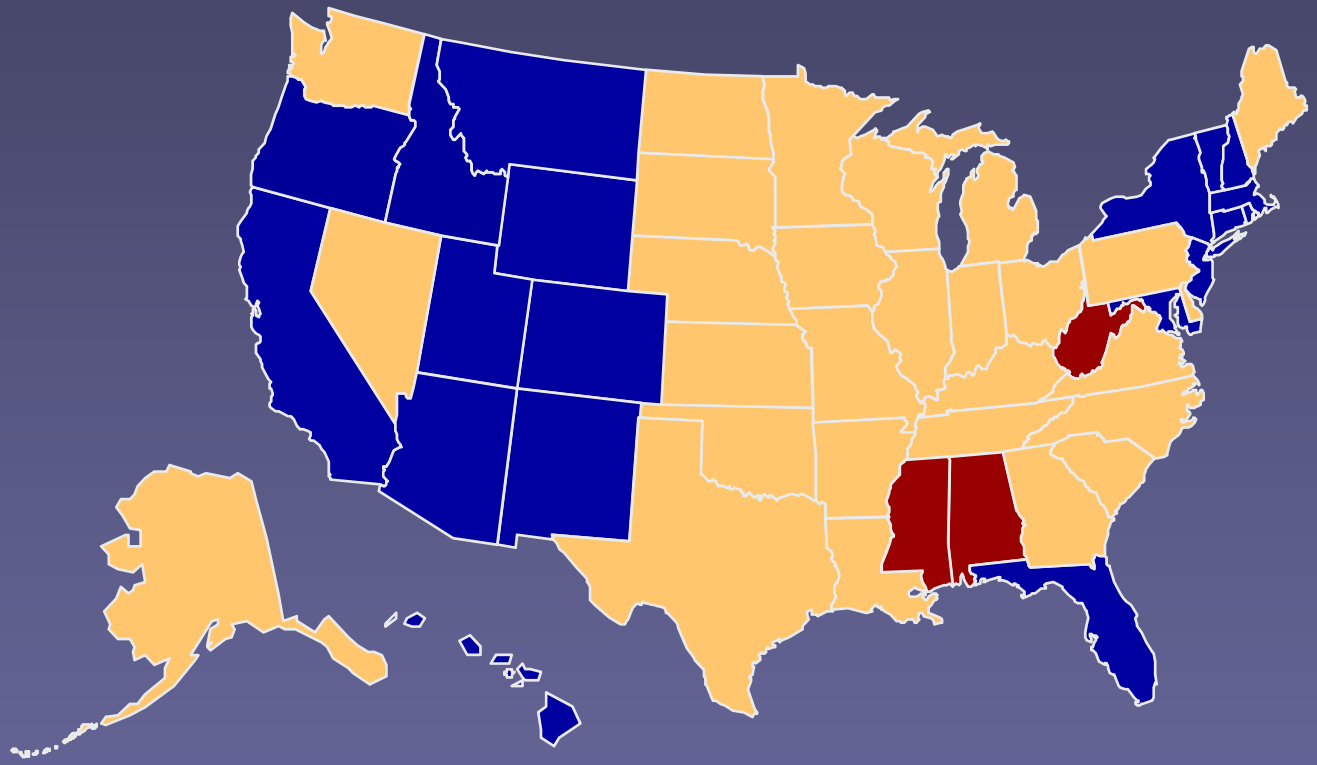


No Data | <10% | 10%–14% | 15%–19% | 20%–24% | ≥25%

Source: Behavioral Risk Factor Surveillance System, CDC.

Obesity Trends Among U.S. Adults

BRFSS, 2002

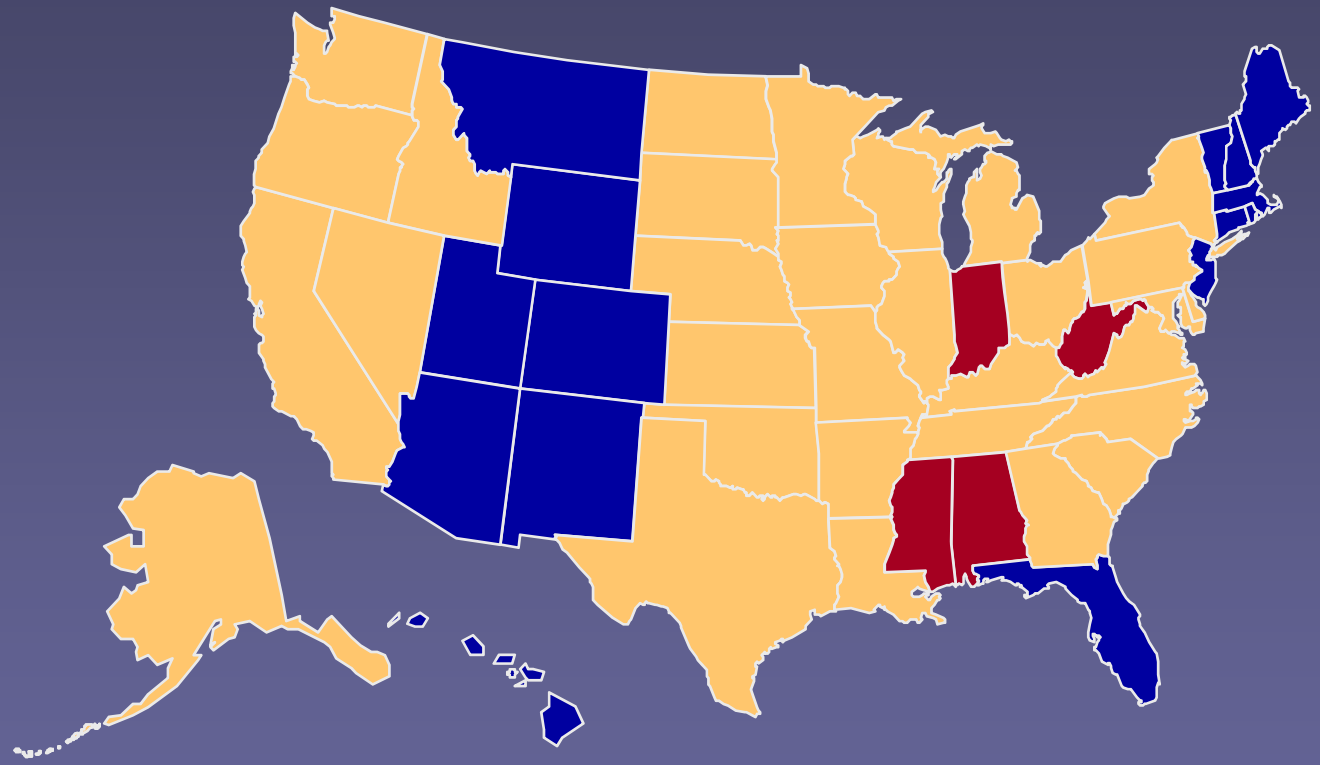


No Data | <10% | 10%–14% | 15%–19% | 20%–24% | ≥25%

Source: Behavioral Risk Factor Surveillance System, CDC.

Obesity Trends Among U.S. Adults

BRFSS, 2003

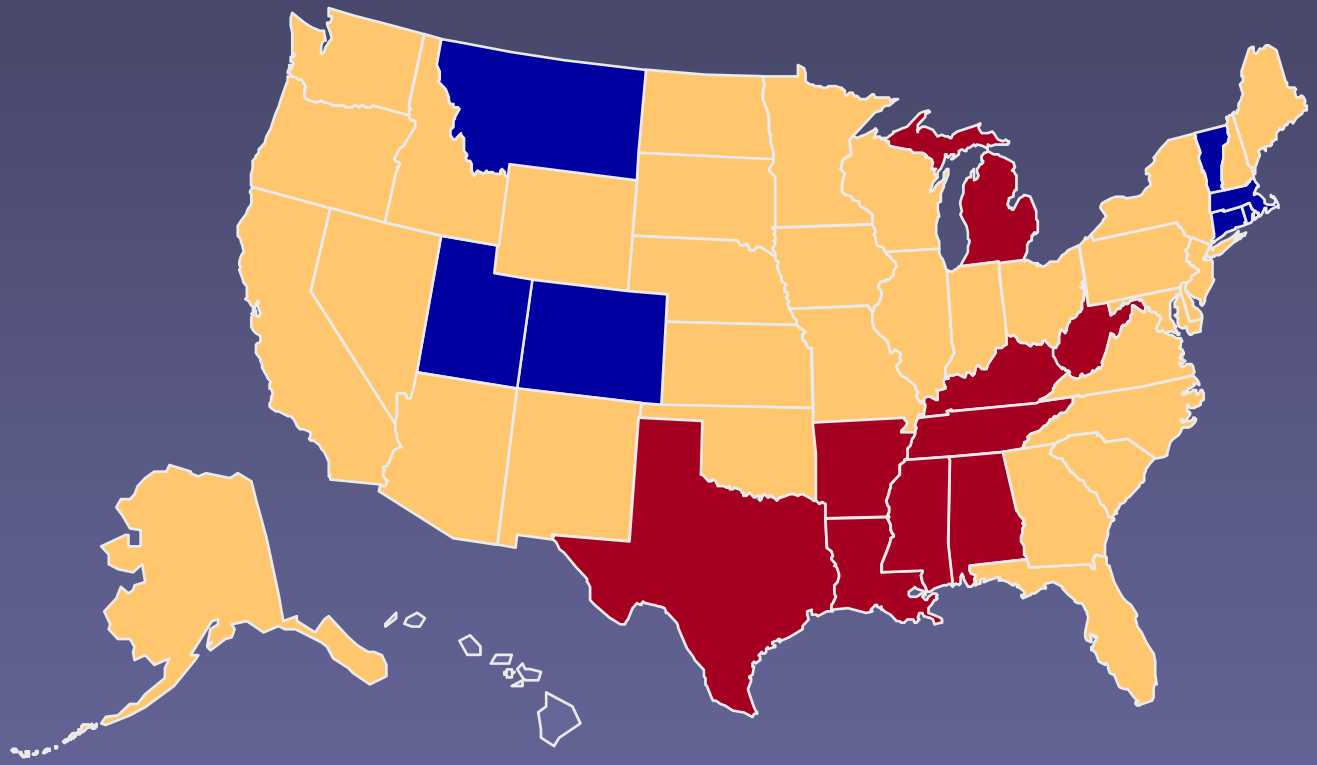


No Data | <10% | 10%–14% | 15%–19% | 20%–24% | ≥25%

Source: Behavioral Risk Factor Surveillance System, CDC.

Obesity Trends Among U.S. Adults

BRFSS, 2004

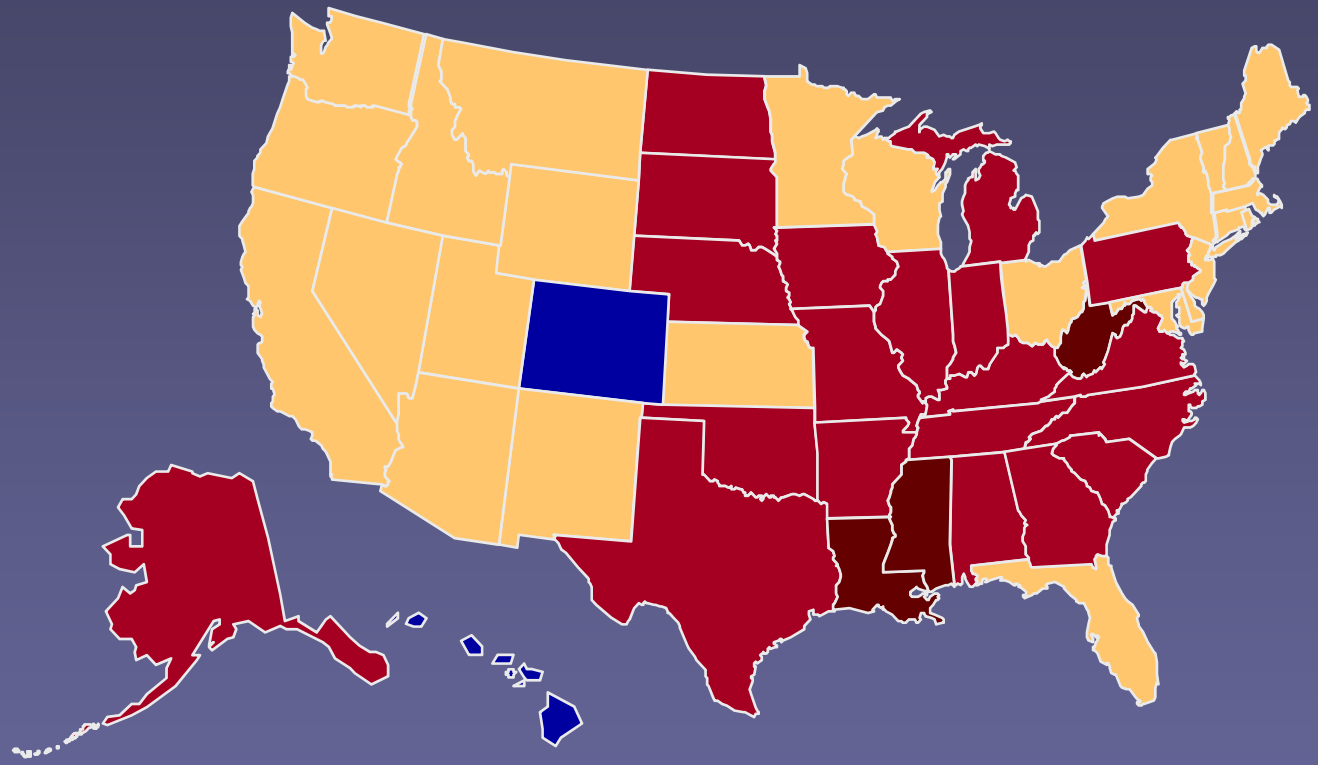


No Data | <10% | 10%–14% | 15%–19% | 20%–24% | ≥25%

Source: Behavioral Risk Factor Surveillance System, CDC.

Obesity Trends Among U.S. Adults

BRFSS, 2005

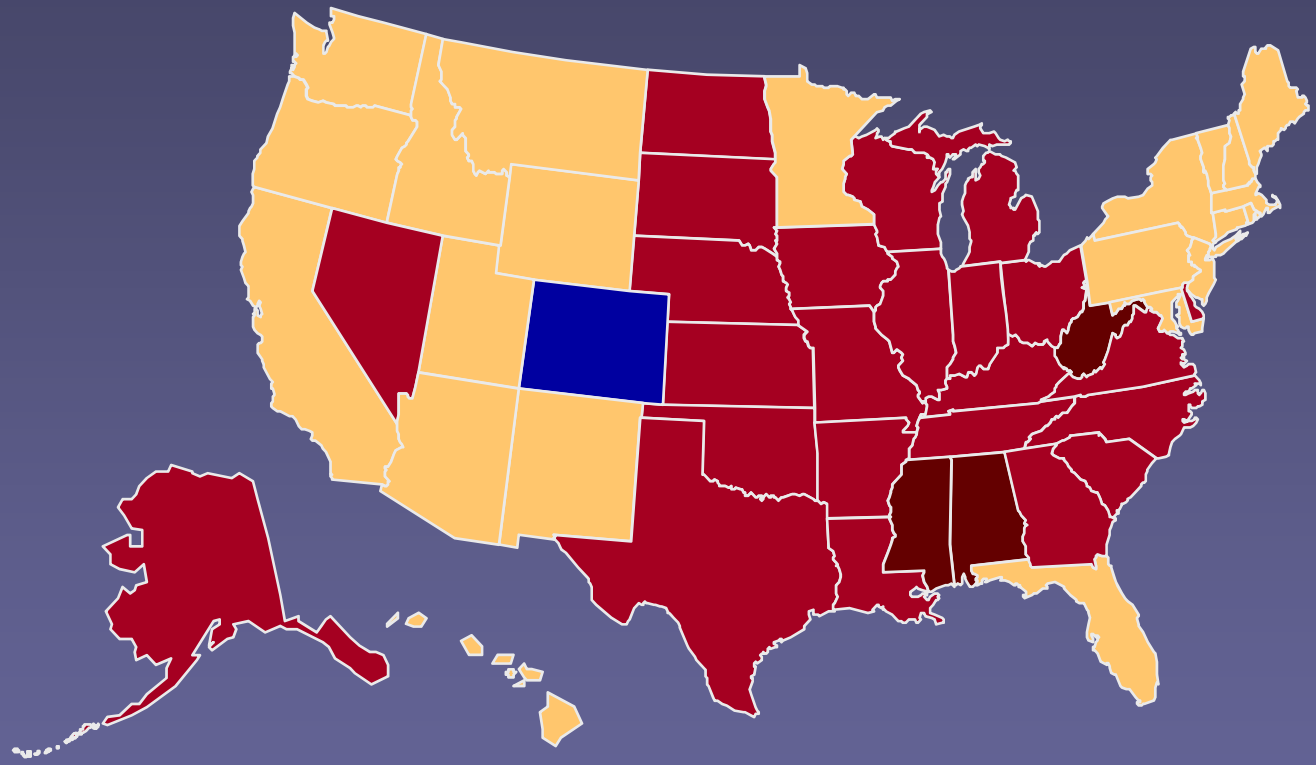


No Data | <10% | 10%–14% | 15%–19% | 20%–24% | 25%–30% | ≥30%

Source: Behavioral Risk Factor Surveillance System, CDC.

Obesity Trends Among U.S. Adults

BRFSS, 2006



No Data | <10% | 10%–14% | 15%–19% | 20%–24% | 25%–30% | ≥30%

Source: Behavioral Risk Factor Surveillance System, CDC.

Poverty and Obesity

- Poverty has been hypothesized to be a risk factor for obesity
- Individual and Aggregate Observations
  - Individuals living in poverty are more likely to be obese [or overweight (BMI >= 25.0)]
  - Areas with high rates of poverty are more likely to have high prevalences of obesity and overweight

Poverty as a Risk Factor for Obesity – Causal Pathways

- SES/income/education influence awareness of health issues, opportunities for healthy behaviors, access to healthy foods, and access to health care
- Stress from living in poor or income disparate environments – stress results in chronic stimulation of the cortisol stress pathway, which is associated with an increased risk of major chronic illnesses

Poverty as a Risk Factor for Obesity – Causal Pathways (cont.)

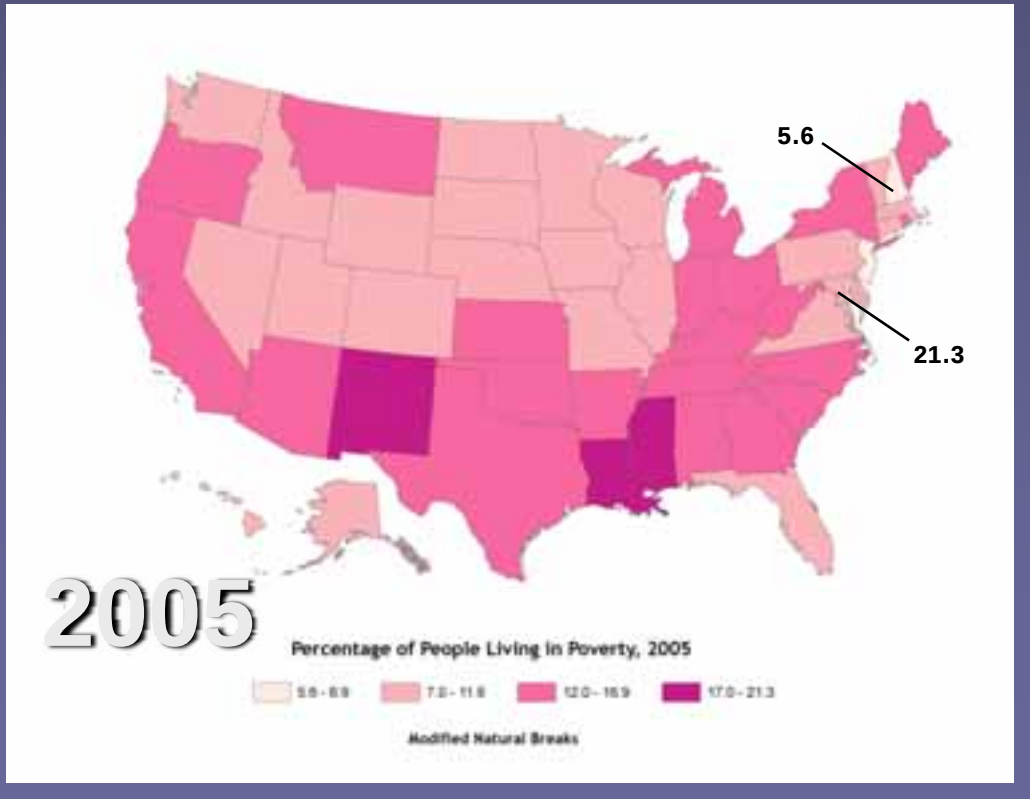
- Food costs and accessibility
  - High energy-dense foods cost less than low energy dense (and healthier) foods
  - High energy density associated with higher energy intakes – reinforced by high palatability of sugar and fat
  - "Obesogenic" environments – ease in time and space of obtaining high energy-dense foods (e.g., fast foods, vending machines in schools); also related to the notion of "food insecurity" or the relative inability to access healthy food choices

Poverty as a Risk Factor for Obesity – Causal Pathways (cont.)

- Environmental
  - Built environment
    - Walkability of neighborhoods : cul-de-sacs versus grid street networks (sidewalks)
    - Urban sprawl – commute length and time constraints on meal preparation and time for physical activity
    - Lack of access to parks and greenspaces
  - Social environment
    - Perception (reality) of safety for physical activity and recreation
    - Social capital – declining social connectedness and social networks and sense of community

Poverty Prevalence

- In 2005, median state poverty rate* = 11.8%
  - New Hampshire 5.6%
  - District of Columbia 21.3%



*Source: U.S. Census Bureau,
Small Area Income and Poverty Estimates

Poverty Trends

- 1996 median state poverty rate = 11.9
- 2001 median state poverty rate = 10.5
- 2005* median state poverty rate = 11.8
- At the end of this period, after a 1.4 percentage point drop in 2001, the rate rose and was essentially unchanged from 1996

* U.S. poverty estimates are not available for 2006.

Poverty – Obesity Correlations

- 1996 r = 0.16
- 2001 r = 0.38
- 2006 r = 0.42

- From 1996 to 2006, the association between poverty and obesity at the state level *more than doubled*

Research Question

- Obesity rates increasing
- Poverty rates stable
- Correlation between obesity and poverty has increased
- Why?
- Is there a spatial component involved in these temporal observations? ...such as a spatial convergence of low poverty/obesity rates and/or high poverty/obesity rates?

Quantification of Spatial Patterns

- Univariate Moran's I
  - For general indication of clustering
- Local Indicators of Spatial Association (LISA)
  - For spatial identification of clusters
- Univariate and Bivariate forms exist
  - Concentration in space of the values of two discrete indicators (e.g., poverty and obesity)

Moran's I (Moran 1948)

$$I = \left(\frac{1}{s^2}\right)\frac{\sum_{i=1}^{N}\sum_{j=1}^{N} w_{ij}(Y_i - \bar{Y})(Y_j - \bar{Y})}{\sum_{i=1}^{N}\sum_{j=1}^{N} w_{ij}}$$

where

$$s^2 = \frac{1}{N}\sum_{i=1}^{N}(Y_i - \bar{Y})^2$$

- One measure of spatial autocorrelation
- Others include Geary's *c* and Getis-Ord G-Statistic
- Global measure
  - Only indicates presence of spatial autocorrelation
  - Does not indicate where it occurs or whether it is confined to one or more areas of the spatial extent of the dataset

Moran's I: Obesity

Year	Moran's I	Z score
1996	0.32	3.45
2001	0.52	5.52
2006	0.53	5.60

- Evidence of clustering in all years, increasing from 1996 through 2006
- Statistically significant at $p < .01$
- Supports visual indications of clustering from the maps

Moran's I: Poverty

Year	Moran's I	Z score
1996	0.26	2.94
2001	0.35	3.77
2005	0.28	3.07

- Evidence of clustering in all years, but relatively constant magnitude between the 1996 and 2005 endpoints
- Statistically significant at $p < .01$
- Supports visual indications of clustering from the maps

Bivariate Moran's I

- Is there general clustering of low (or high) obesity **and** low (or high) poverty rates?
- Has it changed over time?

Year	Moran's I (poverty – lagged obesity)
1996	0.17
2001	0.28
2005/6	0.34

- Low/High rates of obesity and poverty became more clustered over time, suggesting a spatial convergence of low poverty/obesity rates and high poverty/obesity rates.
- *Where* **has this trend been manifested?**

Local Indicators of Spatial Association (LISA)

- Recent development (late 1990s) in recognition of limitations of global measures (esp. Anselin and Fotheringham)
- Disaggregations of global measures of spatial autocorrelation
- Permits identification of spatial concentrations and outliers
- Moran's I indicates *whether* there is clustering, while LISAs help pinpoint *where* the clustering occurs

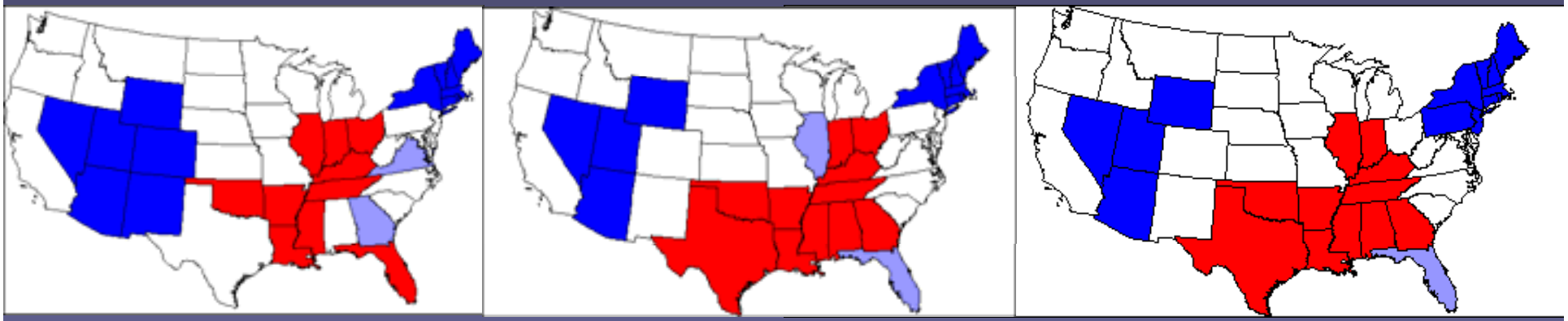
Local Moran's I

$$(Y_i - \bar{Y}) \sum_{j=1}^{N} w_{ij} (Y_j - \bar{Y})$$

- where Y_i are observations at each i^{th} location
- Y_j are observations at all other locations
- w_{ij} is a spatial weights matrix equal to $1/d_{ij}$ in which…
- d_{ij} represents the Cartesian distances between the i^{th} and j^{th} points

LISA: Obesity

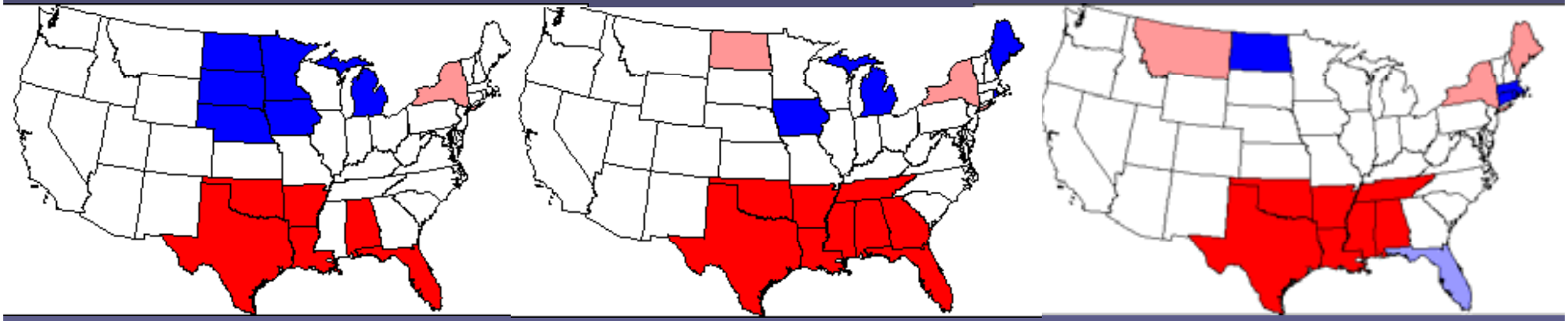
1996 **2001** **2006**



- Dark blue = cluster of low rates
- Dark red = cluster of high rates
- Light blue = low rate that is a spatial outlier

LISA: Poverty

1996 **2001** **2005**



- Dark blue = cluster of low rates
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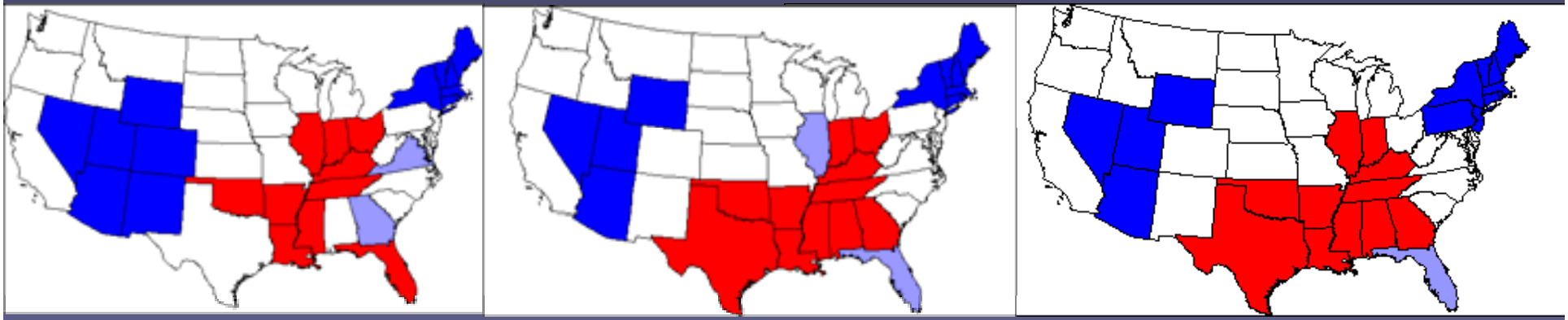
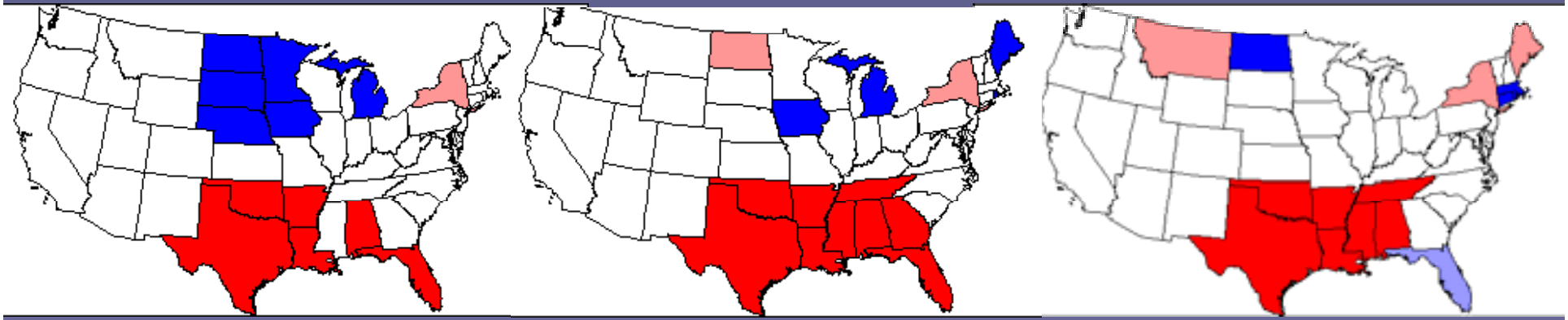
LISAs: Obesity and Poverty

1996 **2001** **2005**

Obesity



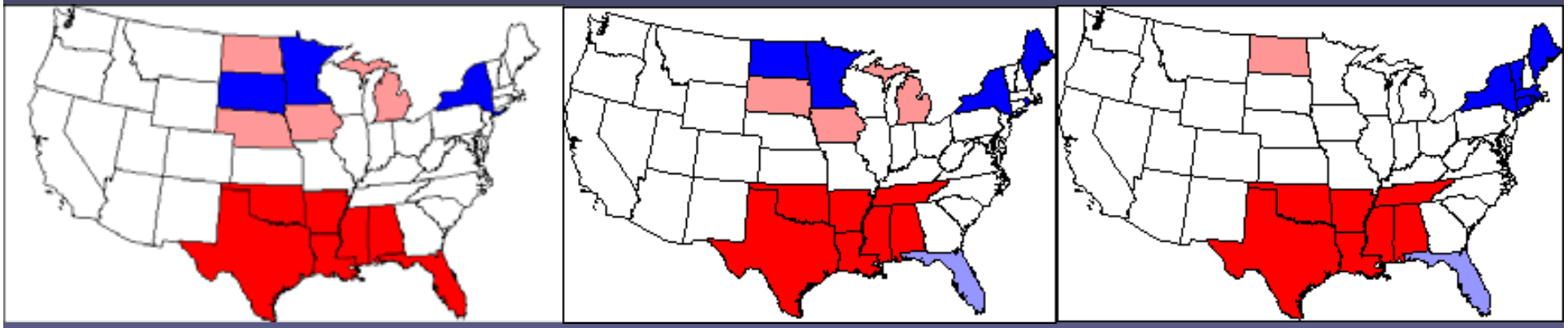
Poverty



Multivariate LISAs

1996 **2001** **2005/6**

Poverty Versus Lagged Obesity:



- In all years, a distinct cluster (S.East and S. Central) of high poverty/obesity
- Over this time period, a growing cluster of low poverty/obesity in the N.East
- In 1996 and 2001, a distinct cluster of low poverty/obesity (N. Central) that diminished by 2005/6

Discussion – Poverty and Obesity

- Spatio-temporal observations
  - Poverty and Obesity have become more spatially concentrated from 1996 – present
  - Poverty and Obesity rates have spatially converged (low with low; high with high)
  - Most pronounced in the Southeast and Southcentral U.S. (high poverty/obesity) and in the Northeast U.S. (low poverty/obesity)

Discussion: Food supply and cost trends (1985-2000)*

- Daily caloric intake increased by 300 kcal (93% from refined grains, sugars, and fats)
- Annual food cost increases
  - Fruits/vegetables 118%
  - Fats/oils 35%
  - Soft drinks 20%
- For areas with high poverty rates, there may have been ever greater economic incentives for the population to consume high energy-dense foods, especially as these foods had lower rates of price increases; while at the same time the population was consuming even greater amounts of these foods

*USDA/ERS estimates, cited in Drewnoski (2004), *AJPM* 27 (35): 154-162

Discussion: Persistence of Poverty

- Chronic poverty has greater negative associations with health status than does current poverty status (cumulative affect of persistent disadvantage)

Discussion: Population Growth and Urban Sprawl

- Built environment
  - Low density development
  - Reliance upon automobiles
  - Cul-de-sac subdivision designs (inability to safely walk)
- Increased commute times (less time for recreational physical activity and for healthy meal preparation

Discussion: Future Research

- This analysis valid for the state level only
- Do these trends and relationships hold for other spatial scales?
- Observations at the state level may be exacerbated or mitigated at the substate level (e.g., sprawl – may negatively impact those who are economically better off…)
- County level data (or aggregations of counties, such as Bureau of Economic Research's Economic Areas)

Recommendations

- We need to understand how to balance food convenience/cost and social policy which encourages healthy behaviors
- We need to recognize that policies focusing on behavioral changes (esp. relating to food) do not consider the economic barriers encountered
- To reverse the trend of rising obesity we must address the issue of poverty and economic disparities
- We need to better understand the impact of the built and social environment as risk factors for both poverty and obesity

Questions?

- Thank you!
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  - 770-488-5510