

Session II  
LIVING IN A RADIOACTIVE  
WORLD

Presented by  
Bruce W. Church  
Consulting Health Physicist  
April 10, 2006

# SESSION II Outline

## (Introduction to Risk, Probability and the biological effects of radiation).

### A. Fear, Risk & Probability

- What is Risk?
  - Relative Risk
  - Absolute RiskSome examples of common risks we take in our daily lives

### Probability

- What is Fear?  
**F**alse **E**vidence **A**ppearing **R**eal!

### B. Exposure to Radiation

- Biological Effects
- Medical Exposure
- Cancer
  - What can we expect from national experience?
  - How does Utah compare with the rest of the nationEpidemiology?

# PROBABILITY

- **Probability** is a subject that deals with uncertainty.
- In everyday terminology, **probability** can be thought of as a numerical measure of the likelihood that a particular event will occur.
- **Probability** values are assigned on a scale from 0 to 1, with values near 0 indicating that an event is unlikely to occur and those near 1 indicating that an event is likely to take place.
- Frequently these values are expressed as a fraction, e.g.,  $\frac{1}{2}$  or as a decimal fraction 0.5, also the fractions may be stated as a percentage, e.g.,  $\frac{1}{2}$ , 0.5 or 50%. For example each time you toss a coin in the air the probability of it landing tails or heads is 50%. If you take the trouble to toss it 100 times you'll generally observe about 50 times it comes up heads and 50 times tails.

# RISK

- What is Risk?

# FEAR

## False Evidence Appearing Real!

- **Fear: noun**

**1 a** : an unpleasant often strong emotion caused by anticipation or awareness of danger **b** (1) : an instance of this emotion (2) : a state marked by this emotion

**2** : anxious concern : **SOLICITUDE**

**3** : profound reverence and awe especially toward God

**4** : reason for alarm : **DANGER**

**synonyms** **FEAR**, **DREAD**, **FRIGHT**, **ALARM**, **PANIC**, **TERROR**, **TREPIDATION** mean painful agitation in the presence or anticipation of danger. **FEAR IS THE MOST GENERAL TERM AND IMPLIES ANXIETY AND USUALLY LOSS OF COURAGE <FEAR OF THE UNKNOWN>**.

- **Fear: verb**

*transitive senses*

**1 archaic** : **FRIGHTEN**

**2 archaic** : to feel fear in (oneself)

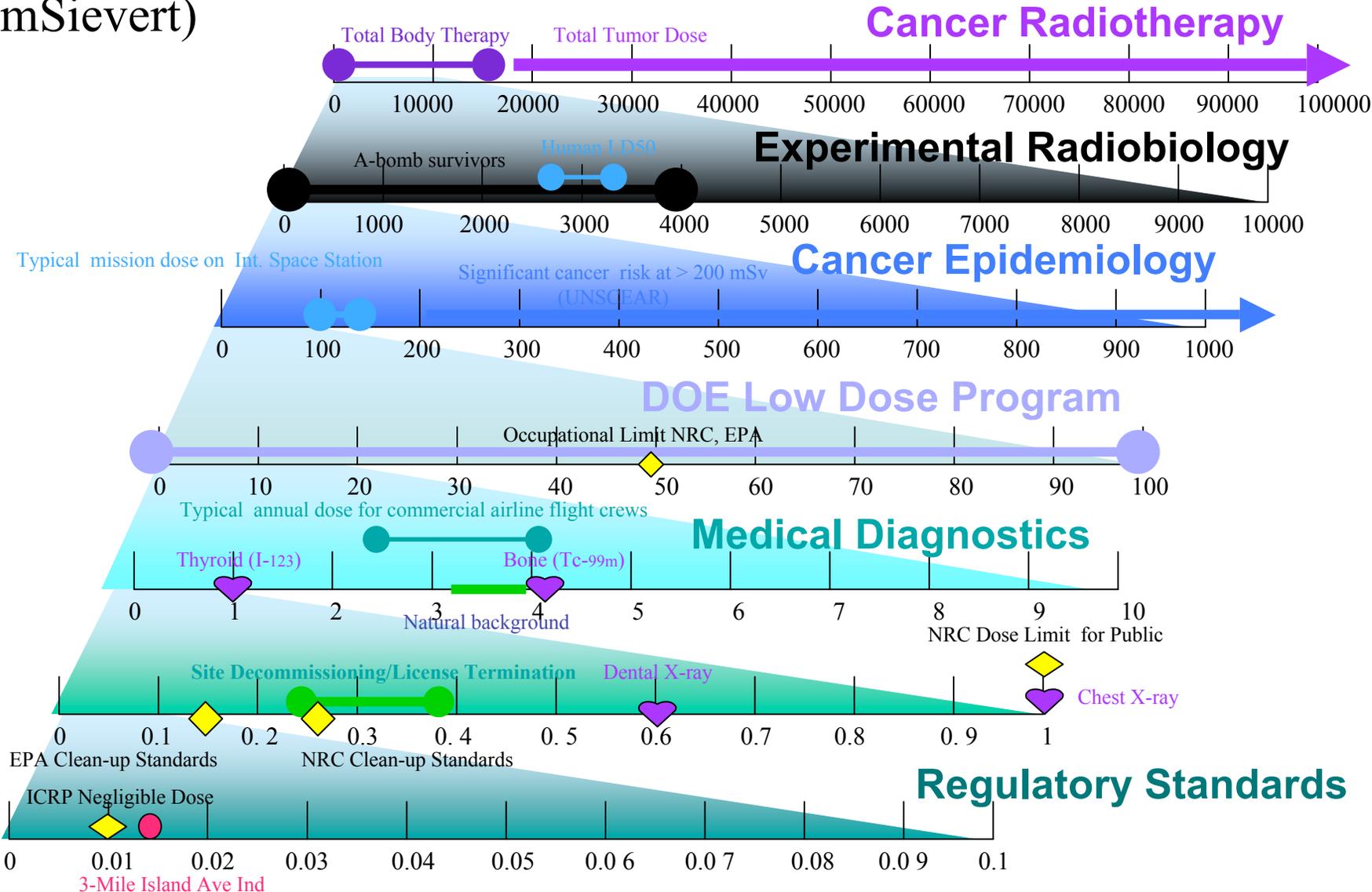
**3** : to have a reverential awe of <fear God>

**4** : to be afraid of : expect with alarm

*intransitive senses* : to be afraid or apprehensive

# Dose Ranges

(mSievert)



# What are the odds of dying?

- The table below was prepared in response to frequent inquiries, especially from the media, asking questions such as, "What are the odds of being killed by lightning?" or "What are the chances of dying in a plane crash?"
- The table has four columns. The first column gives the manner of injury such as motor-vehicle crash, fall, fire, etc. The second column gives the total number of deaths nationwide due to the manner of injury in 2002 (the latest year for which data are available). The third column gives the odds of dying in one year due to the manner of injury. The fourth column gives the lifetime odds of dying from the manner of injury. Statements about the odds or chances of dying from a given cause of death may be made as follows:
- The odds of dying from (manner of injury) in 2002 were 1 in (value given in the one-year odds column).
- The life-time odds of dying from (manner of injury) for a person born in 2002 were 1 in (value given in the lifetime odds column).
- For example, referring to the first line of the table below:
- The odds of dying from an injury in 2002 were 1 in 1,755.
- The lifetime odds of dying from an injury for a person born in 2002 were 1 in 23.
- The odds given below are statistical averages over the whole U.S. population and do not necessarily reflect the chances of death for a particular person from a particular external cause. Any individual's odds of dying from various external causes are affected by the activities in which they participate, where they live and drive, what kind of work they do, and other factors.
- Source: National Safety Council estimates based on data from National Center for Health Statistics and U.S. Census Bureau. Deaths are classified on the basis of the Tenth Revision of the World Health Organization's "The International Classification of Diseases" (ICD). Numbers following titles refer to External Cause of Morbidity and Mortality classifications in ICD-10. One year odds are approximated by dividing the 2002 population (287,941,220) by the number of deaths. Lifetime odds are approximated by dividing the one-year odds by the life expectancy of a person born in 2002 (77.3 years).



**Table 3:** Comparable dose and risk standards

Individual Dose (mrem/y)	Risk Level* (fatalities/y)	Radiation Standard and Observed Experience
1	5.00E-07	IAEA Exemption Level (IAEA Safety Series No. 89)
4		EPA Drinking Water Limit (40 CFR 141)
10	5.00E-06	ENEWETAK Pu Soil Cleanup Dose Standard; EPA NESHAPS Air Dose Limit (40 CFR 61, Subpart I) ~ UMTRA Dose Limit
15	4.30E-06	Proposed EPA Soil Cleanup Limit (Source EPA OSWER No. 9200.4-18, 22 Aug., 1997)
25		NRC D&D Limit; Health Physics Society Screening Level
100	5.00E-05	Public Dose Limit _ ICRP, NCRP, HPS, IAEA, NRC (10 CFR 20 [6]); DOE (5400.5)
300		Average U.S. Background Radiation Level (NCRP Report No. 94)
	2.00E-04	Probability of being involved in a automobile crash with a fatality per year; construction worker annual fatality rate Source NSC
1000	5.00E-04	IAEA Proposed Intervention Level _ optional but rare
2000		Worker Dose Limit DOE (Administrative Level, RADCON Manual)
5000		Worker Dose Limit NRC (10 CFR 20 ), DOE (Order 5480.11)
10000	5.00E-03	IAEA Proposed Intervention Level _ Almost Always Justified; Level of which scientific evidence demonstrates statistically significant increase in cancer incidence, 10 rem and greater (source Wingspread Conf.); Annual probability of developing invasive cancer- Men 0.007; Women 0.005 Source ACS
	5.00E-02	Construction worker annual injury rate Probability of being involved in a automobile crash with disabling injuries (~ 0.01) per year Source NSC
	0.5	Probability of men developing invasive cancer from birth to death (Women-0.3) Source ACS

\* Fatalities for radiation risk are projected for cancer; fatalities for construction workers are from fatal injuries!

# Lifetime Probability of Developing Cancer, by Site, Men, 2000-2002\*

Site	Risk
All sites†	1 in 2
Prostate	1 in 6
Lung and bronchus	1 in 13
Colon and rectum	1 in 17
Urinary bladder‡	1 in 28
Non-Hodgkin lymphoma	1 in 46
Melanoma	1 in 52
Kidney	1 in 64
Leukemia	1 in 67
Oral Cavity	1 in 73
Stomach	1 in 82

† All Sites exclude basal and squamous cell skin cancers and in situ cancers except urinary bladder. \* For those free of cancer at beginning of age interval. Based on cancer cases diagnosed during 2000 to 2002.

‡ Includes invasive and *in situ* cancer cases

Source: DevCan: Probability of Developing or Dying of Cancer Software, Version 6.0 Statistical Research and Applications Branch, NCI, 2005. <http://srab.cancer.gov/devcan>

## Lifetime Probability of Developing Cancer, by Site, Women, US, 2000-2002\*

Site	Risk
All sites†	1 in 3
Breast	1 in 8
Lung & bronchus	1 in 17
Colon & rectum	1 in 18
Uterine corpus	1 in 38
Non-Hodgkin lymphoma	1 in 55
Ovary	1 in 68
Melanoma	1 in 77
Pancreas	1 in 79
Urinary bladder‡	1 in 88
Uterine cervix	1 in 135

† All Sites exclude basal and squamous cell skin cancers and in situ cancers except urinary bladder.

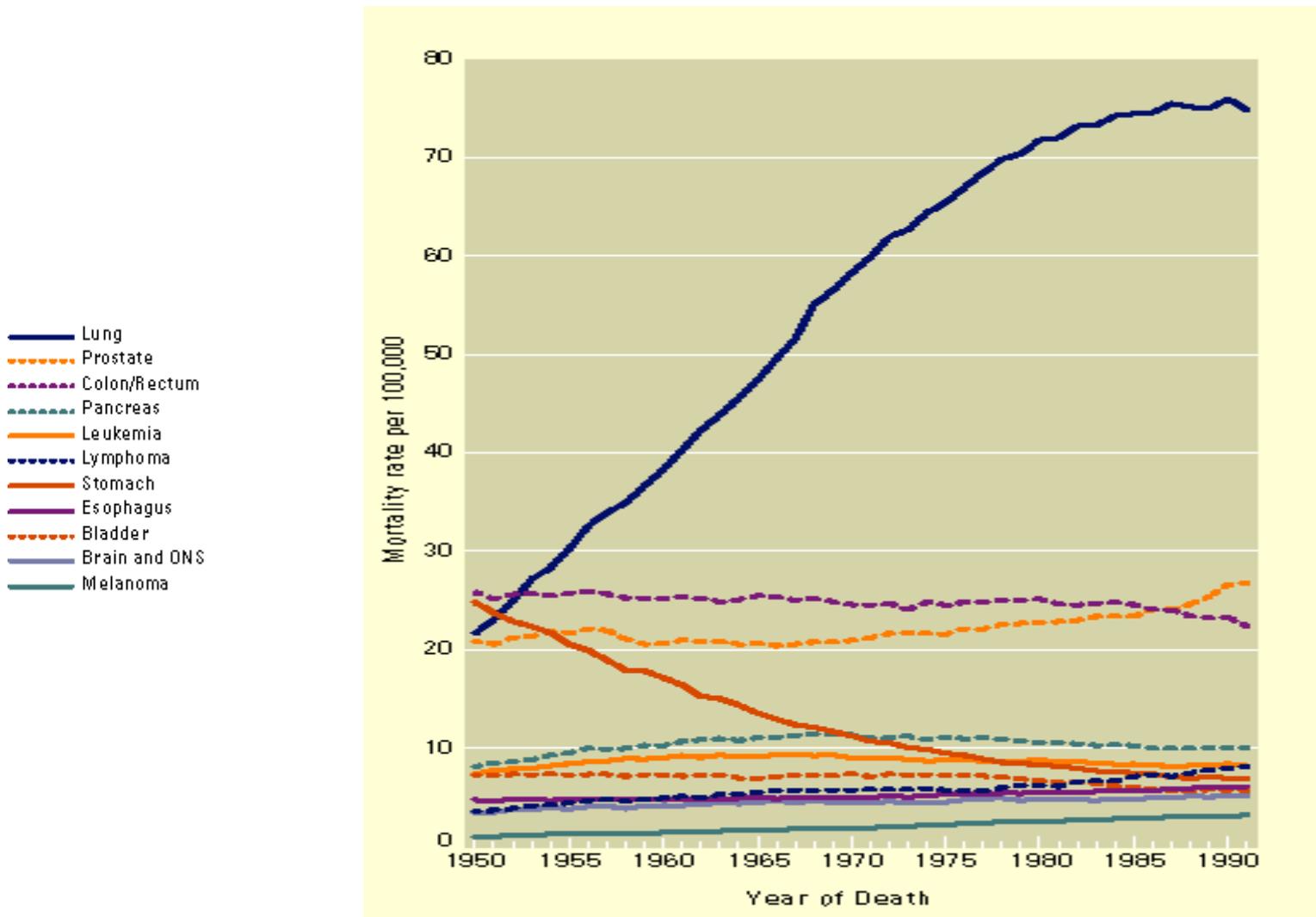
\* For those free of cancer at beginning of age interval. Based on cancer cases diagnosed during 2000 to 2002.  
 ‡ Includes invasive and *in situ* cancer cases

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# Cancer Mortality in the United States

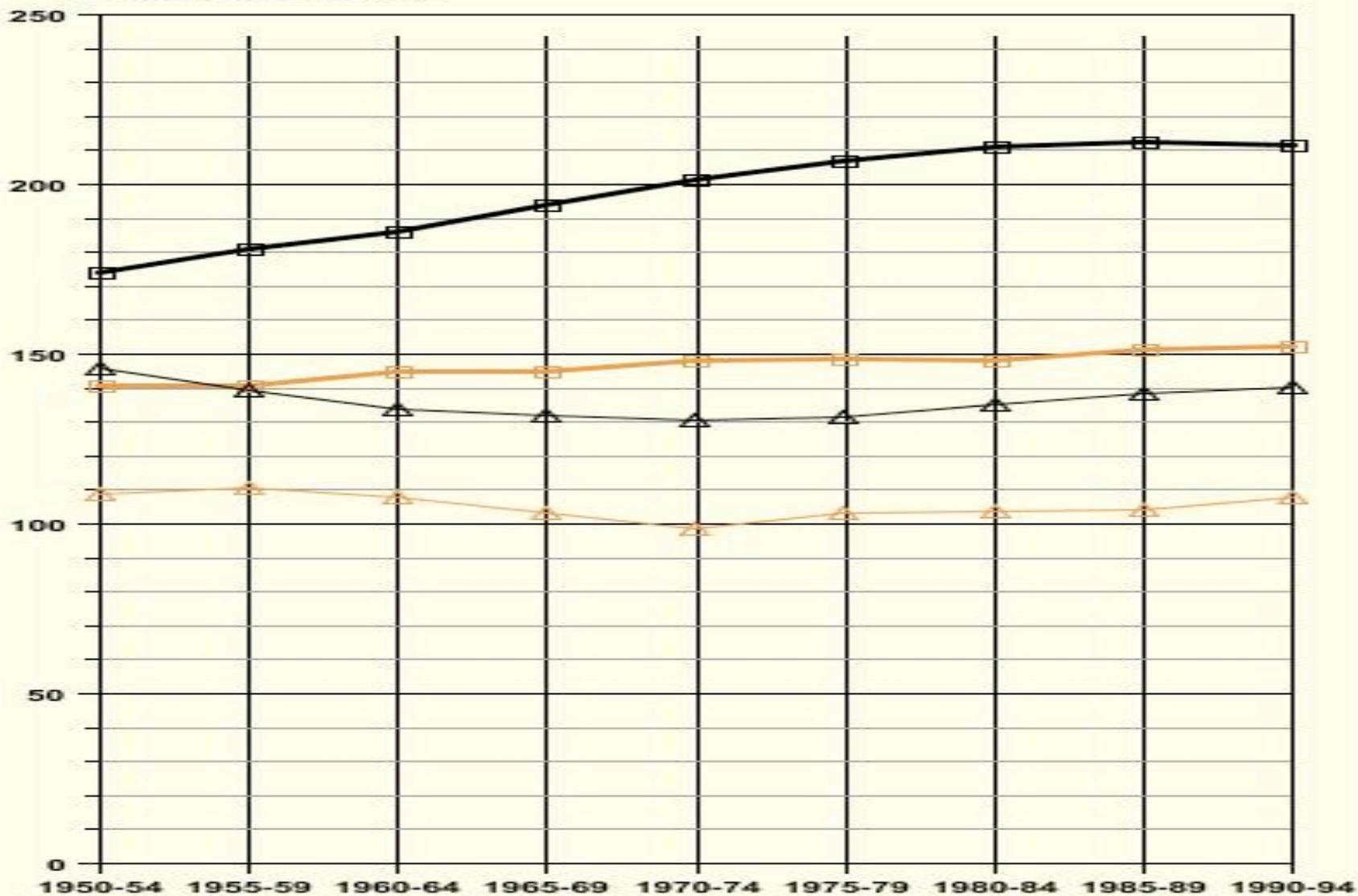
## Changing patterns for 11 Major Cancers in U.S. Males, 1950-91

### Death Rates for Males, per 100,000, for 11 Sites, 1950-91, Age-adjusted to 1970 U.S. Standard



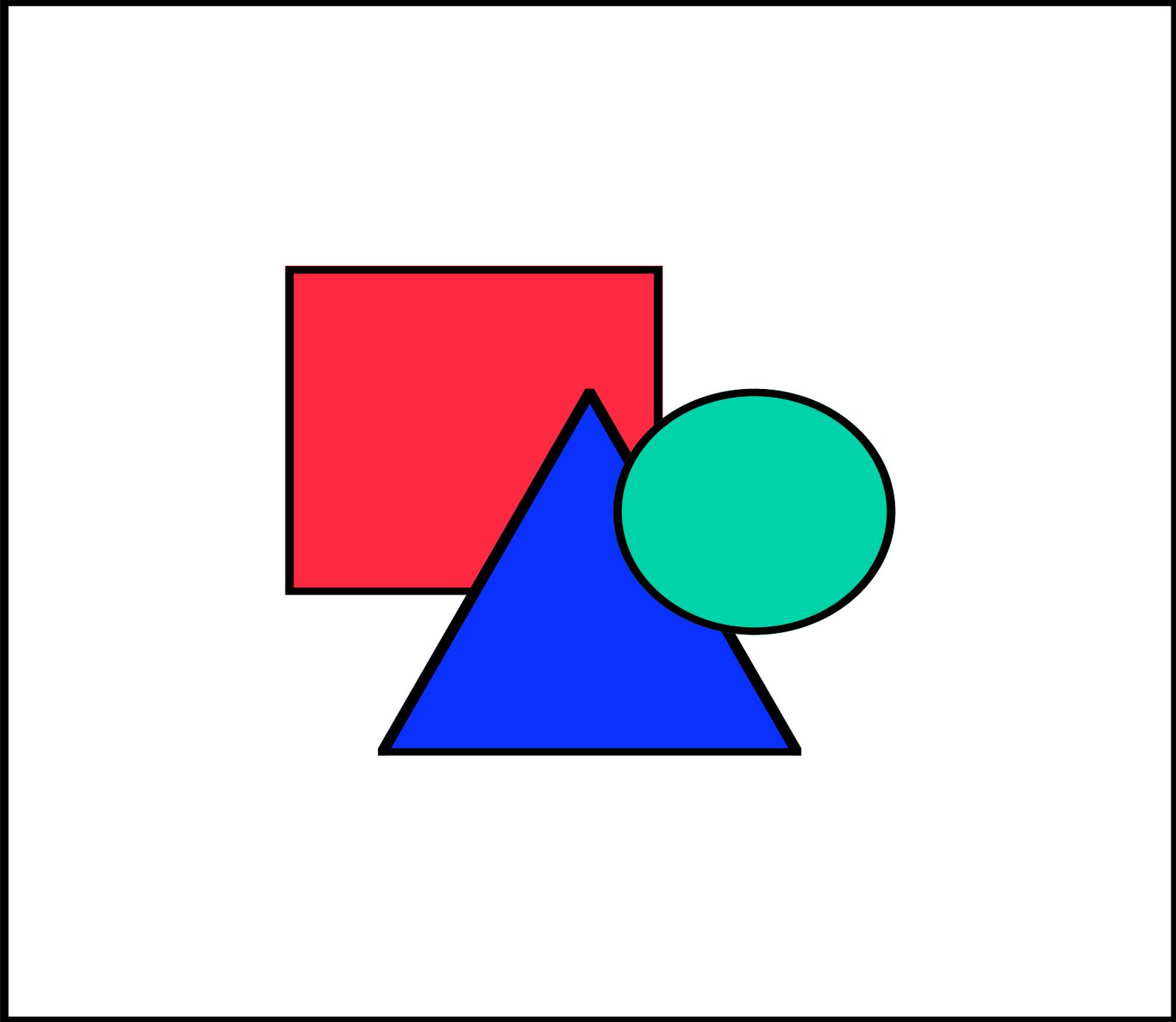
**5-year Cancer Mortality Rates per 100,000 person-years,  
Age-adjusted 1970 US Population  
All Cancers, 1950 to 1994, All Ages**

■ US White Male      ■ Utah White Male      ▲ US White Female  
▲ Utah White Female

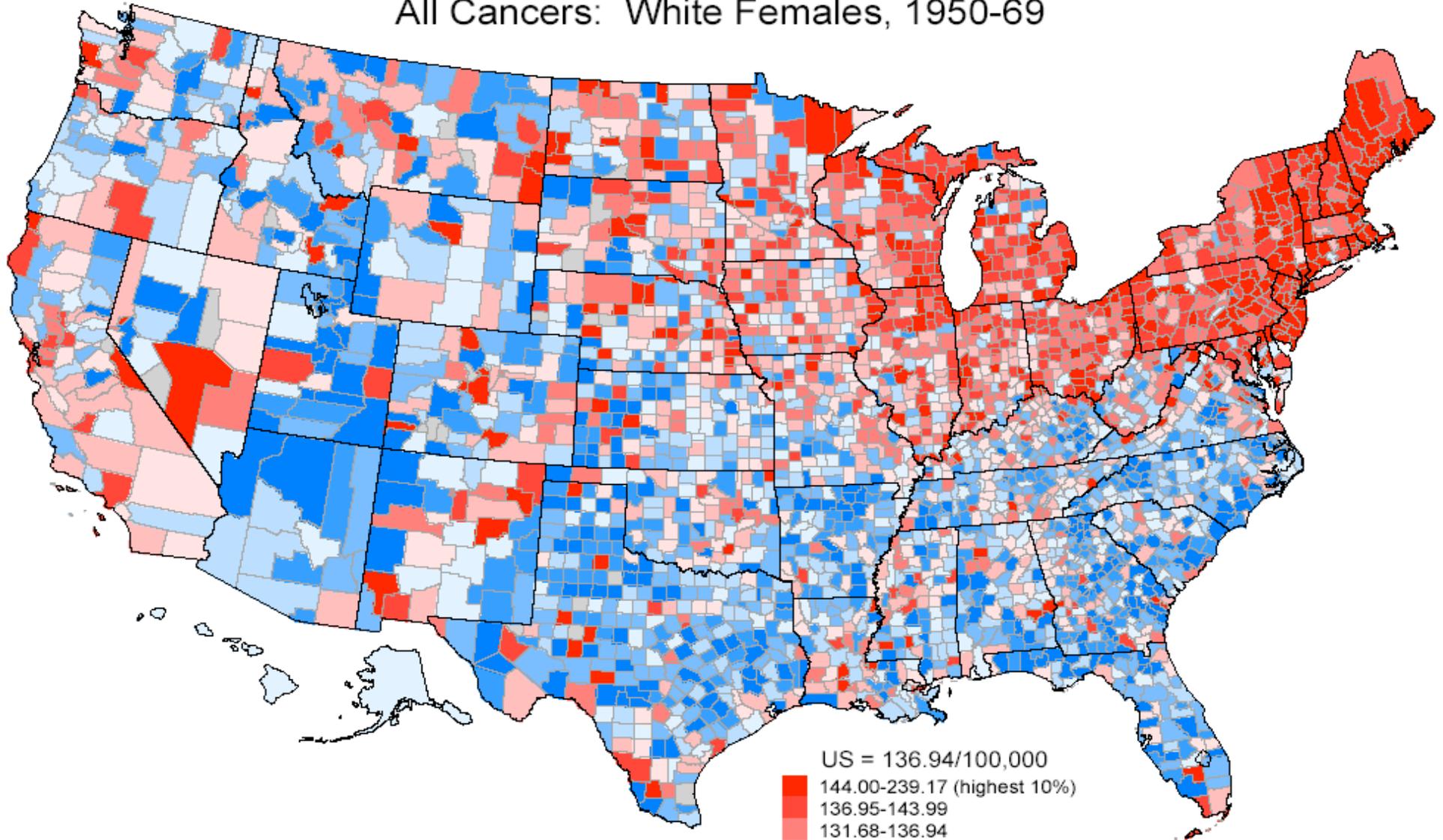


Source: Cancer Mortality Maps & Graphs Web Site,  
a service of the National Cancer Institute  
<http://www.nca.gov/factbook/>

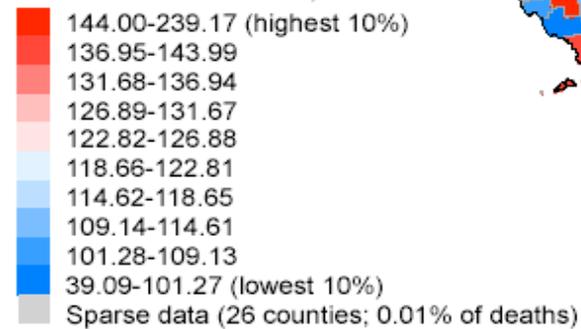
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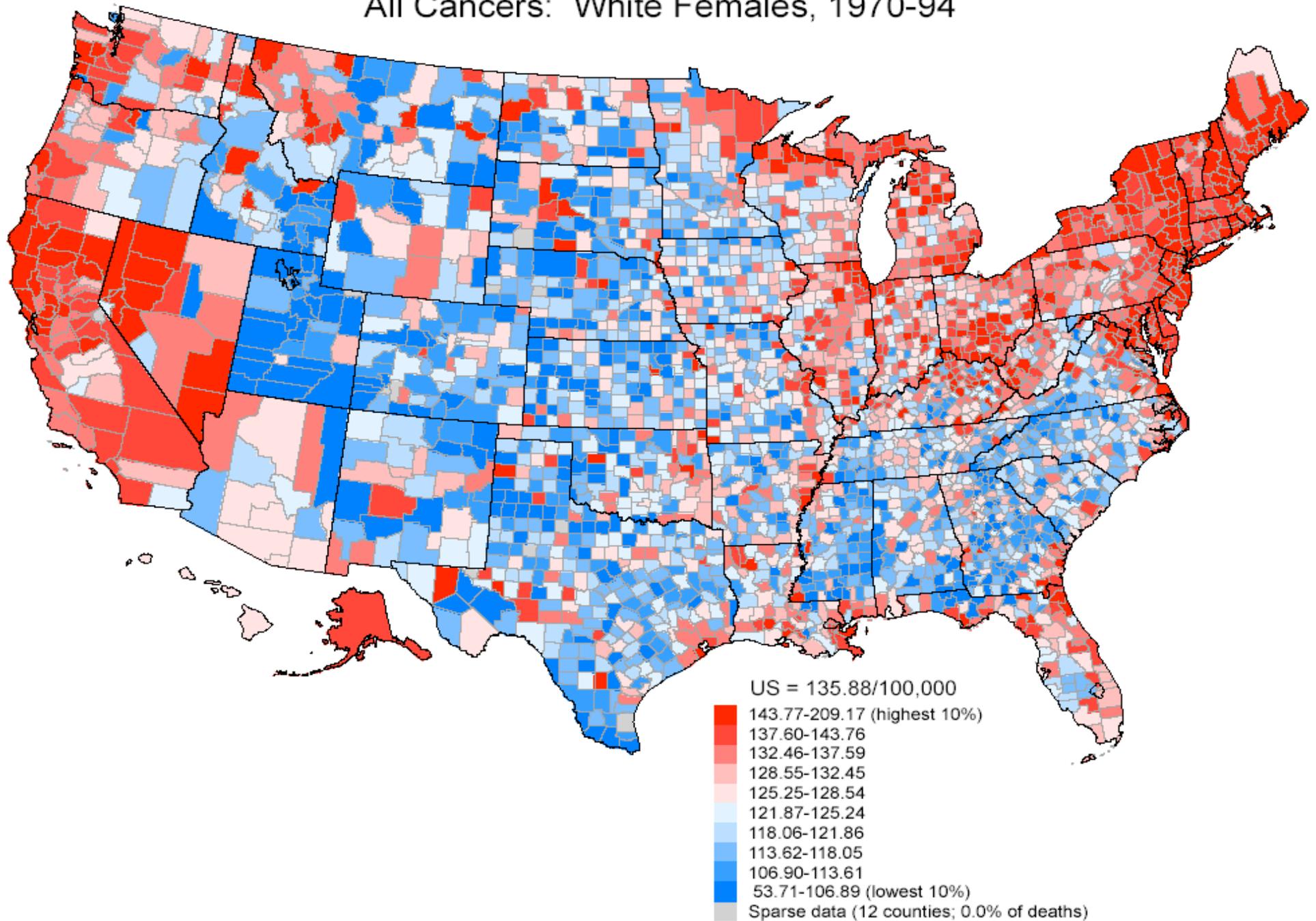
Cancer Mortality Rates by County (Age-adjusted 1970 US Population)  
All Cancers: White Females, 1950-69



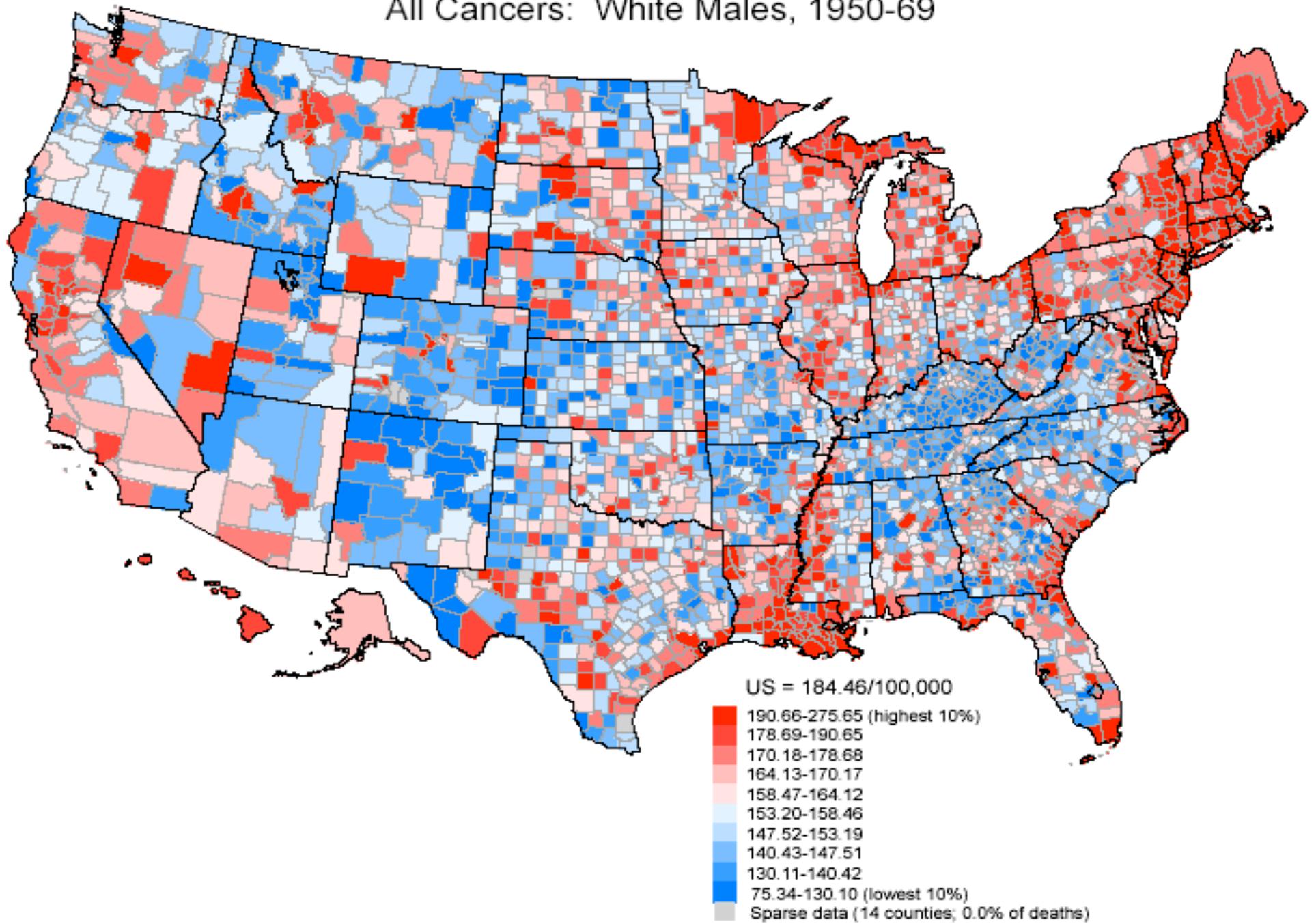
US = 136.94/100,000



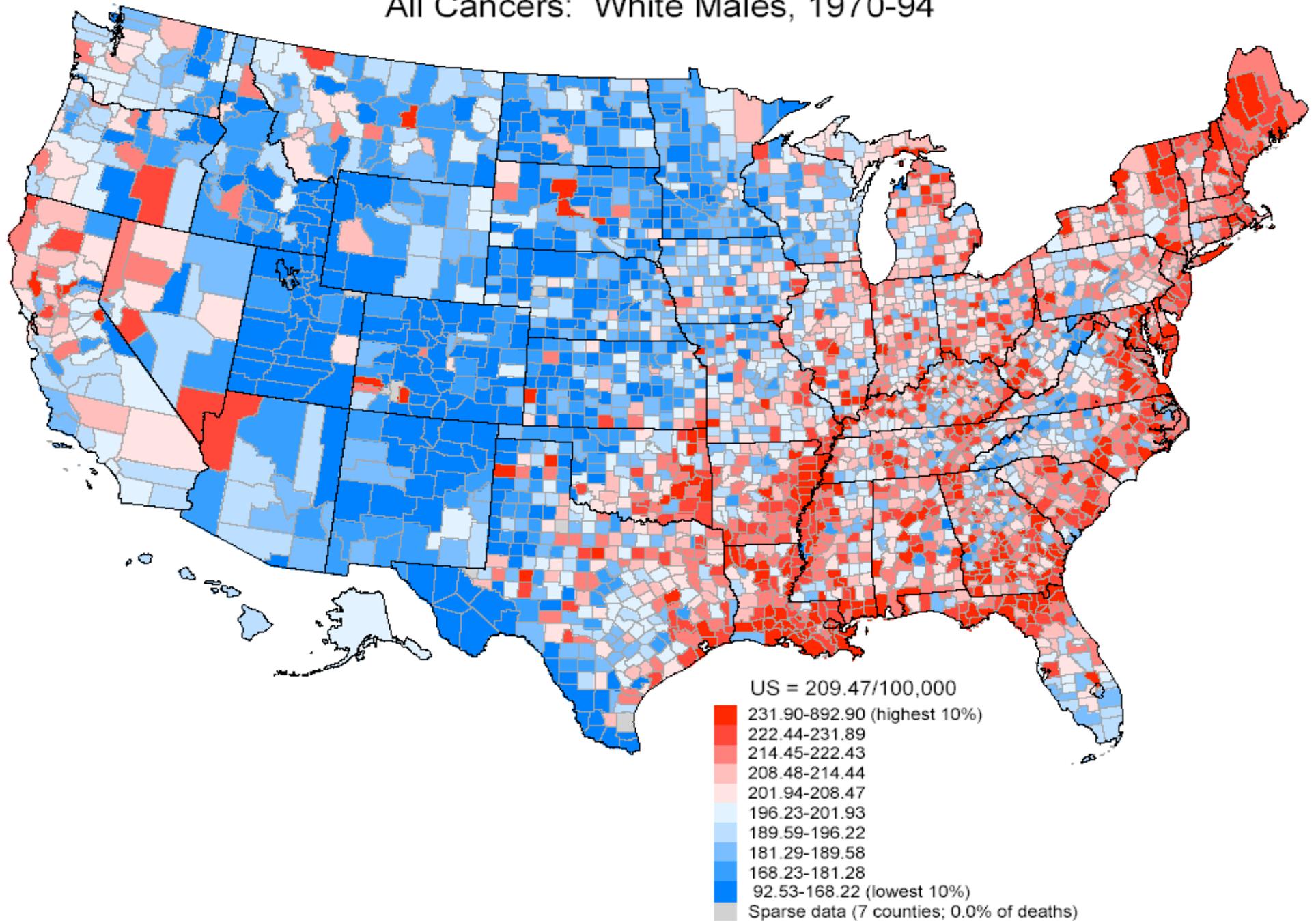
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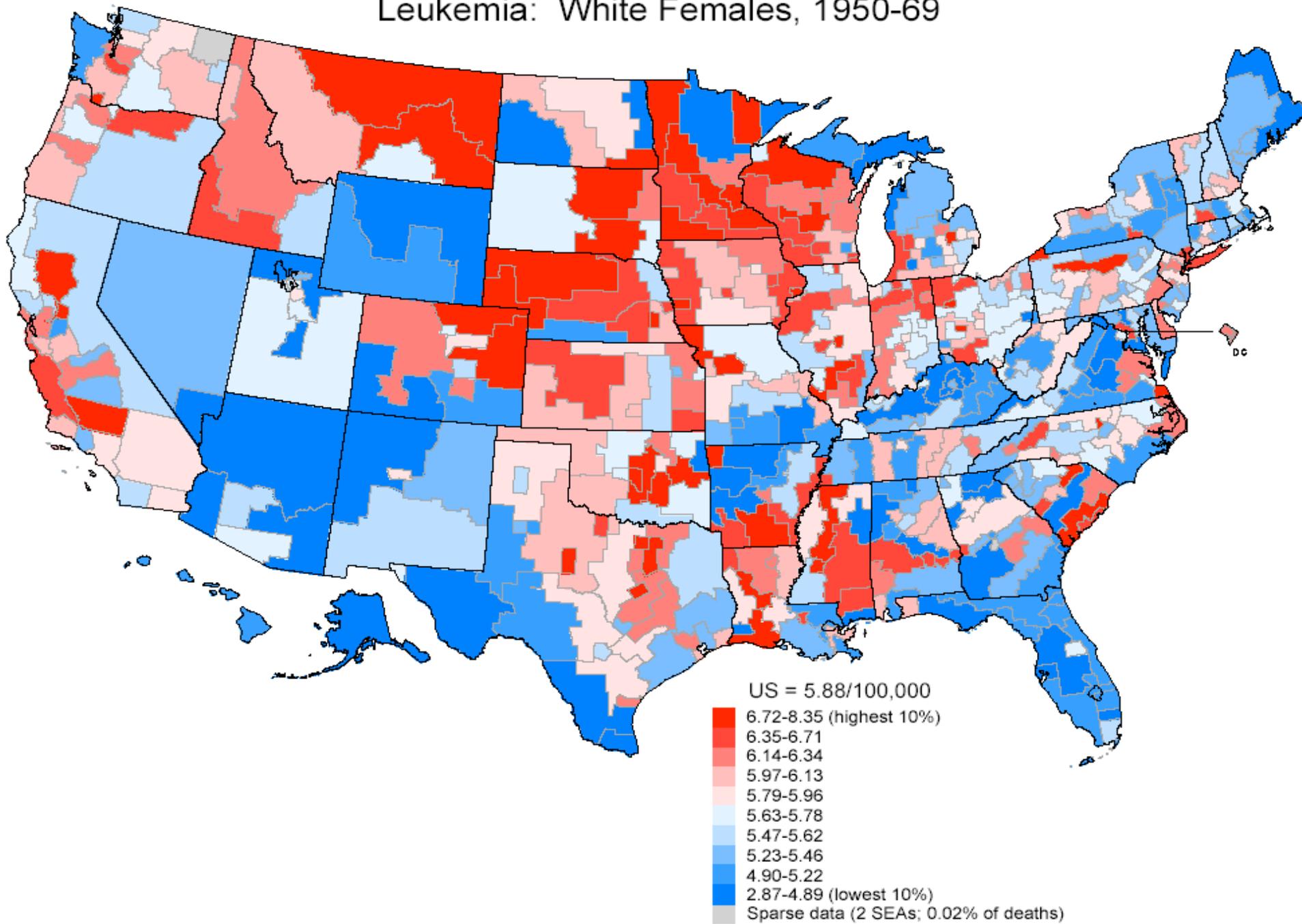
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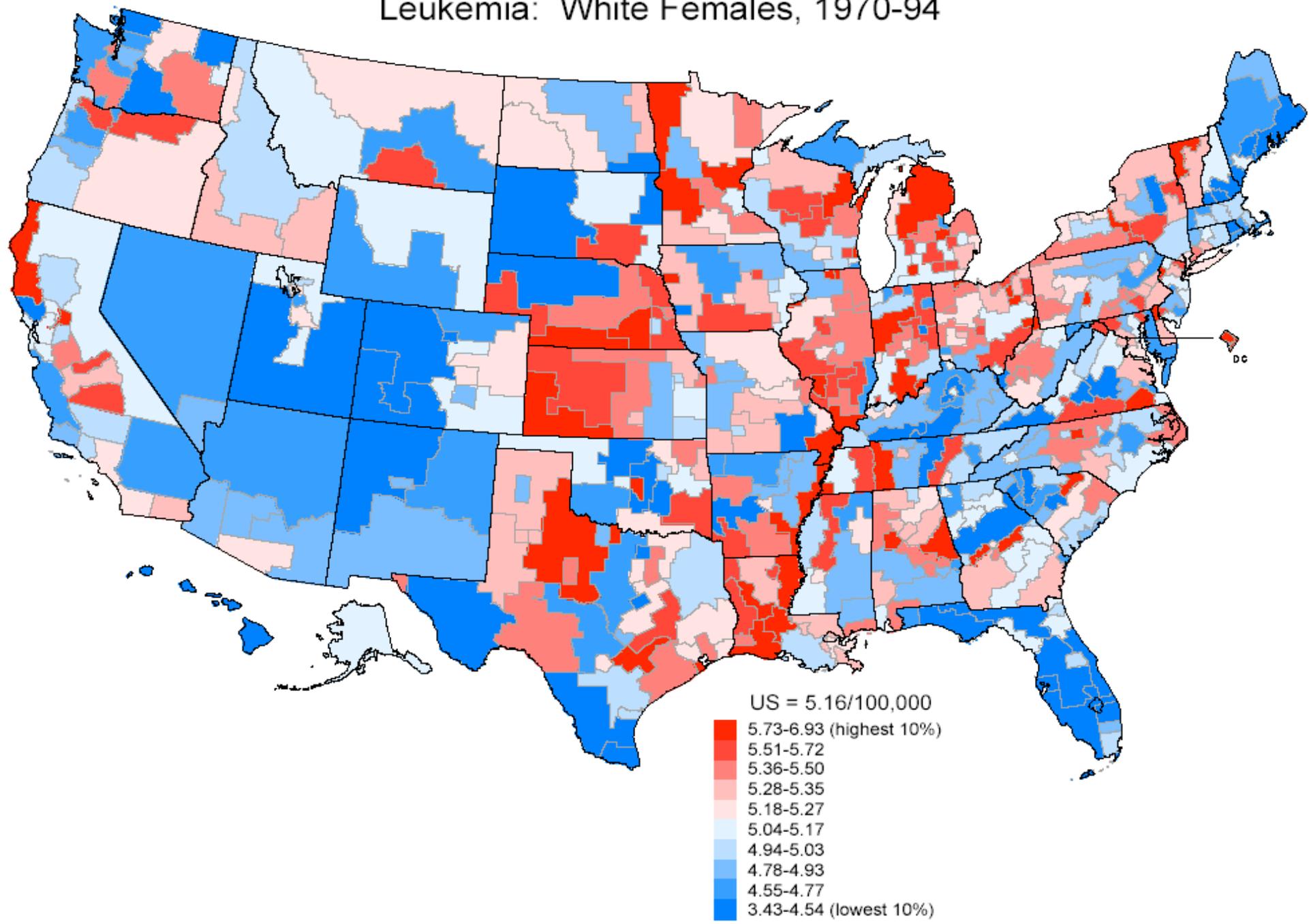
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All Cancers: White Males, 1970-94



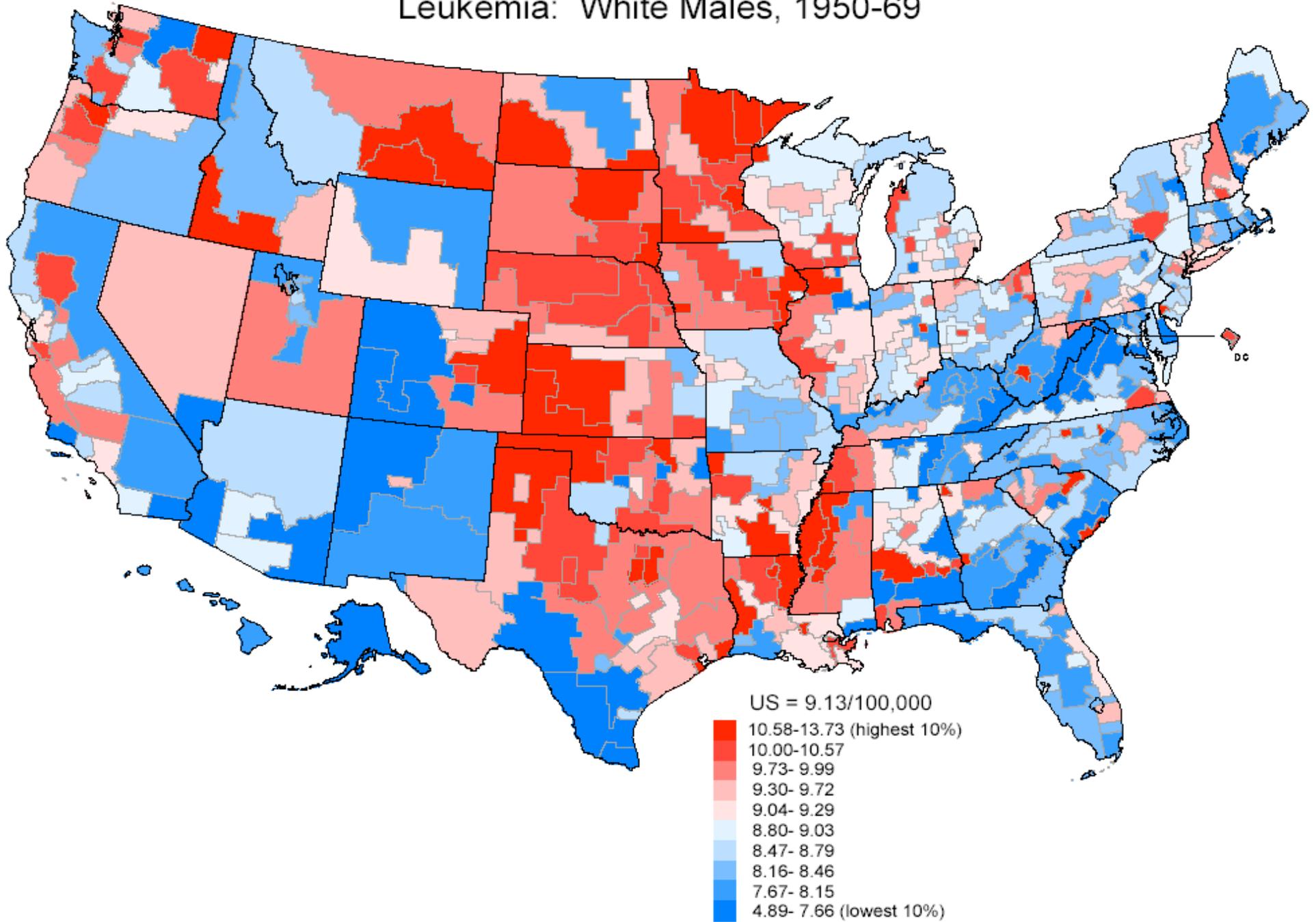
# Cancer Mortality Rates by State Economic Area (Age-adjusted 1970 US Population) Leukemia: White Females, 1950-69



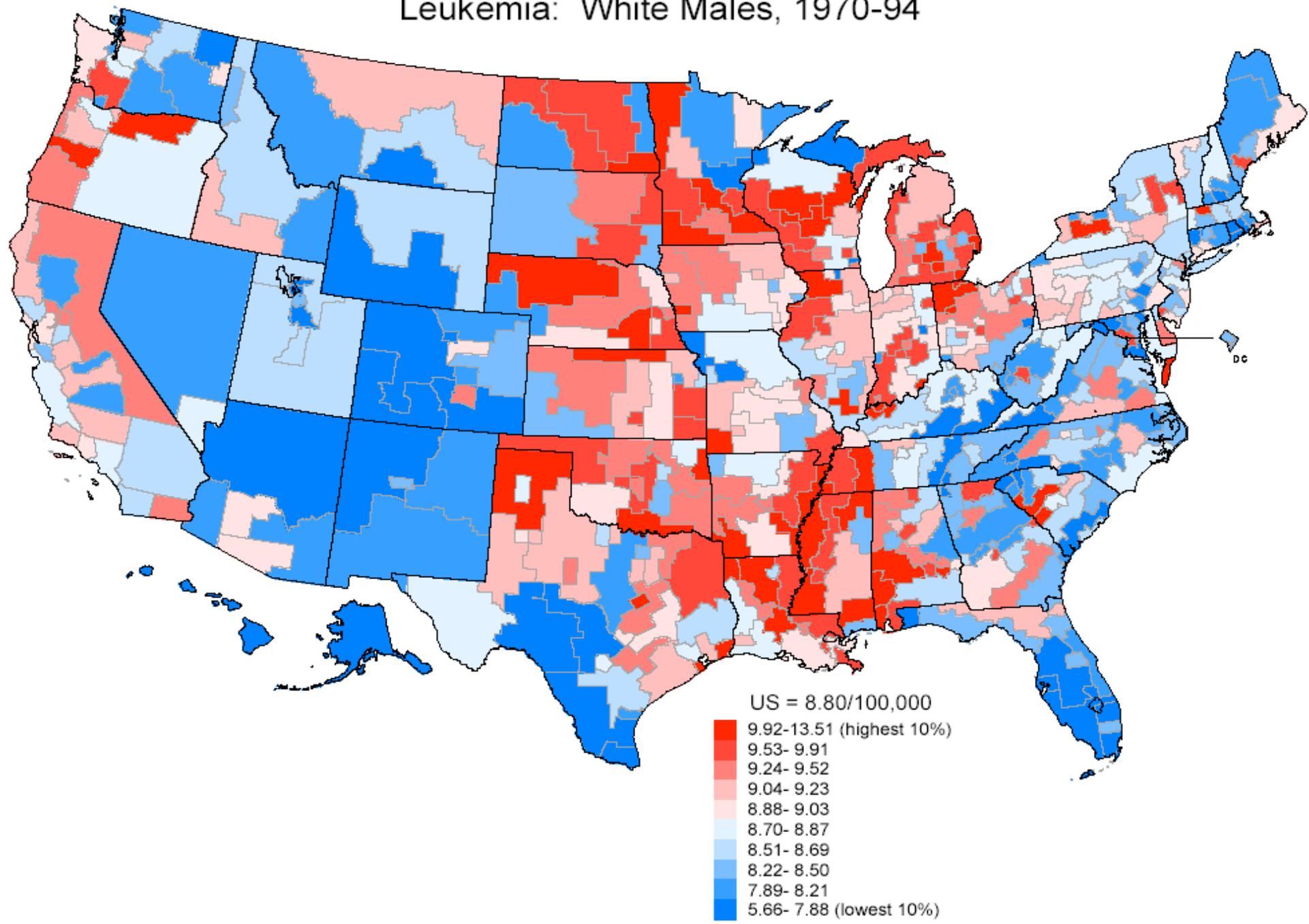
Cancer Mortality Rates by State Economic Area (Age-adjusted 1970 US Population)  
Leukemia: White Females, 1970-94



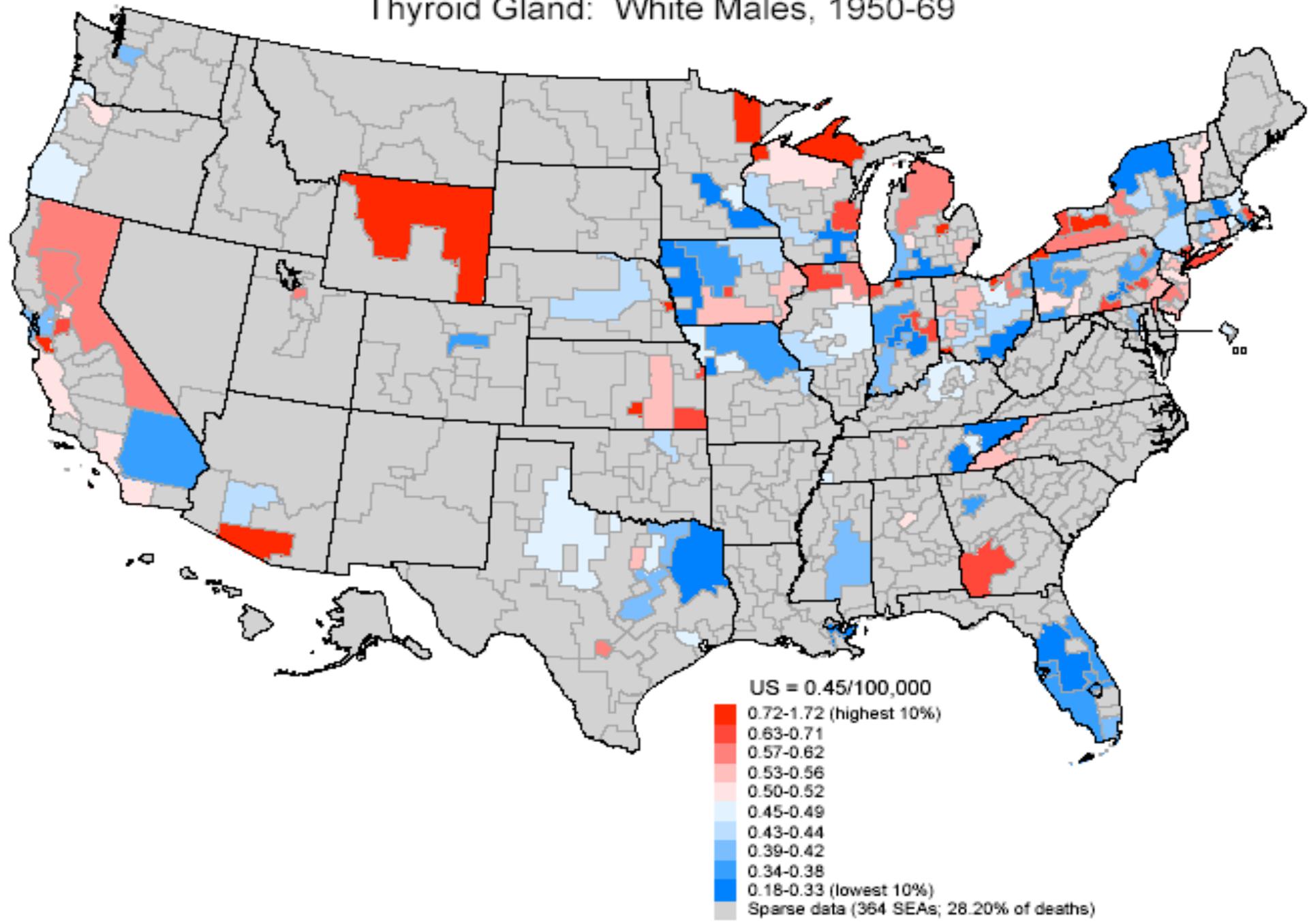
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Leukemia: White Males, 1950-69



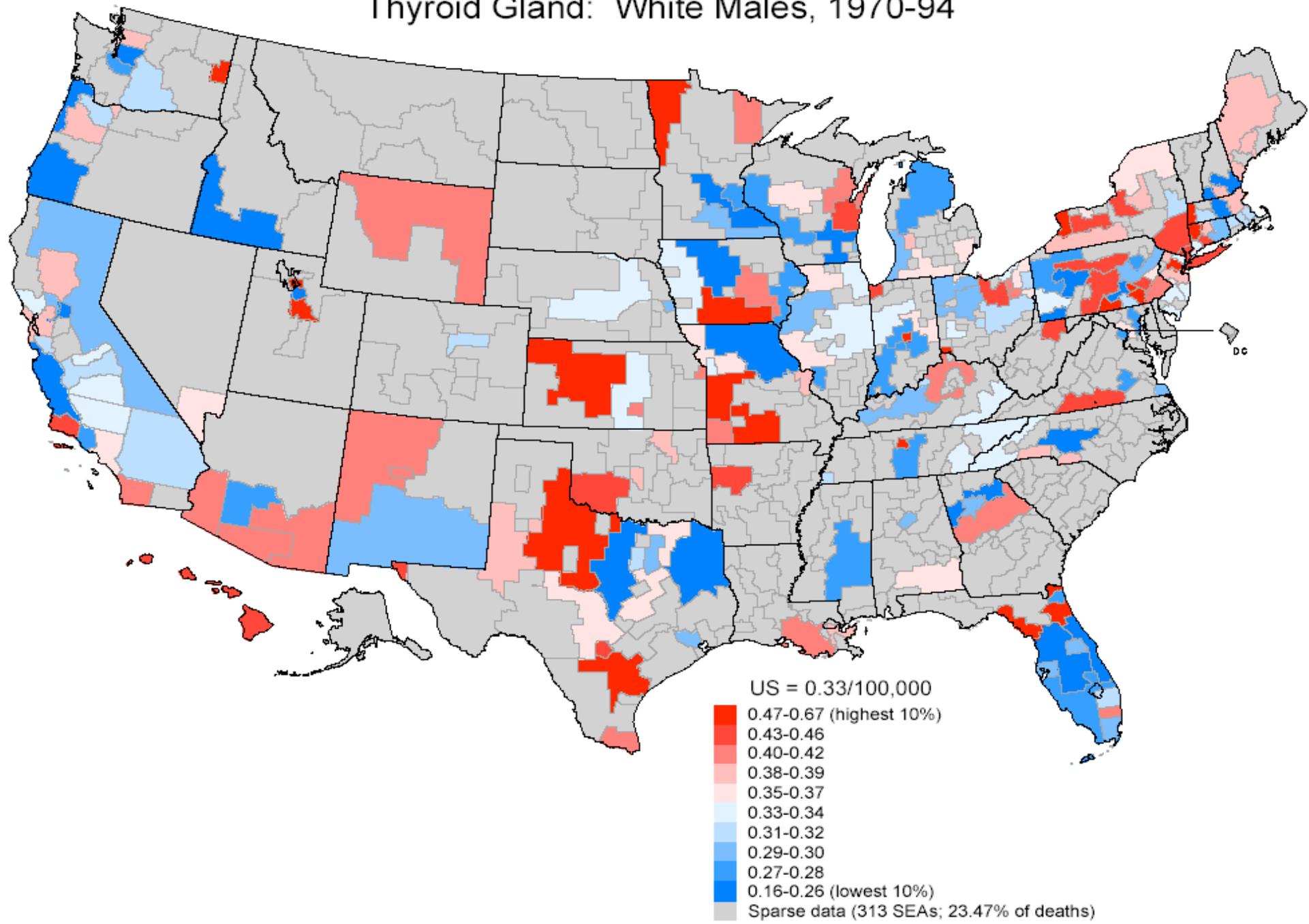
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Leukemia: White Males, 1970-94



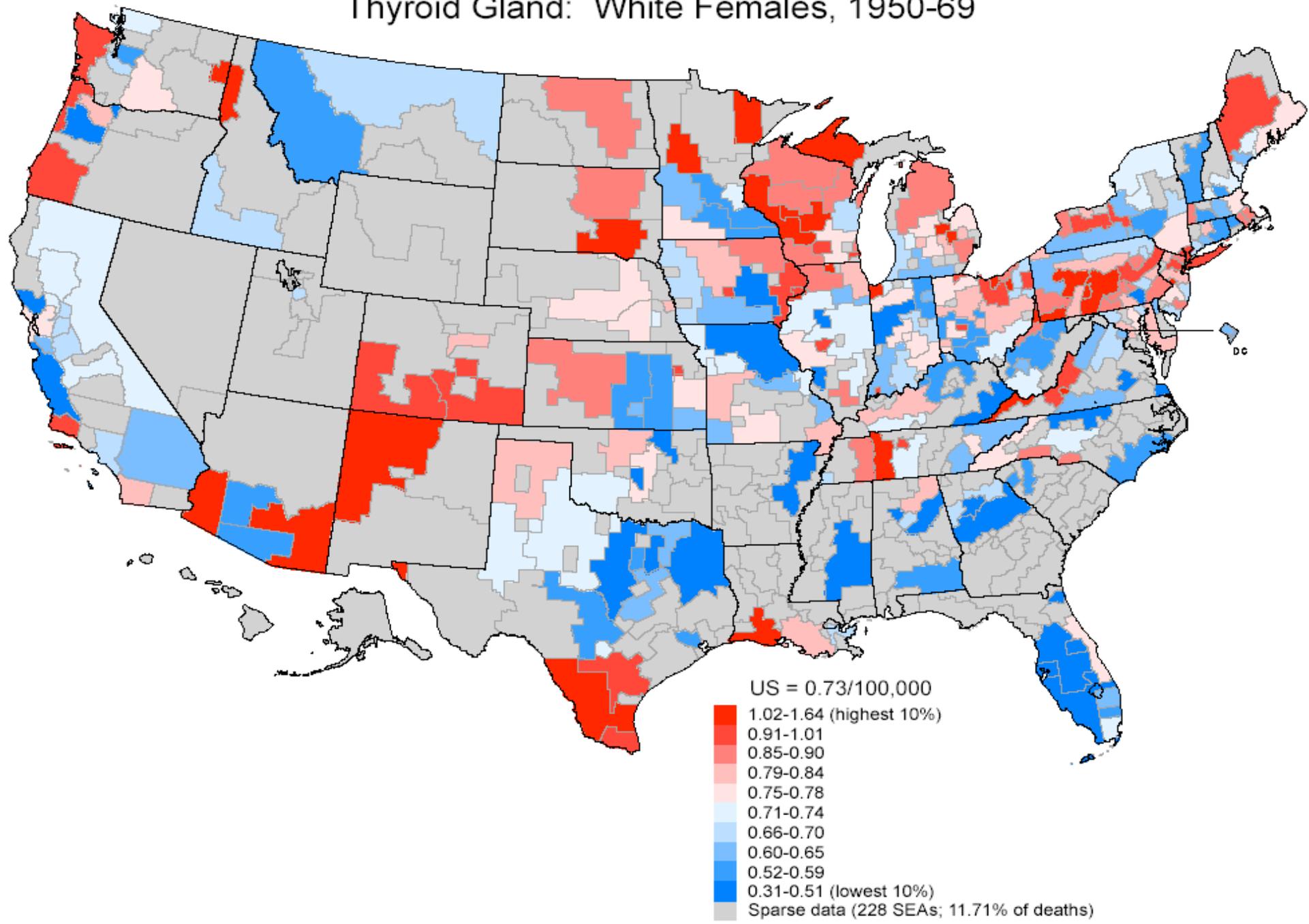
Cancer Mortality Rates by State Economic Area (Age-adjusted 1970 US Population)  
Thyroid Gland: White Males, 1950-69



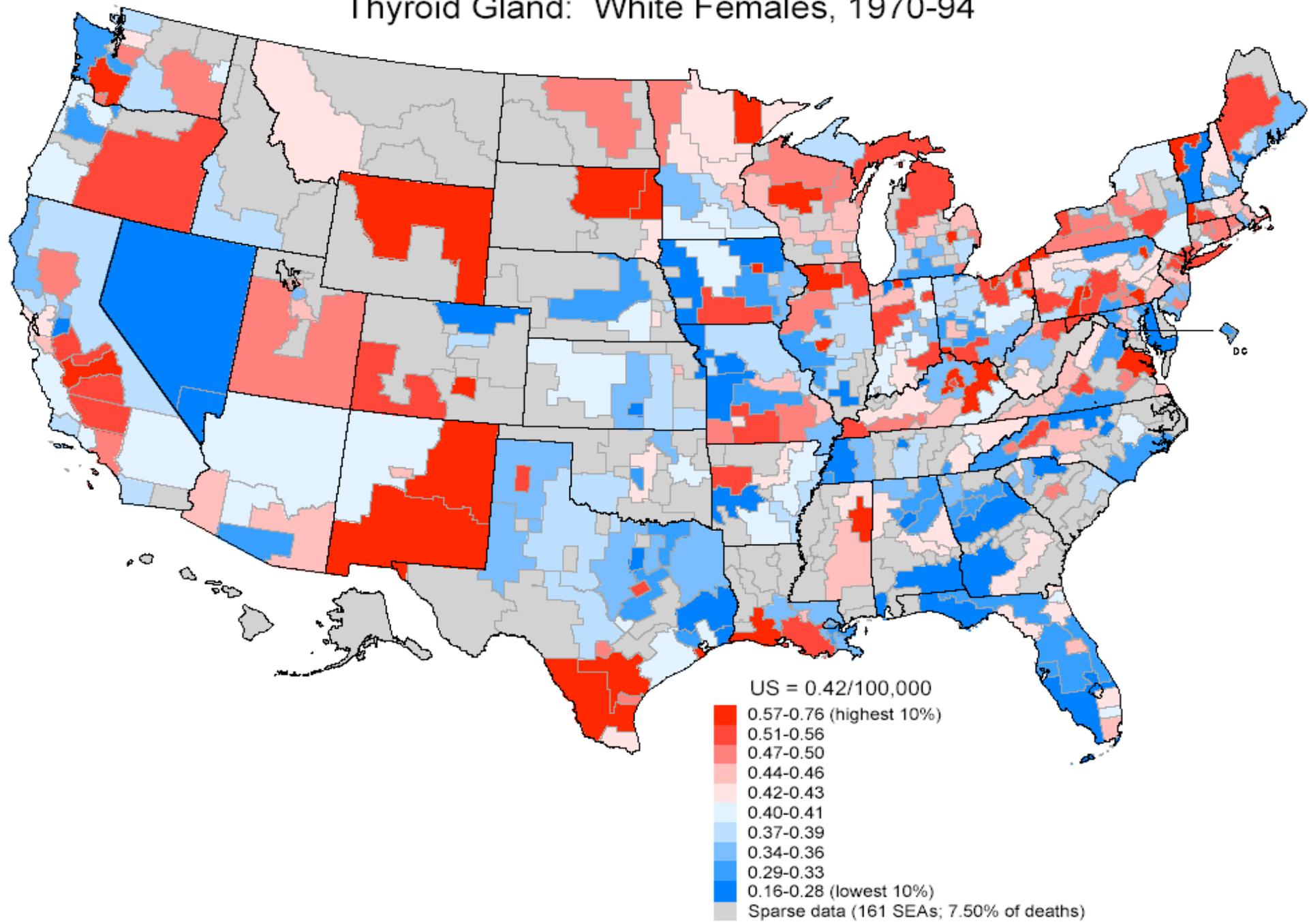
# Cancer Mortality Rates by State Economic Area (Age-adjusted 1970 US Population) Thyroid Gland: White Males, 1970-94



Cancer Mortality Rates by State Economic Area (Age-adjusted 1970 US Population)  
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# Cancer Mortality Rates by State Economic Area (Age-adjusted 1970 US Population) Thyroid Gland: White Females, 1970-94

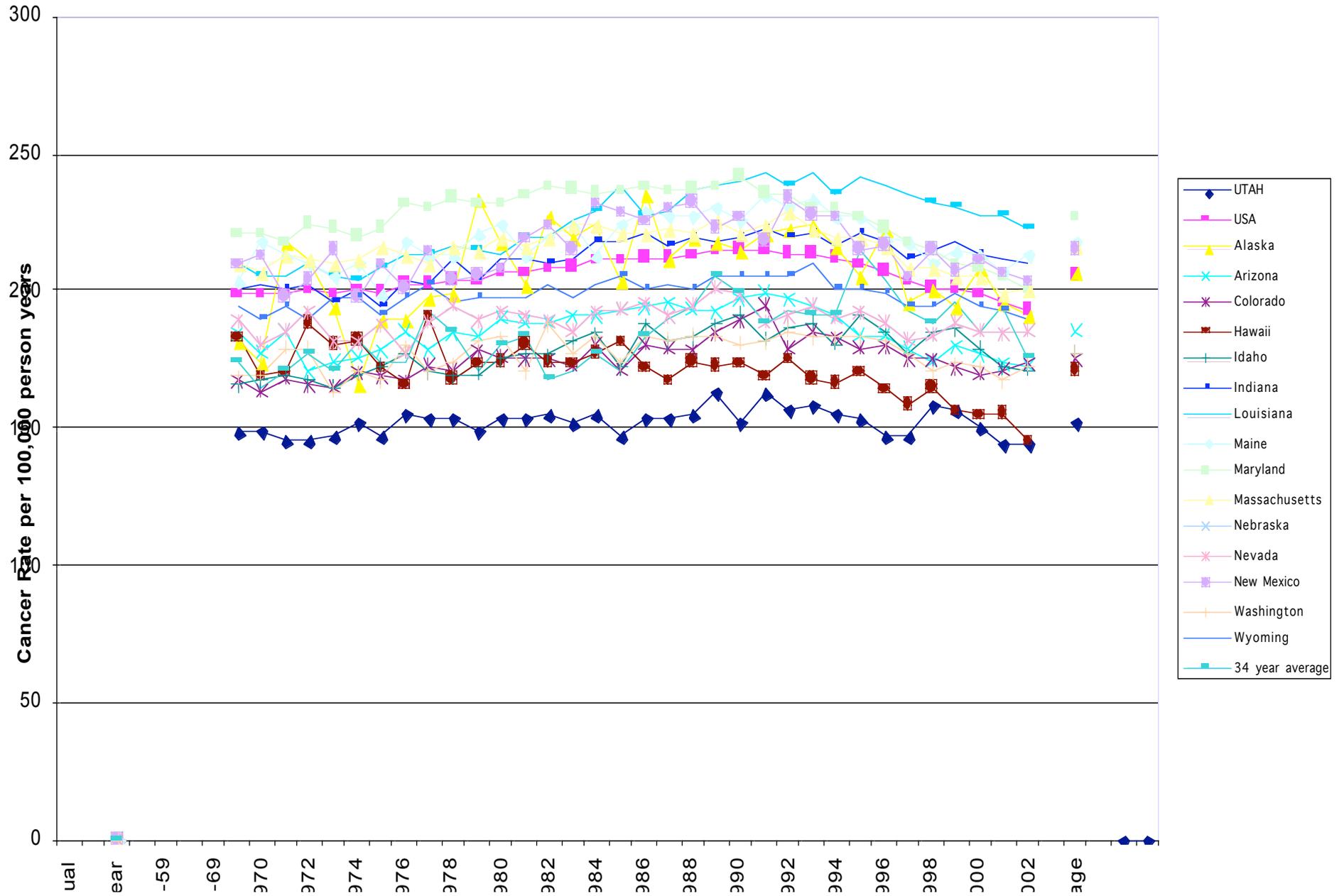




# Comparative Cancer Death Rates

Year	Utah	US	Alabama	Alaska	Arizona	Arkansas	California
1969	148.2	198.6	179.8	181.9	184.8	178.2	194.3
1970	148.9	198.8	178.0	173.9	177.8	177.3	196.9
1971	144.9	198.9	184.4	218.7	185.0	180.3	195.8
1972	145.1	200.4	188.0	212.2	170.1	180.4	196.3
1973	147.0	198.7	185.6	194.1	174.2	184.9	193.3
1974	152.5	199.9	188.0	166.7	175.6	196.7	198.4
1975	146.7	199.1	188.0	189.0	178.1	184.2	198.4
1976	155.4	202.3	189.5	189.3	185.5	187.6	200.3
1977	154.1	203.0	193.5	197.9	178.4	184.1	201.4
1978	154.3	204.4	196.5	198.9	184.9	188.6	203.9
1979	149.2	204.5	198.8	232.9	183.8	192.1	201.8
1980	153.6	207.0	205.5	217.4	190.0	195.3	204.1
1981	153.6	206.4	208.8	202.0	188.2	200.2	204.2
1982	154.8	208.3	207.6	227.1	188.4	199.7	209.0
1983	151.6	209.2	208.7	219.7	190.6	207.5	205.8
1984	154.6	210.9	216.8	224.4	191.2	203.9	209.6
1985	146.6	211.3	216.2	204.3	193.2	208.1	208.7
1986	153.7	211.8	218.6	235.2	193.7	207.7	208.1
1987	153.8	211.9	219.8	211.5	195.9	215.2	207.9
1988	154.6	212.6	220.2	219.6	193.3	217.9	205.4
1989	163.5	214.3	221.0	217.5	192.4	219.4	203.3
1990	152.0	214.9	219.4	214.3	197.0	224.2	202.9

Annual Age-Adjusted Cancer Death Rates by State, 1969-2002



# Percentages of cancer deaths attributed to various factors

Factor	Source of Estimate			
	Doll & Peto [2]	EPA [3]	Willett [3]	Ames et al. [3]
Diet	35 (10–70) <sup>1</sup>	–	32 (20–42)	20–40
Tobacco	30 (25–40)	–	–	35
Infection	10 (1–<10) <sup>2</sup>	–	–	–
Reproductive and sexual behavior	7 (1–13)	–	–	–
Occupation	4 (2–8)	1–4	–	5
• Ionizing radiation – 0.3 %				
Alcohol	3 (2–4)	–	–	–
Geophysical Factors				
• UV (sunlight on white skin) 1–2 %				
• Ionizing radiation <sup>3</sup> 1.4 % (cosmic, radon, + other radionuclides in air, our bodies & all natural materials, i.e., Natural Background)	3	3–6	–	–
Pollution	2 (<1–5)	1–3	–	–
Food Additives	1 (–5–2)	–	–	–
Medicines & medical procedures	1 (0.5–3)	–	–	–
Industrial (consumer) products	<1 (<1–2)	<1	–	–
Unknown	?	–	–	–

<sup>1</sup> The best estimate is presented followed by the 'range of acceptable estimates.'

<sup>2</sup> Doll & Peto considered these numbers very uncertain.

<sup>3</sup> Doll & Peto do not consider these cancers derived from 'natural background' avoidable.

# The Influence of Age on Cancer and Survival

