Geographic, Socioeconomic, and Racial Disparities in Cancer Survival

GIS and Public Health Day

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Outline

- Cancer Surveillance
- Cancer-Related Health Disparities
- Geographic Analysis of Health Disparities
- Case Study: Geographic Variation in Colorectal Cancer Survival

Cancer Surveillance

- A quantitative portrait of cancer and its determinants in a defined population (NCI)

- Core functions of cancer surveillance include measuring:
  - Incidence- How many people get cancer?
  - Mortality- How many people die from cancer?
  - Survival- How long do people live after they get cancer?

- Uses of high quality cancer surveillance data:
  - Alert us to populations in need of increased research.
  - Evaluate the impact of advances made in treatment and diagnosis, improved access to screening and treatment, or changes in risk exposure.
  - Describe temporal changes in incidence, stage, therapy, and survival

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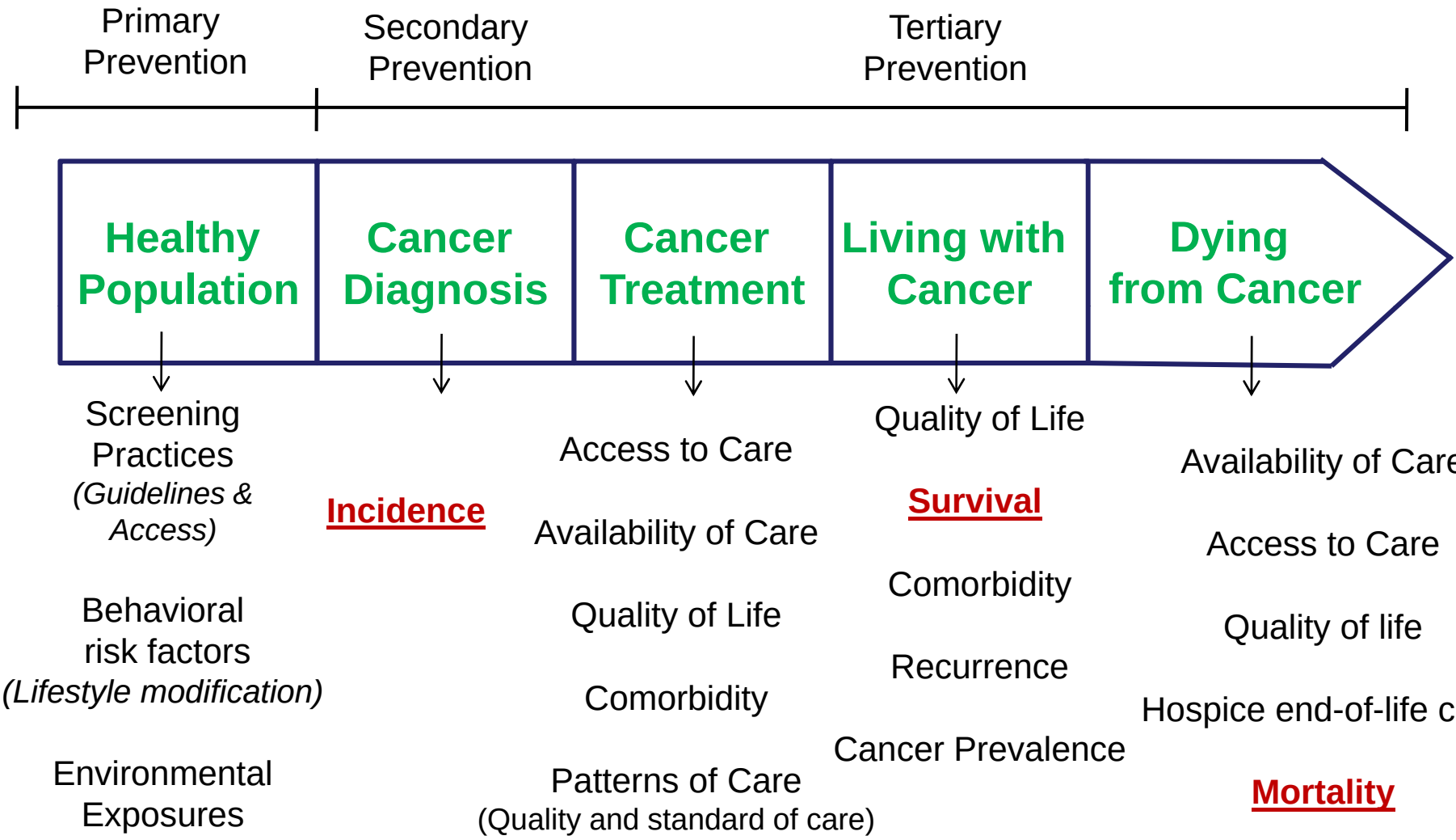
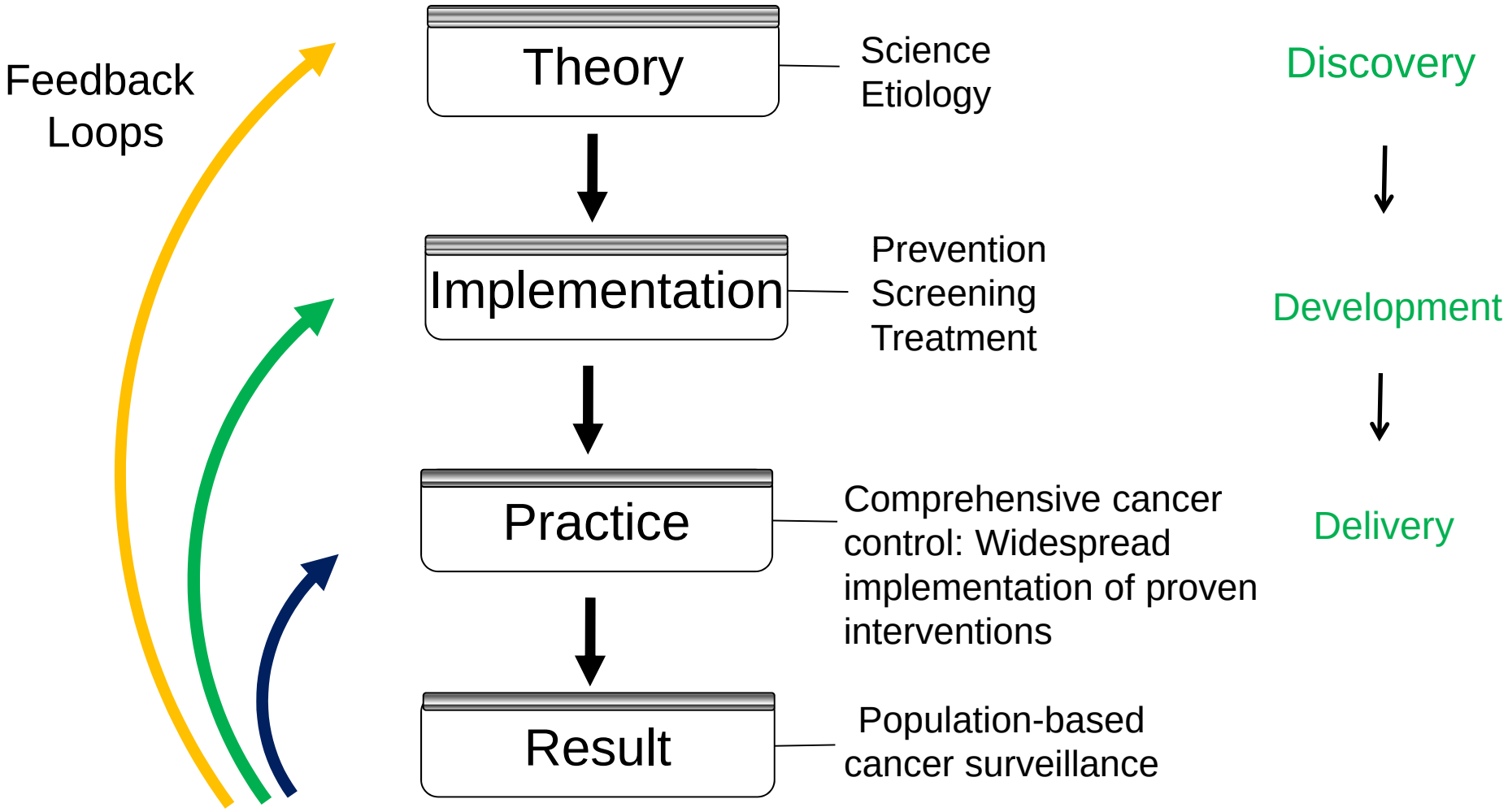
Expanded Scope for Cancer Surveillance



Adapted from Quantitative Methods in Cancer Surveillance, NCI , 2006

The Role of Cancer Surveillance in Cancer Research



Adapted from Quantitative Methods in Cancer Surveillance, NCI , 2006

Cancer-Related Health Disparities

- "Health disparities: differences in the incidence, prevalence, mortality, and burden of diseases and other adverse health conditions that exist among specific population groups." (NIH Strategic Research Plan and Budget to Reduce and Ultimately Eliminate Health Disparities, Vol. 1, Fiscal Years 2002–2006)

- Healthy People 2010 specify eliminating health disparities by gender, income and education, disability, geographic location, and sexual orientation in addition to race and ethnicity .

NCI definition of cancer disparities:

"adverse differences in cancer incidence (new cases), cancer prevalence (all existing cases), cancer death (mortality), cancer survivorship, and burden of cancer or related health conditions that exist among specific population groups in the United States"

Measuring Health Disparities

Relative disparity: e.g. relative risk

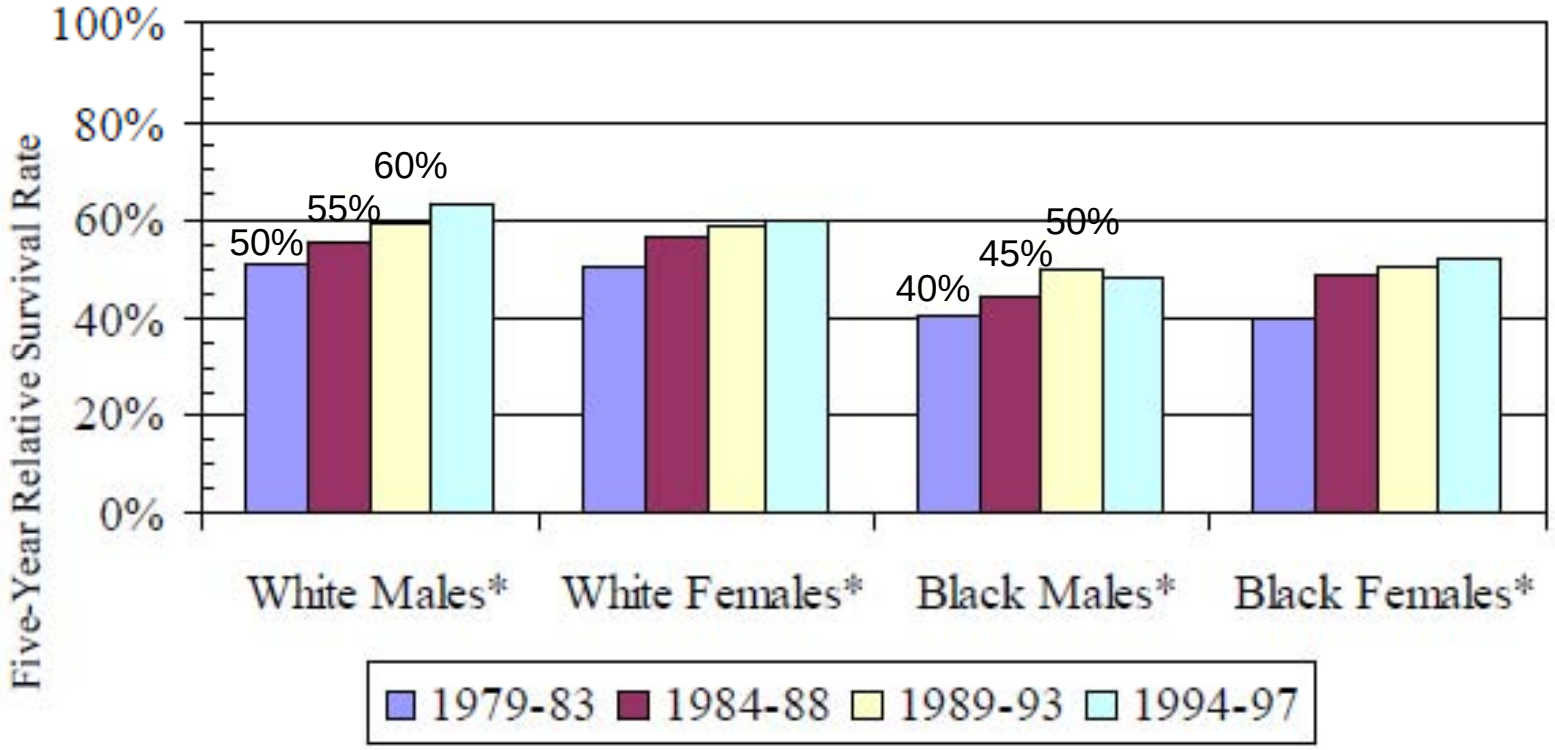
- Measure of “effect size”
- Disparity is relative to the rate in the comparison group.
- Most frequent method of communicating information about disparities

Absolute disparity: e.g risk difference; Between-Group Variance (BGV)

Important to state which measure(s) you use, specifically when examining temporal trends.

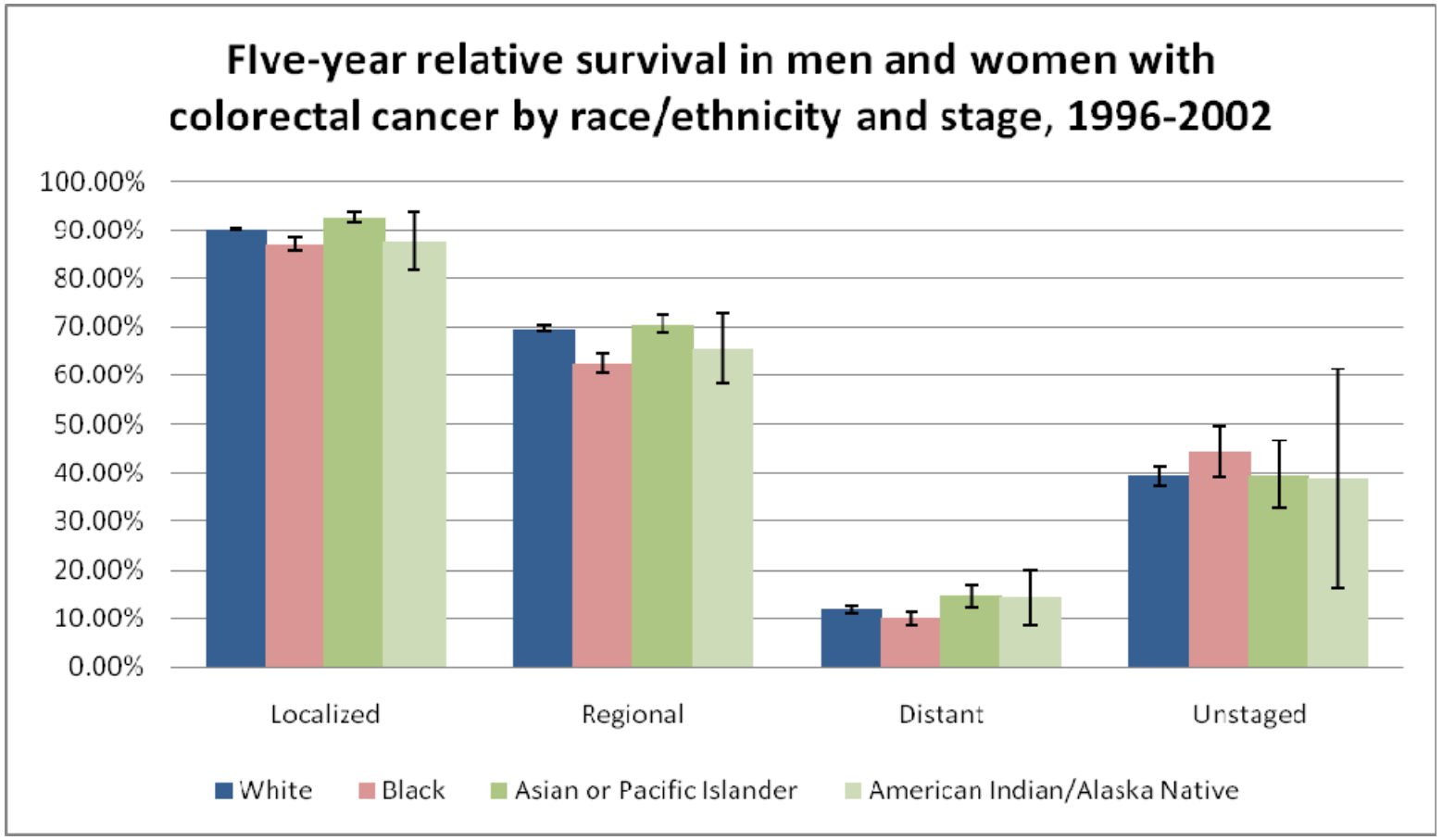
Cancer Health Disparities

Colorectal cancer Five-Year Relative Survival Trends by Race and Sex, 1979-1997



Source: Niu et al , Source: New Jersey State Cancer Registry, New Jersey Department of Health and Senior Services, 2006

Cancer Health Disparities



Source: SEER 11, 2010

Cancer-Related Health Disparities

Possible Causes of Disparities:

- Differences in environmental exposures
- Discrimination preventing access to diagnosis and care
- Inequalities in socio-economic status
- Neighborhood deprivation
- Social and cultural attitudes about health and the health care system
- Local health care supply
- Access to prevention care and treatment
- Differences in risk-behavior and diet
- Quality of medical care

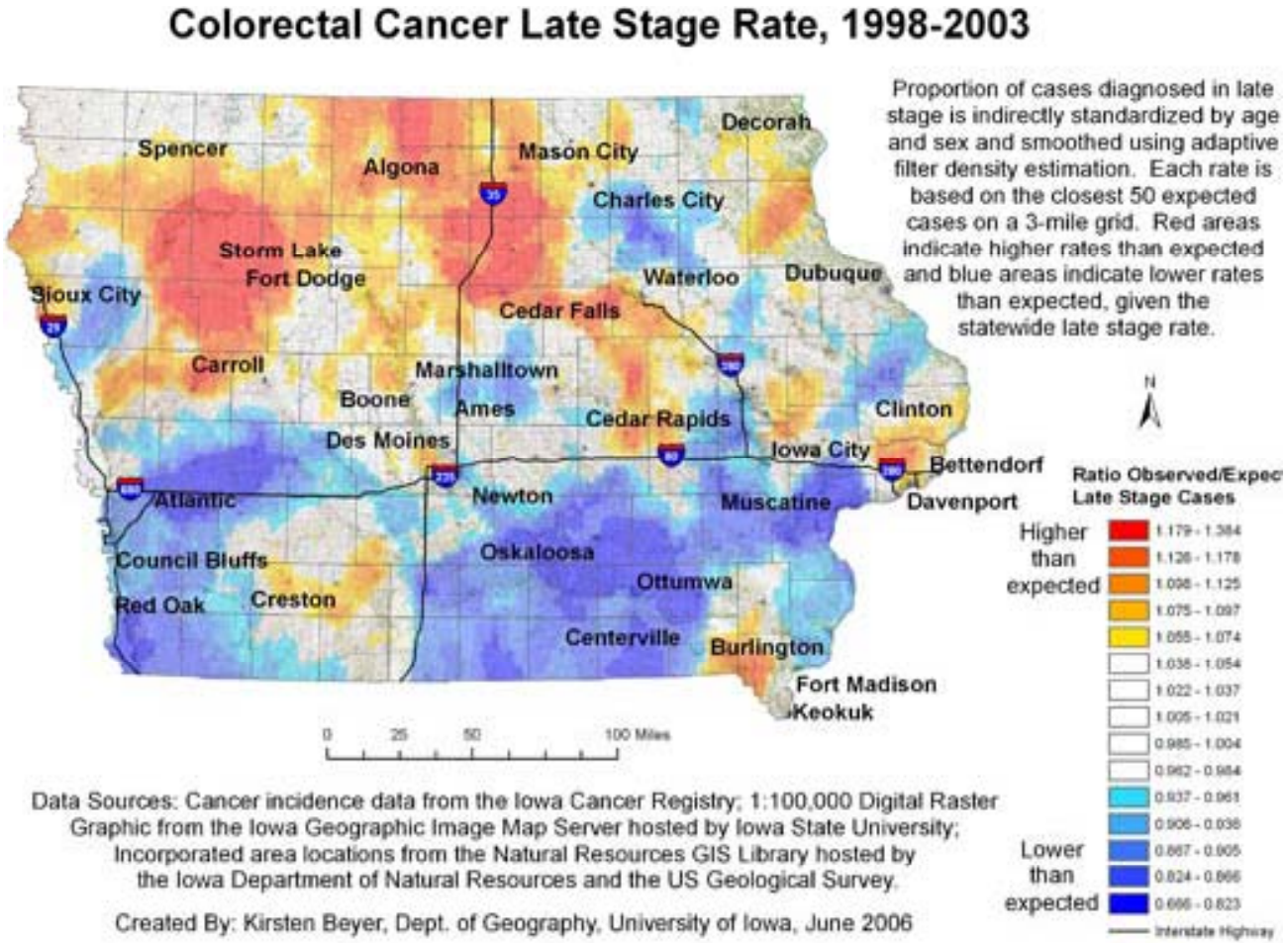
Geographic Analysis of Cancer Data

Why Geographic Analysis?

- Identify broad spatial patterns (descriptive)
- Hypothesis generation (cause of pattern)
- Define and compare patterns (health disparities)
- Changing pattern over time (cancer control)
- Allows research, prevention, intervention, and treatment activities to be targeted more effectively
- Communicate cancer information to health officials, elected officials, and the public.

Geographic Analysis of Cancer Data

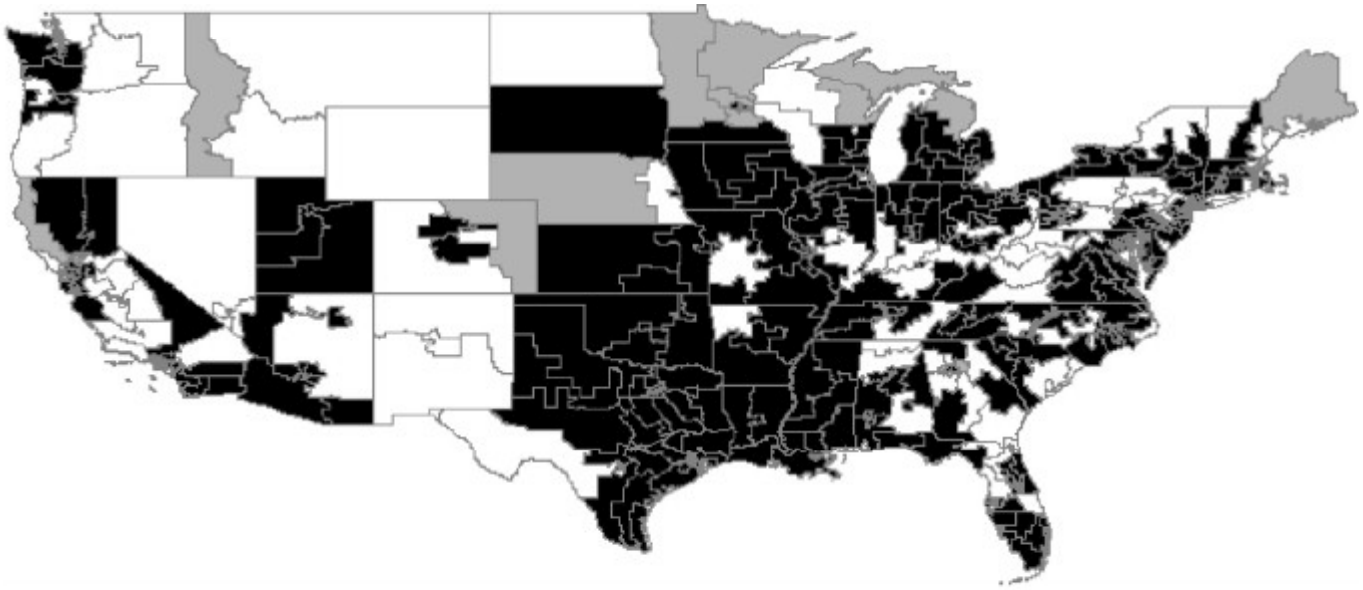
Adaptive spatial filter density estimation



Source: Beyer KMM, Rushton G. Mapping cancer for community engagement. Prev Chronic Dis 2009;6(1). http://www.cdc.gov/pcd/issues/2009/jan/08_0029.htm. Accessed March 21, 2010

Geographic Analysis of Cancer-Related Disparities

Lung cancer mortality in U.S. congressional districts, 1990–2001



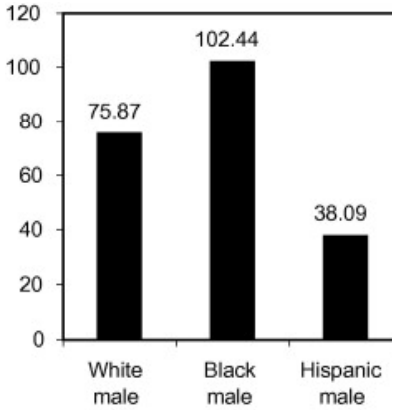
Black males have higher mortality rates compared with white males (p≤0.05)

Black males have lower mortality rates compared with white males (p≤0.05)

No statistically significant difference between black and white male mortality rates

Note: Black (non-Hispanic) males are the target group and white (non-Hispanic) males are the reference group. Rates age-adjusted to 2000 U.S. population.

Age-Adjusted Mortality Rate

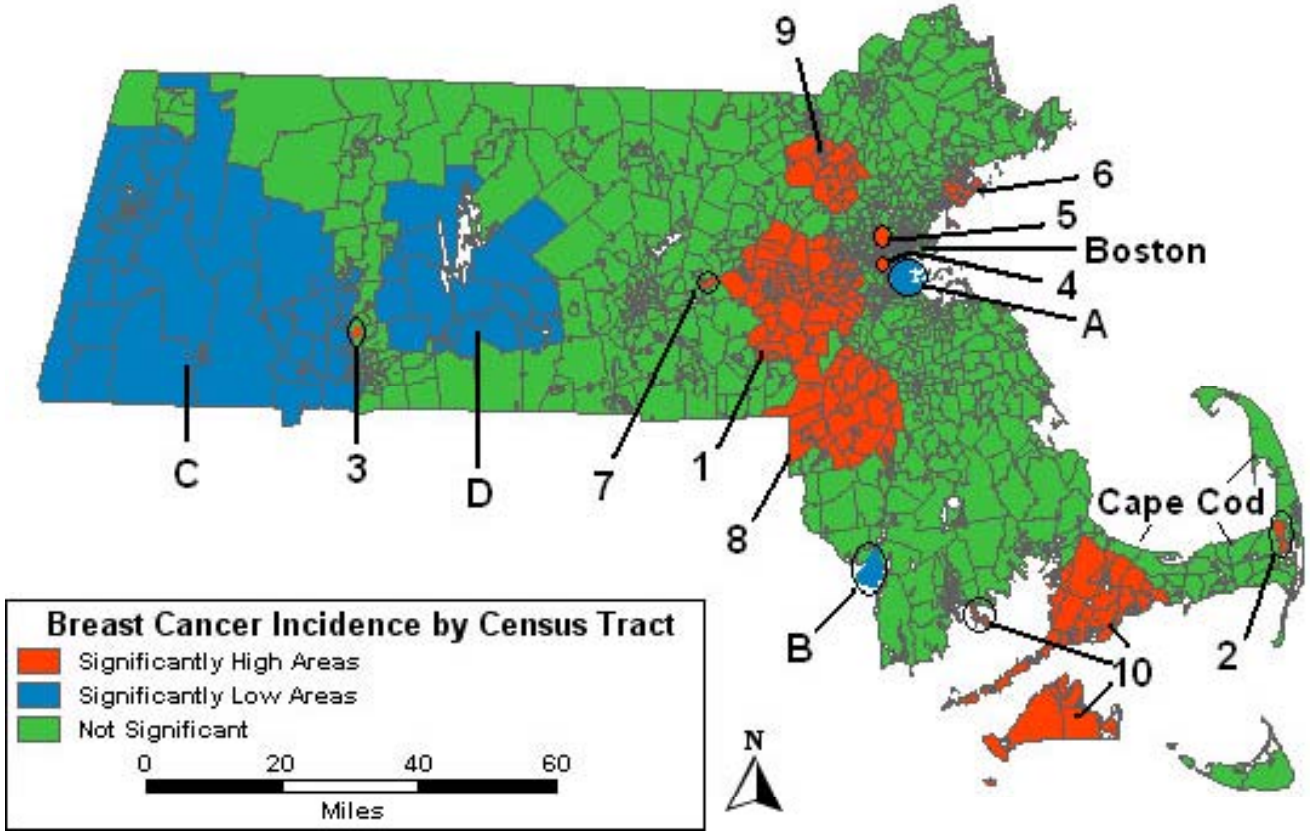


Source: Racial disparities in lung cancer mortality in U.S. congressional districts, 1990-2001.
Gallagher CM, Goovaerts P, Jacquez GM, Hao Y, Jemal A, Meliker JR.. Spat Spattemporal Epidemiol. 2009;1(1):41-47

Geographic Analysis of Cancer-Related Disparities

Cluster Detection:

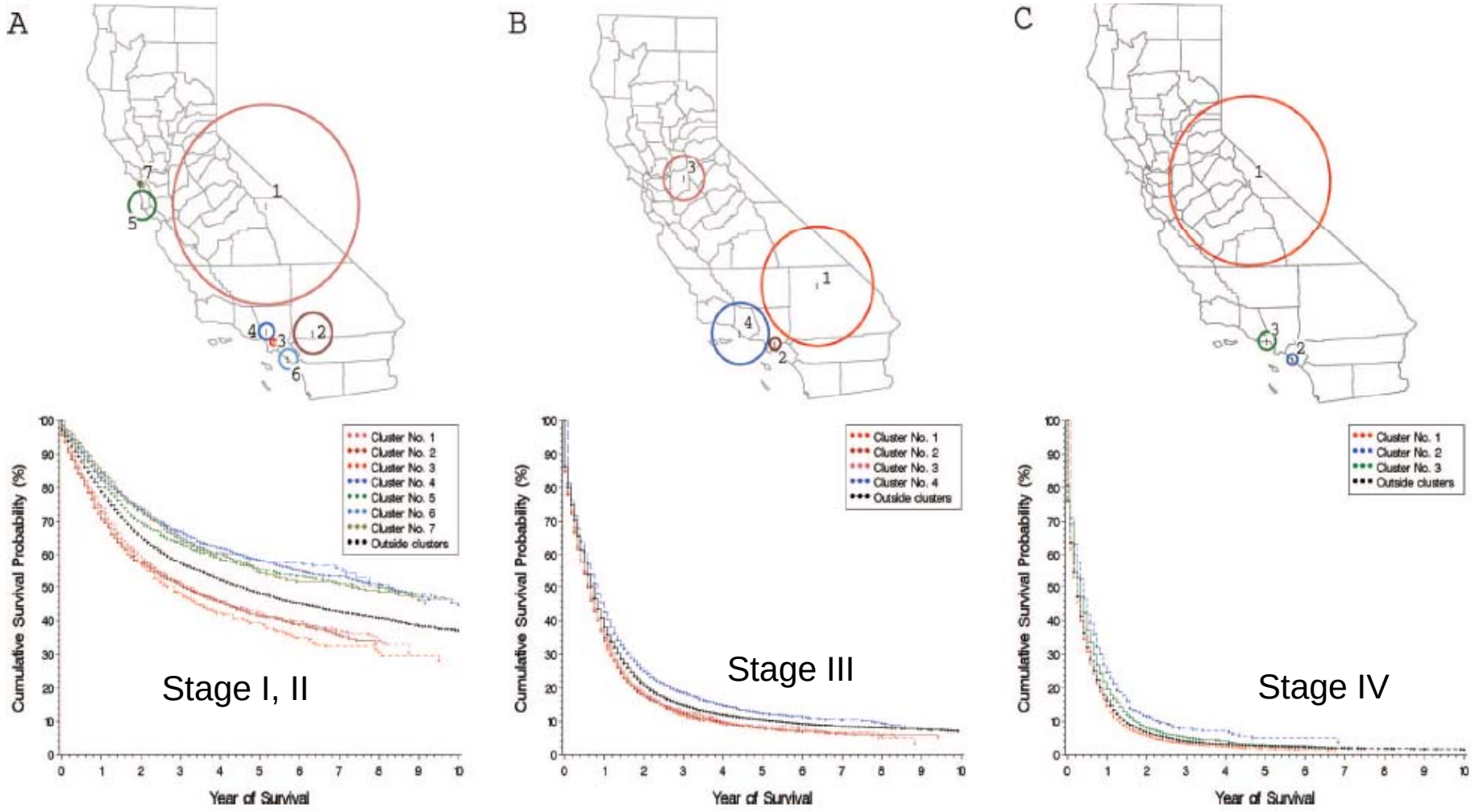
Age-adjusted analysis of breast cancer incidence
in Massachusetts from 1988 to 1997



Source: Joseph Sheehan *et al. International Journal of Health Geographics* 2004 **3**:17 doi:10.1186/1476-072X-3-17

Geographic Analysis of Cancer-Related Disparities

Spatial Clusters of Survival for Patients Diagnosed with Lung Cancer (1988-2002)



Source: Detection of Spatial Clusters. Huang, L Pickle, L; Stinchcomb, ; Feuer, E. Epidemiology,18, 1. January 2007

Case Study:
Detecting Geographic Disparities in Colorectal Cancer Survival: New Jersey, 1996-2003

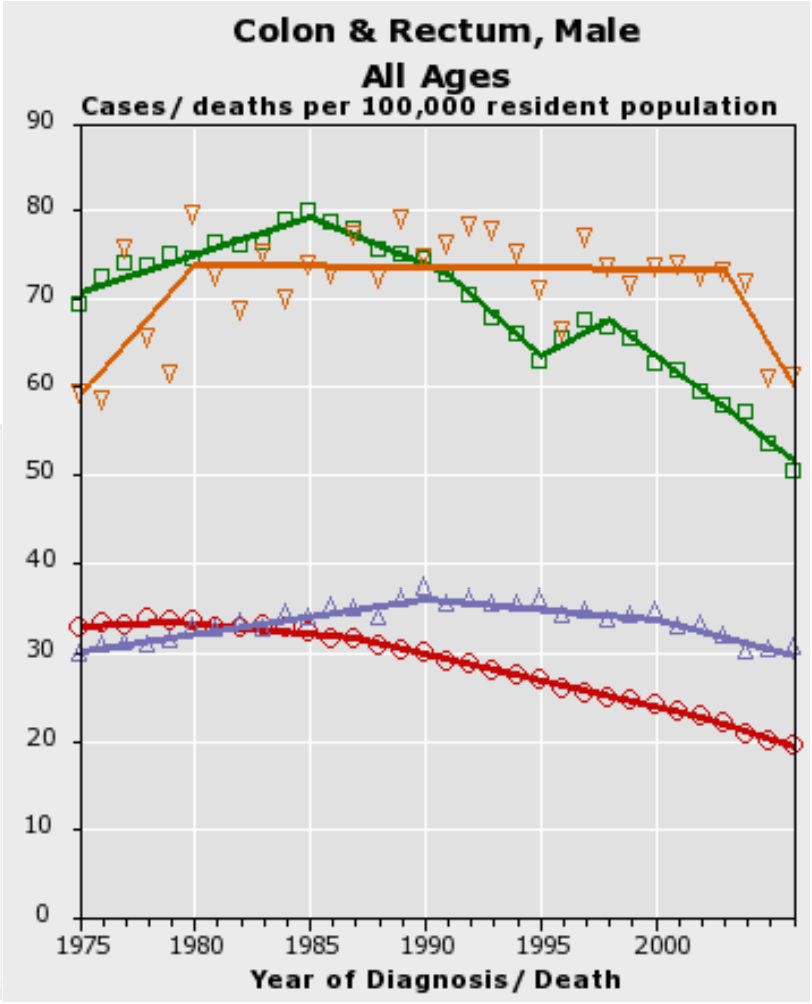
Background

- Cancers of the colon and rectum (CRC) are the second leading cause of cancer deaths among men and women in the US (49,920 deaths each year; 146,970 new cases)

- Significant progress in reducing CRC incidence and mortality rates

- An unequal CRC burden is borne by blacks, relative to whites, and by individuals of lower socioeconomic position
  - Higher incidence and mortality rates
  - Greater percentage diagnosed at advanced stage
  - Poorer survival rates

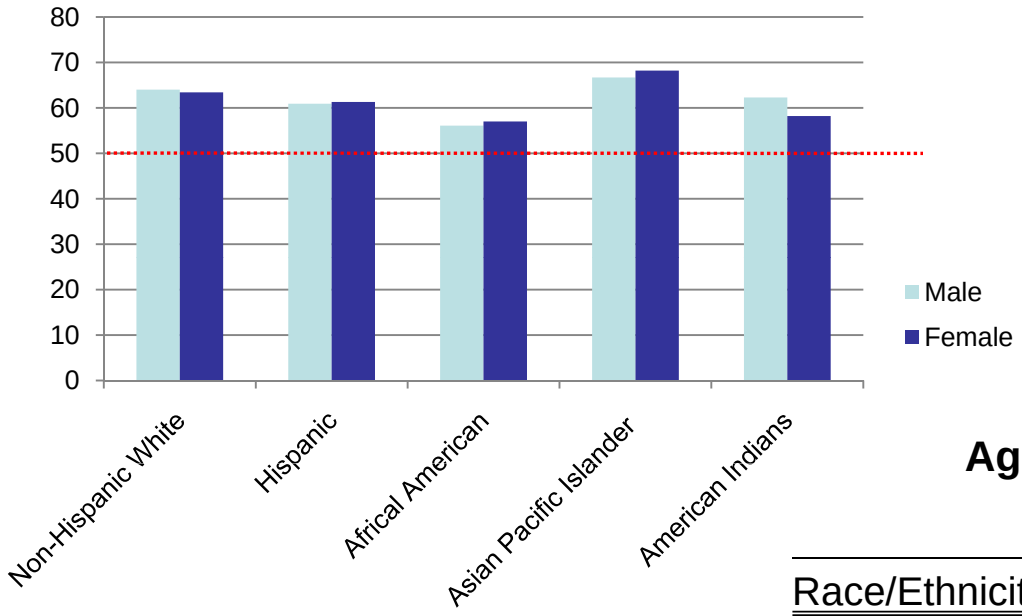
Background



Source: Source: Incidence data provided by the SEER Program. (http://seer.cancer.gov) Rates calculated by the National Cancer Institute using SEER*Stat. (http://seer.cancer.gov/seerstat/) Rates are age-adjusted to the 2000 US standard population (http://www.seer.cancer.gov/stdpopulations/single_age.html) (19 age groups: <1, 1-4, 5-9, ... , 80-84, 85+).

Background

Five –year Colorectal 'Cancer Specific' Survival



Age and Stage-Adjusted Relative Risk of CRC Deaths (1992-2000)

Race/Ethnicity	**Male**	**Female**
Non-Hispanic White	Reference	Reference
Hispanic	1.05 (0.99-1.11)	1.05 (0.99, 1.11)
African American	**1.26 (1.2-1.32)***	**1.18 (1.13, 1.23)***
API	0.95 (0.9-1.0)	**0.9 (0.85, 0.96)***
American Indians	1.14 (0.95,1.35)	**1.38 (1.16, 1.64)***

Source: Annual report to the nation on the status of cancer, 1975-2001, with a special feature regarding survival. Jemal A, Clegg LX, Ward E, Ries LA, Wu X, Jamison PM, Wingo PA, Howe HL, Anderson RN, Edwards BK. Cancer. 2004 Jul 1;101(1):3-27.

Background

- Survival disparities may reflect:
  - More aggressive tumor and more advanced stage
  - Differences in access to and receipt of quality and recommended treatment; and post treatment follow-up
  - Comorbidity
  - Individual risk factors (diet, smoking, exercise)
  - Neighborhood or area-based characteristics

Background

- Survival analysis methods utilized for cancer surveillance most often focus on:

Group having the worst survival

high poverty areas vs. low poverty areas

rich vs. poor

treatment A vs. treatment B or treatment C

old vs. young

private insurance vs. no insurance or Medicaid

white vs. black

early stage vs. advanced stage

Background

- Geographic disparities in survival have been observed in several international and US studies for several cancer sites including CRC
- Physical, social, behavioral factors linked by geography can assist or impede patient survival.
- Shorter than expected survival in certain locations may highlight high rates of harmful behavioral risk factors and/or poor access and poor quality of care.
- Longer than expected survival may highlight protective factors and possibly advanced clinical care and better post treatment follow-up

Study Purpose

- Utilize an extension of the spatial scan statistic (Huang et al.) designed for time-to-event data to identify whether colorectal cancer (CRC) survival varies by place of residence in New Jersey

- Generate hypotheses about the underlying causes of possible geographic disparities in CRC survival

Study Question:

Are there geographical areas with exceptionally short or long CRC survival after adjusting survival times for significant prognostic factors?

Methods

Cancer cases

- New Jersey residents
- Histologically confirmed, first primary, invasive tumor of the colon or rectum (ICD-O C18.0–C20.9, C26.0, excluding histologies 9590–9989)
- Localized or regional stage diagnosis
- Diagnosed from January 1, 1996 - December 31, 2003
- Source: New Jersey State Cancer Registry

Exclusions

- Death certificate only
- Unknown follow-up date
- No address
- Other and unknown races (including American Indians)
- Missing age at diagnosis

Methods

Individual level case variables

- Cause of Death (ICD-9, & 10)
- Date of diagnosis
- Vital status
- Date of last contact
- Age (continuous)
- Race/Ethnicity: (Non-Hispanic White; Non-Hispanic Black, Hispanic, Asian/Pacific Islander)
- Cancer stage (SEER Summary)

Census tract (CT) area-based measure

Percent living below poverty

Low	**Q1:**	<3%
	Q2:	>3% - <5.5%
	Q3:	>5.5% - <12%
High	**Q4:**	>12%

Case Geocoding

Full Street Address	95.4%
Zip code imputed to CT	3.6%
Zip codes with only one CT	1.1%

Methods

Cancer specific survival

Deaths from causes other than diagnosed colon or rectum were censored at the time of death

Case follow-up

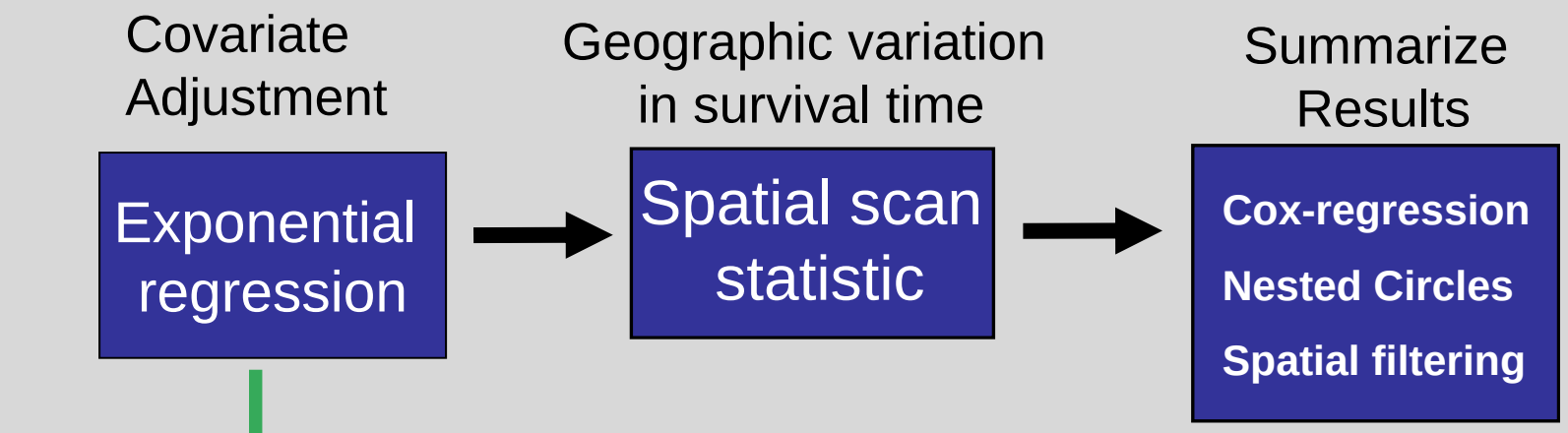
- Cases followed until December 31, 2007
- Completeness of vital status follow-up: 96%

Follow-up sources

- State and national death files
- State taxation file,
- Hospital discharge files
- Medicare and Medicaid files
- Social Security Administration Services
- Motor vehicle registration records
- Annual follow-up from reporting hospitals

Methods

Analysis Workflow



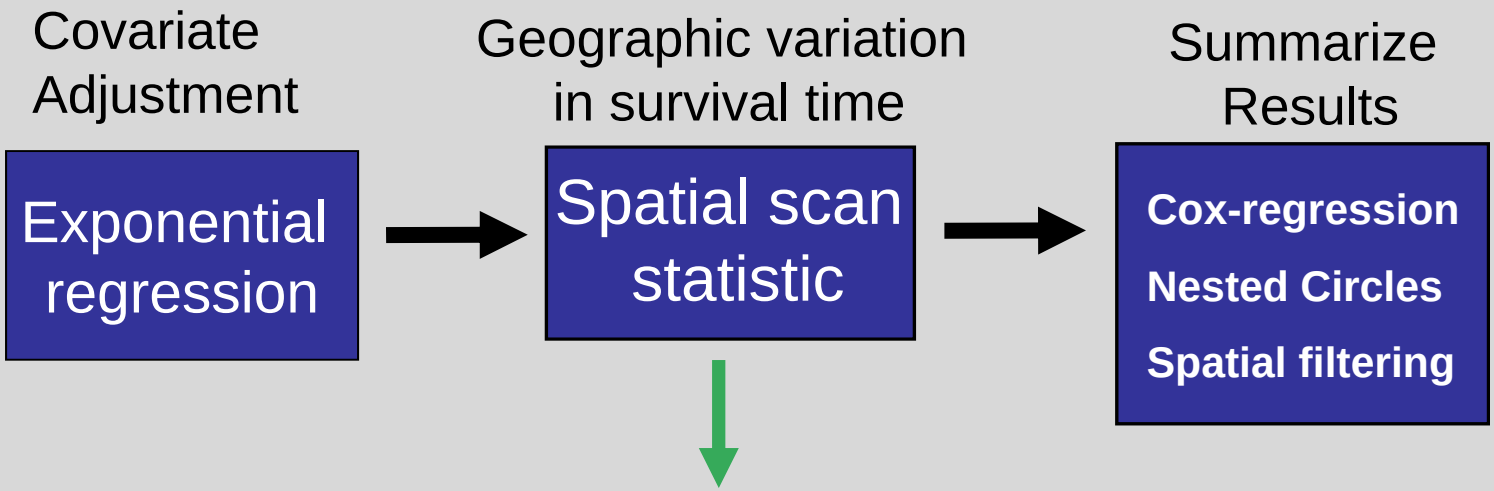
Models:

1. Age, sex, stage
2. Age, sex, stage, race/ethnicity
3. Age, sex, stage, race/ethnicity, area poverty

Proc lifereg (SAS v.9.1)

Methods

Analysis Workflow

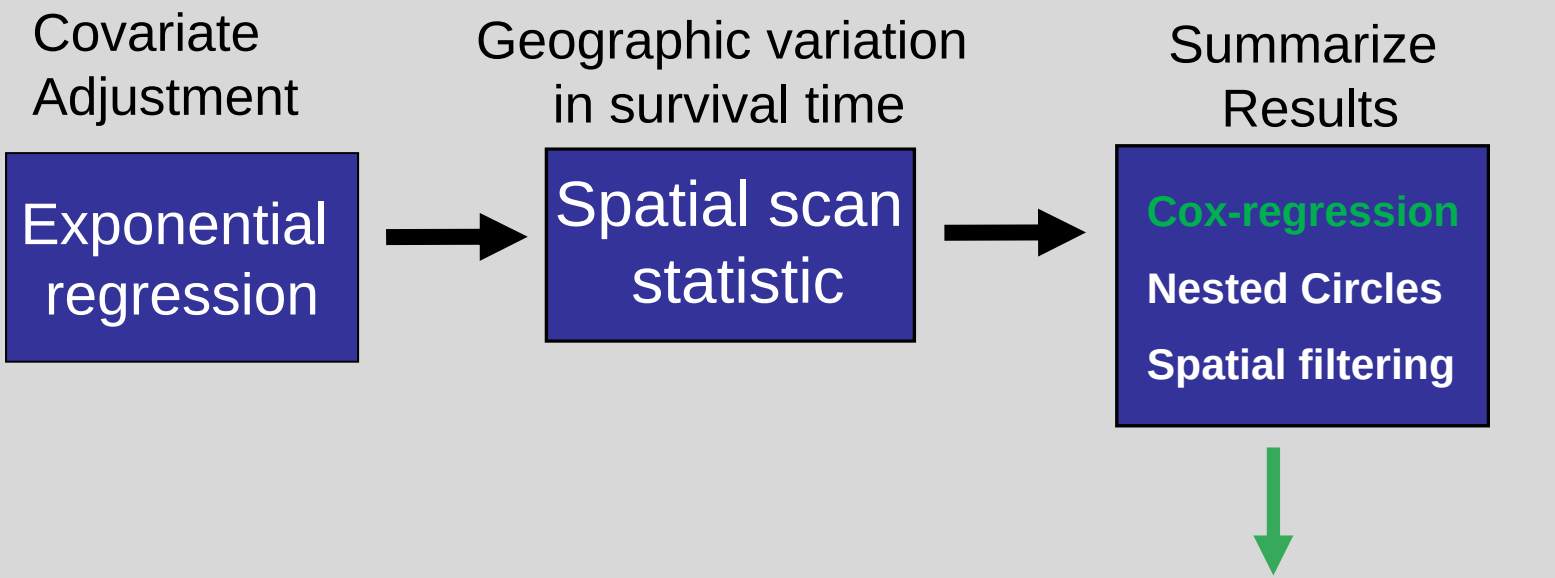


-SaTScan *v7.03*
-Input: adjusted survival time for each model
-Probability model: exponential
-Short or long survival areas
-No cluster reporting restrictions
-Randomization: permutation of survival time across locations (1000 times)

Source:Huang L, Kulldorff M, Gregorio D. A spatial scan statistic for survival data. Biometrics, 2006

Methods

Analysis Workflow



-Adjusted five-year survival rates (Zhang et al., 2007)

Methods

Analysis Workflow

Covariate Adjustment

Exponential regression

Geographic variation in survival time

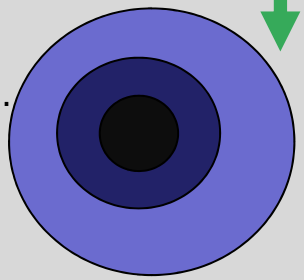
Spatial scan statistic

Summarize Results

Cox-regression

Nested Circles

Spatial filtering

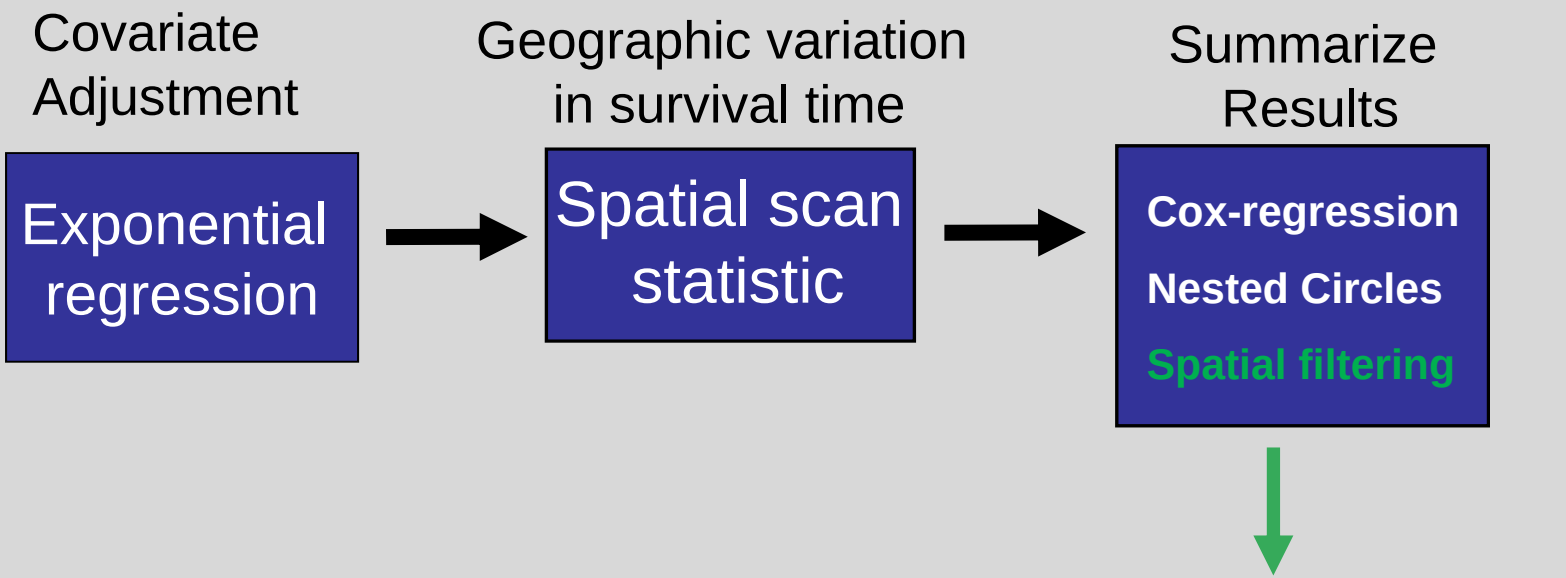


1.Select statistically significant areas (<=0.05)
2.Stratify into equal risk intervals risk (obs/exp CRC deaths).
3.For each interval map areas with highest likelihood ratio (lowest p value) .
4.Map areas with lower likelihood ratios if they don't overlap previous areas within the same risk interval.

Source: Boscoe FP, McLaughlin C, Schymura MJ, Kielb CL: **Visualization of the spatial scan statistic using nested circles.** *Health Place* 2003, **9**(3)**:**273-277

Methods

Analysis Workflow



-Ratio of observed/expected CRC deaths (obs/exp)
-Adaptive spatial filtering (DMAP IV)

Source: DMAP IV, Cai and Rushton, 2007; http://www.uiowa.edu/~gishlth/DMAP4/

Results

Case characteristics

	Registry Population N=35, 886		Survival Analysis N=25,040	
	n	%	n	%
Age (mean) ±SD	69.8 ±13.2		69.1 ±13	
Gender				
Male	17,611	49.1	12,423	49.6
Female	18,275	50.9	12,617	50.4
Race/Ethnicity				
Non-Hispanic White (NHW)	29,194	81.4	20,620	82.4
Non-Hispanic Black (NHB)	3,732	10.4	2,464	9.8
Hispanic	2,040	5.7	1,444	5.8
API	720	2.0	512	2.0
Other, Not Specified	200	0.56	0	0.0
Missing	0	0	0	0.0
SEER Summary Stage				
Localized	11,816	32.9	11,308	45.2
Regional, direct extension	6,345	17.7	6,001	24.0
Regional , lymph nodes only	2,882	8.0	2,780	11.1
Regional direct extension and regional lymph nodes	4,848	13.5	4,658	18.6
Regional, Nos	313	0.87	293	1.2
Distant	6,212	17.31	0	0
Missing stage	3,470	9.7	0	0
Death Certificate Only Cases	397	1.1	0	0

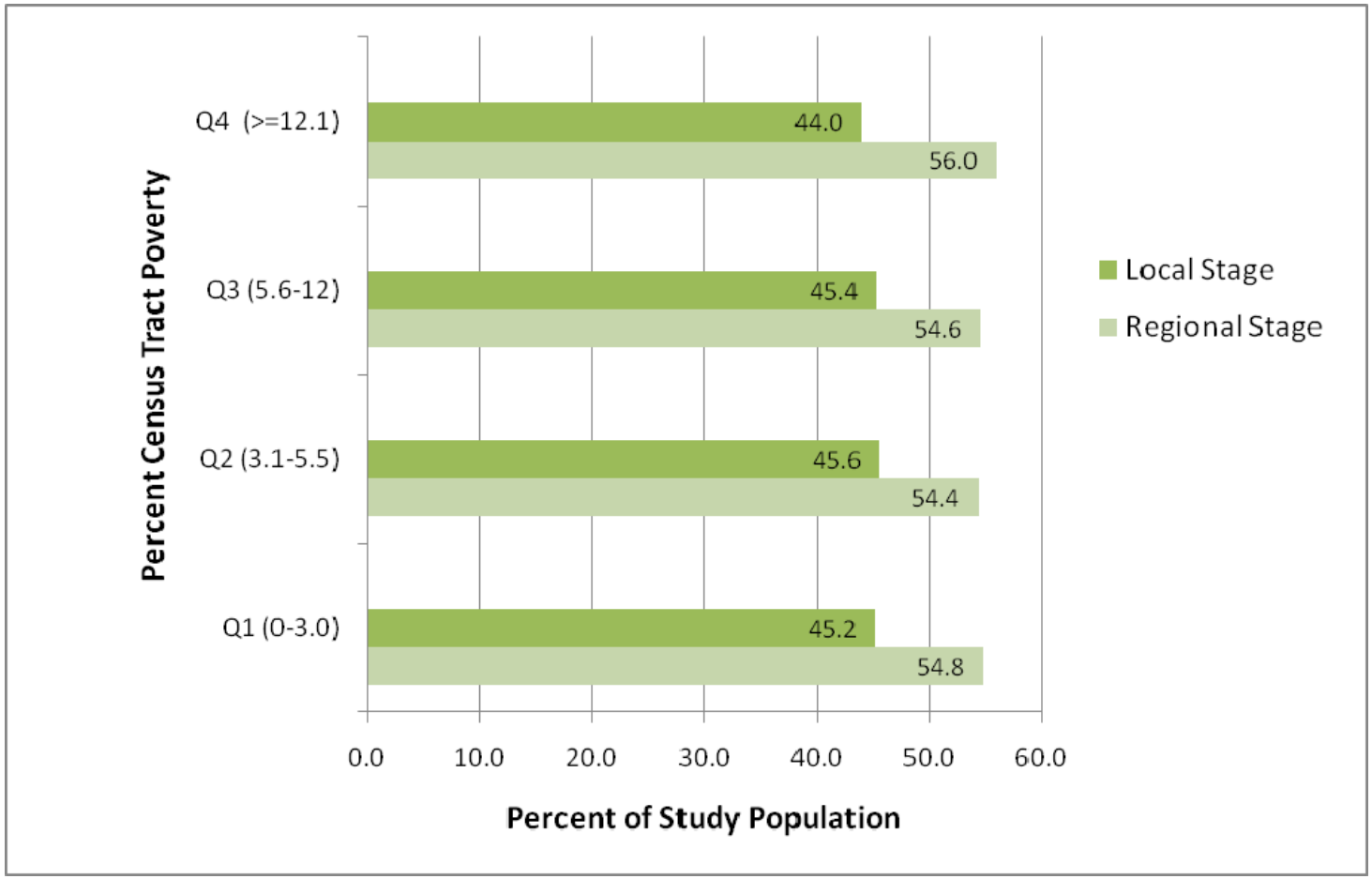
Results

Case characteristics and five-year survival

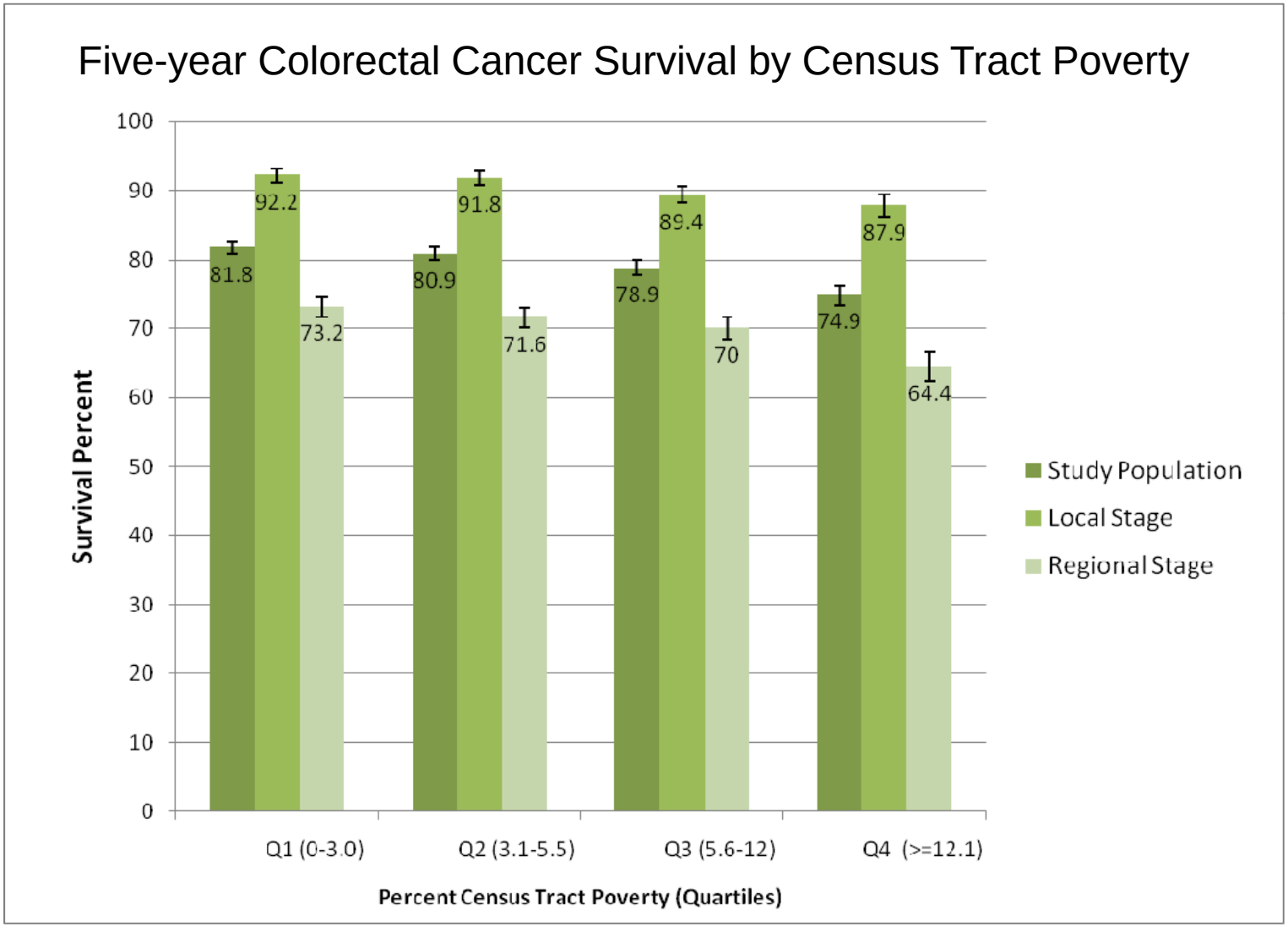
	Study Population **5 Year Survival (95%CI)**	% Cases	Local Stage **5 Year Survival (95%CI)**	% Cases	Regional Stage **5 Year Survival (95%CI)**
	n=25,040		n=11,308		n=13,732
Total population	79.6 (79.1, 80.2)	45.2	90.7 (90.1, 91.2)	54.8	70.4 (69.5, 71.2)
Sex					
Male	80.2 (79.5, 81.0)	45.9	90.9 (90.0, 91.7)	54.1	71.1(69.8, 72.7)
Female	79.0 (78.2, 79.4)	44.4	90.4 (89.6, 91.2)	55.6	69.8 (68.6, 71.0)
P value from Log-rank	0.01		0.79		0.03
Race/Ethnicity					
Non-Hispanic White	83.2 (79.6, 86.9)	45.5	**92.2** (87.9, 96.5)	54.53	**77.6** (72.4, 82.8)
Non-Hispanic Black	75.6 (73.9, 77.6)	45.1	**87.6** (85.4, 89.7)	54.95	**65.7** (62.9, 68.6)
Hispanic	79.1 (76.8, 81.4)	43.7	**90.1** (87.6, 92.6)	56.23	**70.5** (67.1, 74.0)
API	80.0 (79.4, 80.6)	37.1	**91.0** (90.3, 91.6)	62.89	**70.7** (69.8, 71.7)
P value from Log-rank	**<0.0001**		**0.009**		**0.0002**

Results

Study Population (N=25,040):
Stage Distribution by Census Tract Poverty



Results

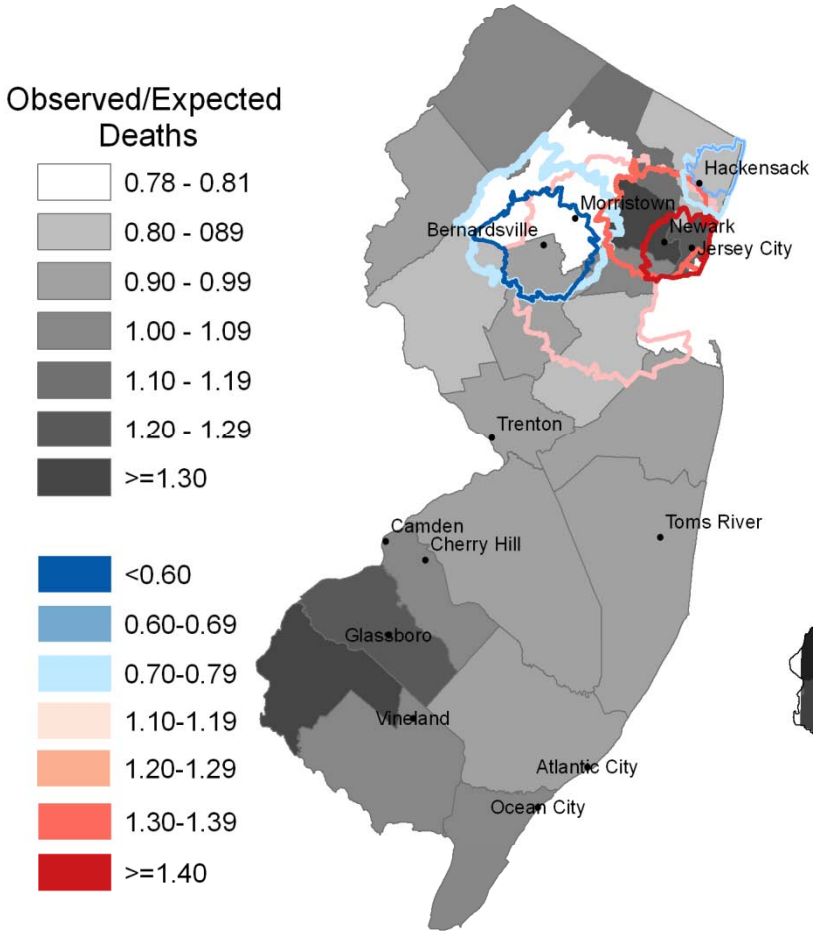


*P value from Log-rank <0.001; Cause-specific survival; N=25,040

Results

Areas with Statistically Significantly Shorter or Longer CRC Survival

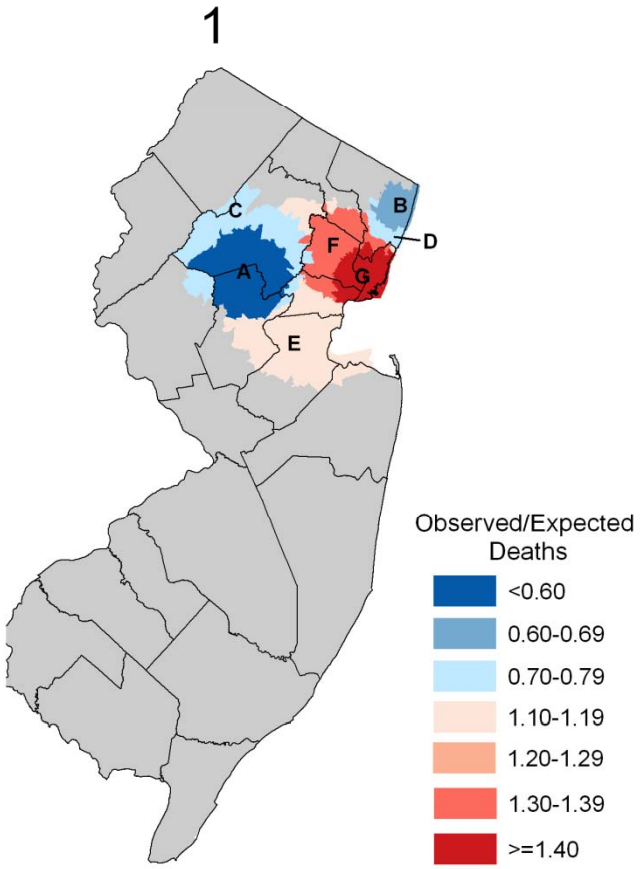
(Adjusted for sex, age, stage at diagnosis)



Results

Areas with shorter or longer than expected survival

Survival time adjustment :	Survival Area	No. of cases	Obs Deaths	O/E Deaths	P-value
Age, sex, stage	A	486	61	0.54	0.010
	B	1,252	188	0.72	0.040
	C	1,713	271	0.75	0.047
	D	954	133	0.67	0.043
	E	10,113	2,124	1.10	0.008
	F	5,804	1,324	1.24	<0.001
	G	2,771	666	1.40	<0.001

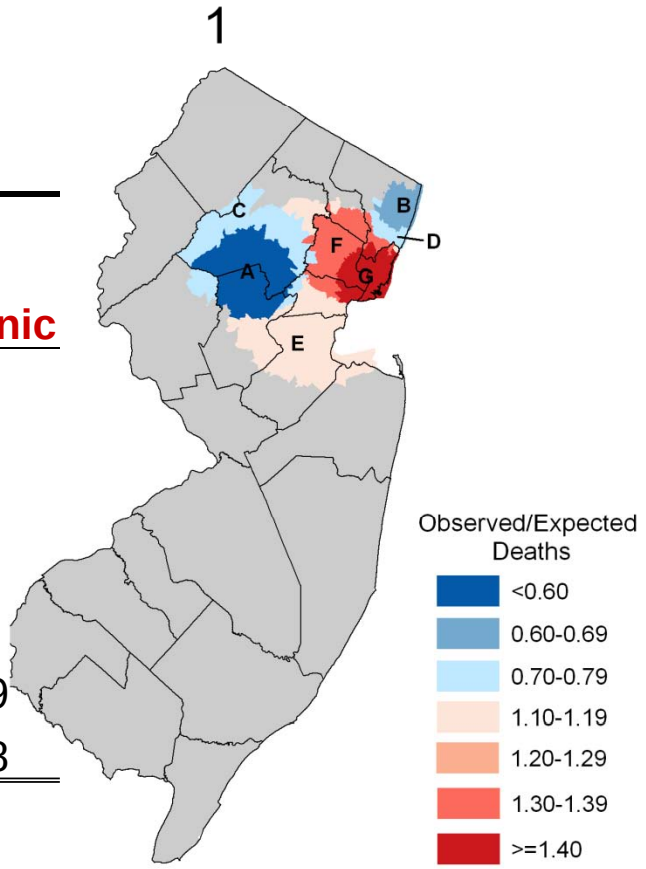


Source: Henry KA, Niu X, Boscoe FP: **Geographic disparities in colorectal cancer survival.** ***Int J Health Geogr 2009, 8:48.***

Results

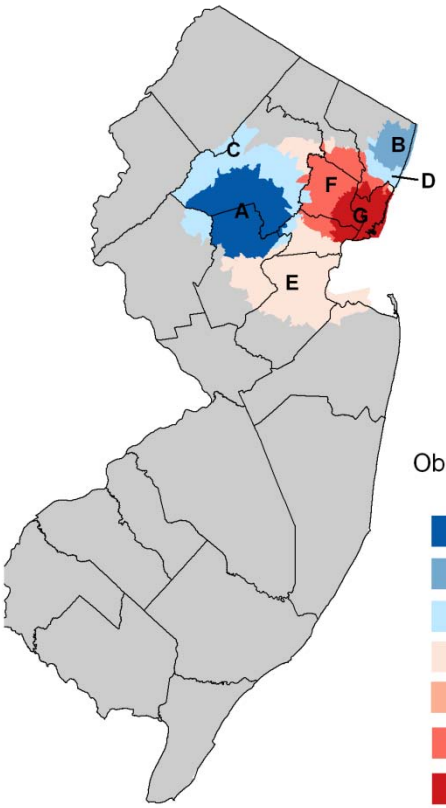
Areas with shorter or longer than expected survival

Survival time adjustment:	Survival Area	O/E Deaths	Average % CT Poverty	% NHW	% NHB	% Hispanic
Age, sex, stage	A	0.54	3.2	91.6	3.3	1.9
	B	0.72	3.4	91.1	2.2	3.8
	C	0.75	5.9	82.6	5.3	6.8
	D	0.67	4.4	80.7	8.2	6.2
	E	1.10	9.3	73.6	14.4	9.8
	F	1.24	12.2	65.5	19.5	12.9
	G	1.40	17.8	50.1	27.7	19.8



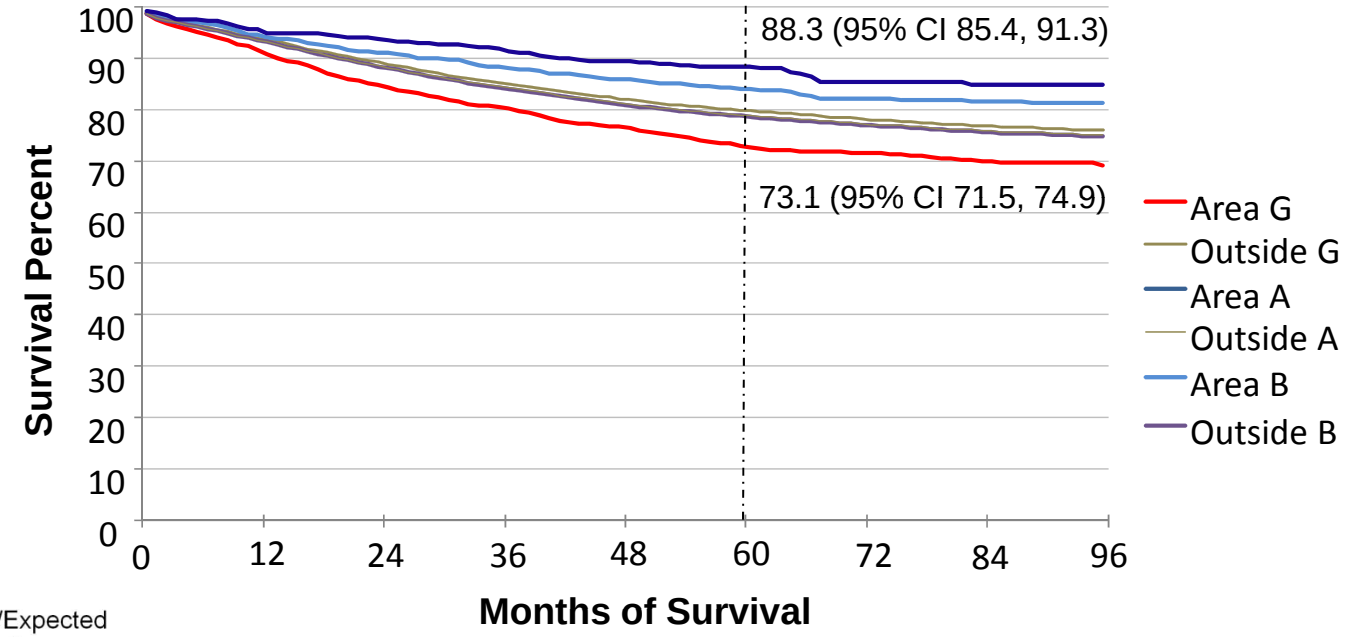
Results

Survival adjusted for sex, age, stage at diagnosis



Observed/Expected Deaths

- <0.60
- 0.60-0.69
- 0.70-0.79
- 1.10-1.19
- 1.20-1.29
- 1.30-1.39
- >=1.40



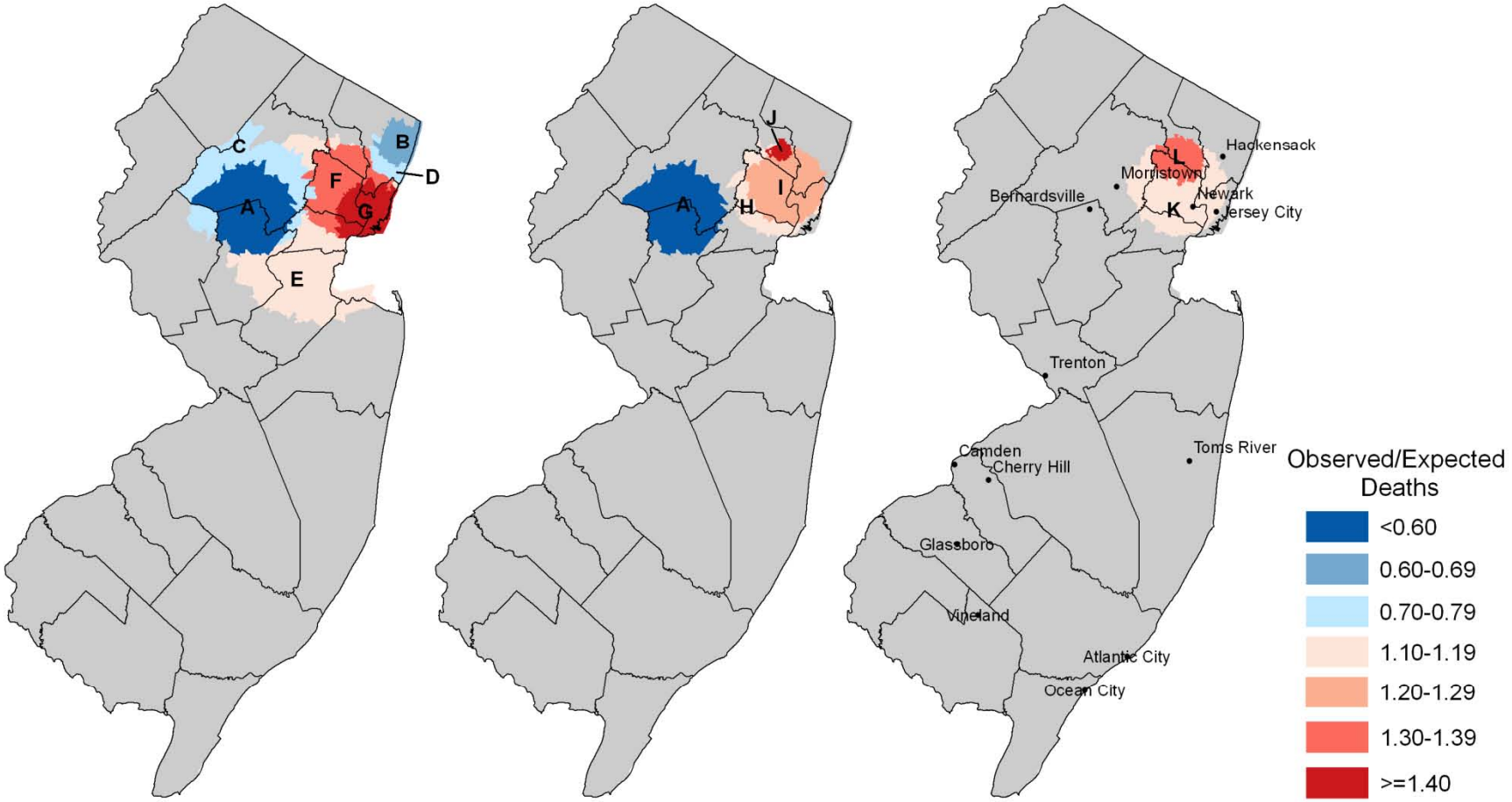
Results

Statistically Significantly Shorter or Longer CRC Survival

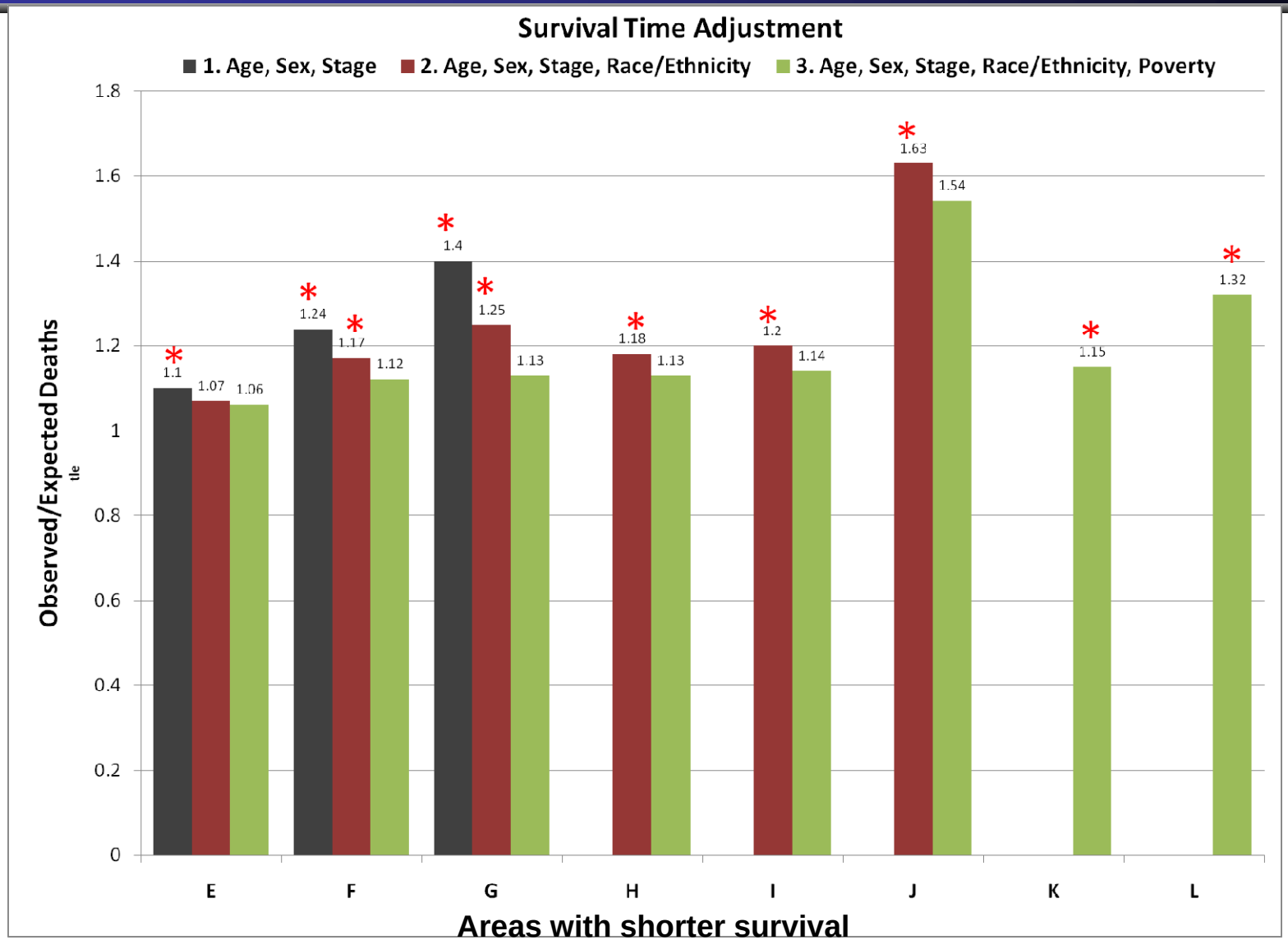
Model 1:
age, sex, stage

Model 2:
age, sex, stage, race/ethnicity

Model 3:
age, sex, stage, race/ethnicity, poverty



Results



* Statistically significant differences in survival based on the results from the spatial scan statistic

Discussion

- Significant differences in age and stage adjusted CRC survival by geographic location in New Jersey
- Survival times were not meaningfully affected by place of residence for those living in southern New Jersey
- Survival disparities persisted after adjustment for area-based poverty

- Where adjustment changed the geographic survival patterns and reduced the risk of death, these factors may be contributing causes of the disparities
- Smoothed map of observed/expected deaths helpful for interpreting results

Discussion

Possible explanations of geographic survival disparities

- Comorbidity
- Local problem of access to health care
- Local health care supply
- A pattern of care at one or more hospitals
- Other modifiable risk factors that are geographically patterned
- Additional factors not accounted for by area poverty

Limitations

- Misclassification of cause of death
- Unknown Cause of death (6%)
- Exclusion of cases missing stage of disease at diagnosis (approximately 9.6%)
  - (Whites, 9.3% versus blacks, 10.8%)
  - (Low poverty, 9% versus high poverty 10.8%),
- No information on comorbidity or lifestyle risk factors

Conclusion

- Prognosis of persons with CRC may differ, in part, by where they live when diagnosed.
- Several areas in New Jersey might benefit from additional clinical and ancillary services.
- Further studies need to focus on identifying specific pathways by which local factors and area deprivation explain survival disparities.
- Mapping survival disparities complements traditional non-spatial methods for describing survival outcomes.

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Thank you

Questions?