

Air Pollution and Hospitalization Rates in 8 U.S. Cities

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History

- Agricola(1556): "In the mines of Carpathian Mountains women are found who have married seven husbands, all whom this terrible consumption has carried of to a premature death."
- Chadwick(1842): "In some of the 'dusty trades' the excessive amount of premature mortality is so great as to justify interference."

Donora, PA 1948



London, 1952



London 1952

- Exposure levels: 4,500 $\mu\text{g}/\text{m}^3$
- Excess deaths: 4,000

Current EPA Standards

- PM_{10}
 - 50 $\mu\text{g}/\text{m}^3$ for 1 year
 - 150 $\mu\text{g}/\text{m}^3$ for 24 hour period
- $\text{PM}_{2.5}$
 - 15 $\mu\text{g}/\text{m}^3$ for 1 year
 - 65 $\mu\text{g}/\text{m}^3$ for 24 hour period

Harvard Six Cities Studies (1974-93)

- Six eastern US cities
 - Portage, WI
 - Topeka, KS
 - Watertown, MA
 - Kingston/Harriman, TN
 - St. Louis, MO
 - Steubenville, OH
- Selected to represent range of exposures to fossil fuel air pollution

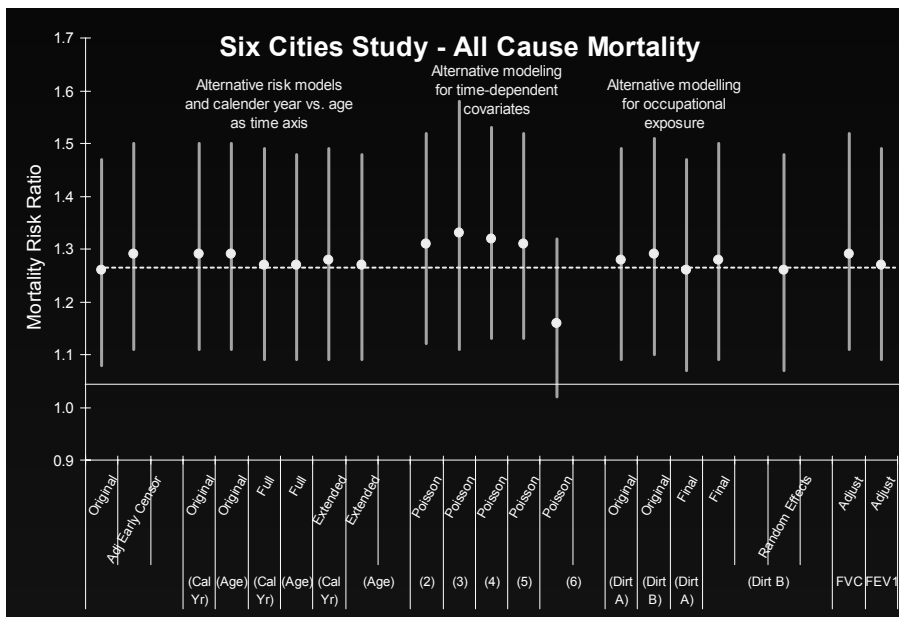


Six Cities Mortality Study

- Study of survival - years until death
- Predictors of survival?
 - Age and sex
 - Smoking, obesity, socioeconomic status
 - Occupation
 - Air pollution of city

Harvard Six Cities Mortality Study

- 8,111 adults enrolled in mid-1970's
- Determined personal characteristics
- Monitored deaths
 - Periodic visits (3,6, and 12 years)
 - Annual post-cards
 - Search of Social Security Records and National Death Index
- Compared survival to air pollution



Six Cities Results

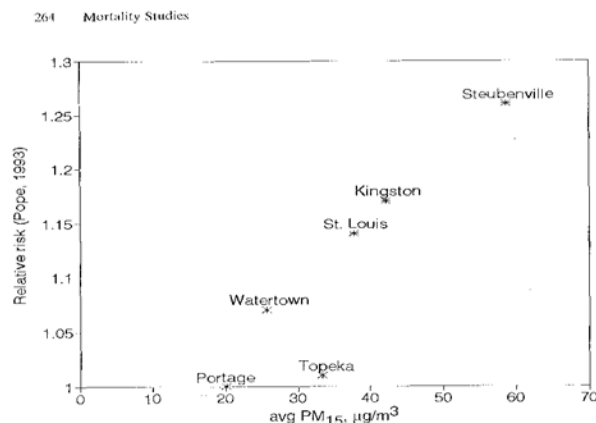


FIGURE 7-19. Relative mortality risk based on individual survival rates in 6 cities (Pope *et al.*, 1993) vs. average PM₁₀ levels (Speizer, 1989).

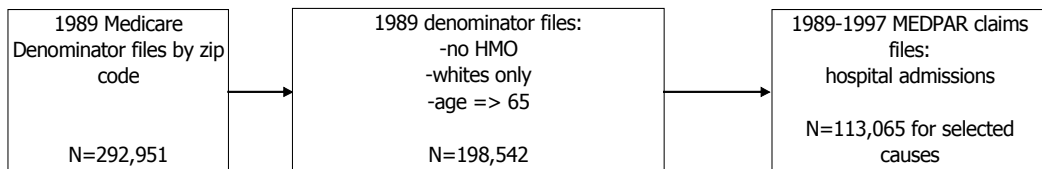
1990 Census Demographics for Six Cities

	WI	KS	MA	TN	MO	OH
Number of Residents	17,580	150,793	33,956	29,798	1,033,138	36,086
% Female over 65	61.0	61.5	65.3	58.9	63.2	60.8
% African American over 65	0.0	6.5	0.0	3.0	19.0	6.6
% Less than HS diploma	22.9	16.4	16.6	33.0	27.0	28.7
% over 65	16.1	13.1	16.9	14.2	15.5	18.9
% rural	100.0	88.0	0.0	100.0	0.2	11.0

Purposes of Current Study

- To attempt to replicate Dockery's findings on a cohort of elderly Medicare patients
- Outcome of interest: hospitalization rates
- Two additional sites were added
 - Salt Lake City, UT
 - Coos County, NH

Overall Study Design



1989 Cohort Prior to Exclusions

	MA	TN	OH	WI	KS	MO	NH	UT	p-value
age < 65 (%)	11.8	19.3	14.7	14.1	15.9	13.7	14.8	13.8	0.0001
black race (%)	0.4	2.7	7.7	0.01	3.7	18.6	0.07	0.62	0.0001
female (%)	63.5	55.8	58.3	57.2	59	61.4	57.0	57.2	0.0001
HMO enrollment (%)	3.4	0.6	0.6	12.4	7.2	5.5	0.3	1.85	0.0001

Final Cohort: N= 198,542

	MA	TN	OH	WI	KS	MO	NH	UT	p-value
Number	5,015	3,811	5,792	2,036	15,421	117,559	5,399	43,509	
Sex (%female)	65.3	58.5	61.1	58.1	63	64	59.5	59.2	0.0001
Age (%80 or over)	28.5	19.9	20.5	26.1	27.9	27.5	23.9	23.5	0.0001
Mean Age	75.4	73.5	74.0	74.9	75.0	75.2	74.4	74.3	0.0001
Not HS graduate(%)*	16.2	32	27.9	21.6	14.7	23.4	30.3	14.5	0.0001
Urban Environment (%)*	100.0	0.0	89.3	0.0	91.9	99.8	0.0	99.7	0.0001
mean income*	43,565	25,267	21,181	25,915	28,921	33,608	25,878	28,762	0.0001

ICD-9 Codes Used In Analysis, N

Diagnosis	ICD-9 Codes	Total Number 1989
Esophageal Cancer	150.0-150.9	199
Lung Cancer	162.0-162.9	3,032
Breast Cancer	174.0-174.9	1,833
Prostate Cancer	185.0-185.9	3,427
Congestive Heart Failure	428.0-428.9	37,204
	398.91	
	402.01-402.91	
	404.01-404.93	
Diabetes	250.0-250.9	18,624
Acute Myocardial Infarction	410.0-410.91	10,081
Chronic Obstructive Lung Disease	496.0-496.9	21,005
	491.2-491.29	
	492.8-492.89	
Renal Disease	584.0-586.9	7,479

ICD-9 Codes, continued

Alcoholism	303.0-303.9	3,696
	571.0-571.39	
	291.0-291.9	
	305.0-305.9	
	425.5	
	535.3	
	357.5	
	790.3	
	E880.0-E880.1	
	265.2	
Hypertension	401.0-405.9	50,883
Pneumonia	480.0-483.9	26,790
	485.0-486.9	
	487.0-487.09	
	507.0-507.09	
<u>Cardiovascular Diseases</u>	<u>400.00-440.99</u>	<u>90,360</u>

Number of Cases by City: 1989-1997

Diagnosis	MA	TN	OH	WI	KS	MO	NH	UT	Total
Esophageal Cancer	5	7	11	1	13	120	11	31	199
Lung Cancer	86	107	114	32	165	2,026	107	395	3,032
Breast Cancer	37	26	31	9	98	819	33	329	1,382
Prostate Cancer	67	54	92	31	216	1,876			2,336
CHF	996	893	1,367	389	2,447	22,164	978	7,970	37,204
Diabetes	288	239	364	77	569	5,548	282	2,831	10,198
AMI	69	54	94	18	156	1,532	75	883	2,881
COPD	521	739	865	310	1,745	12,729	740	3,356	21,005
Renal Disease	42	27	49	7	74	961	49	431	1,640
Alcoholism	66	193	84	48	494	1,886	125	800	3,696
Hypertension	672	409	546	227	1,691	13,369	537	6,034	23,485
Pneumonia	119	158	166	28	307	3,567	130	1,532	6,007

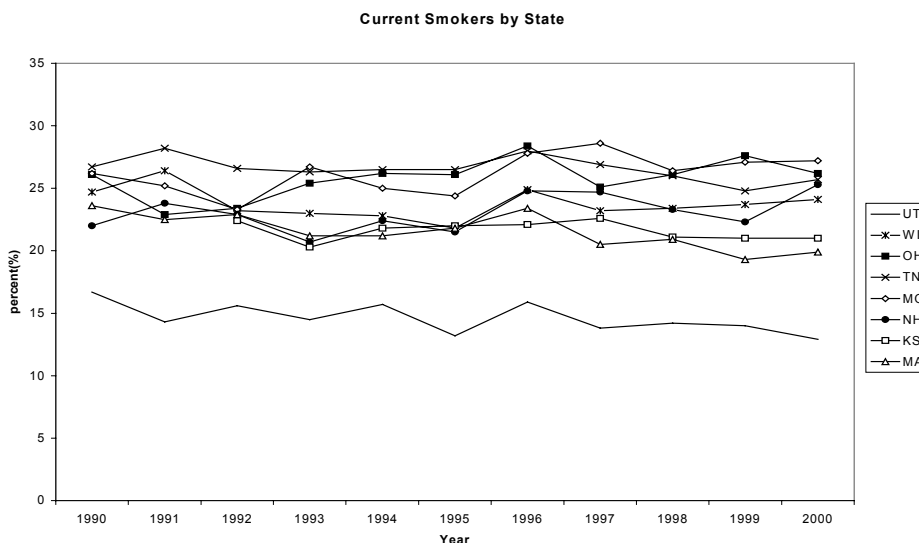
Other Pollutants in 8 Cities

County	Superfund Sites (N)	TRI* Sites(N)	Predominant site	Types of Pollutants**
Coos County, NH	0	0		
St. Louis, MO	6	187	Times Beach	dioxin
Middlesex County, MA	14	303	W.R. Grace***	VOCs
Jefferson County, OH	4	9		
Salt Lake County, UT	7	117		lead, arsenic, chromium, PCBs, VOCs
Shawnee County, KS	1	15		copper, chromium
Roane County, TN	1	2	Oak Ridge	mercury, cesium-137
Columbia County, WI	0	15		

Toxic Release Inventory (TRI)

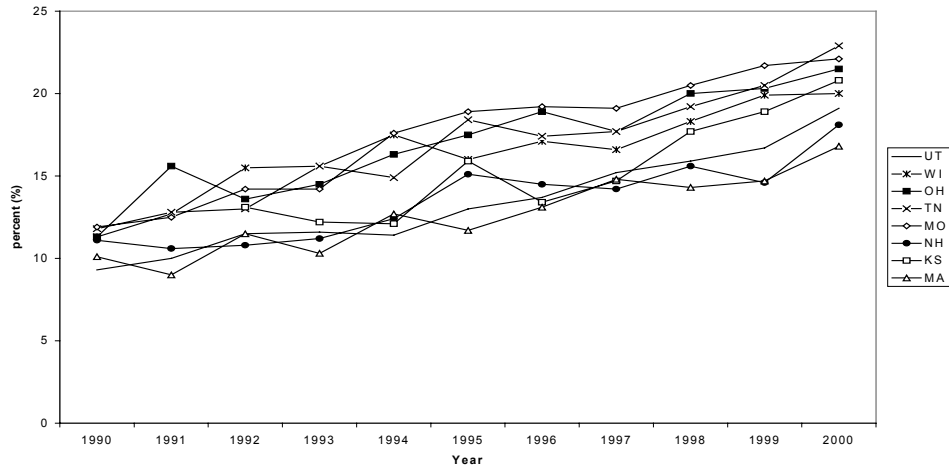
- History: In 1984, Union Carbide released large quantities of methylisocyanate in Bhopal, India, killing hundreds
- 1986, the U.S. passed community right to know laws
- TRI is the list of released chemicals required to be reported to the community

Current Smoking Rates by State, 1990-2000



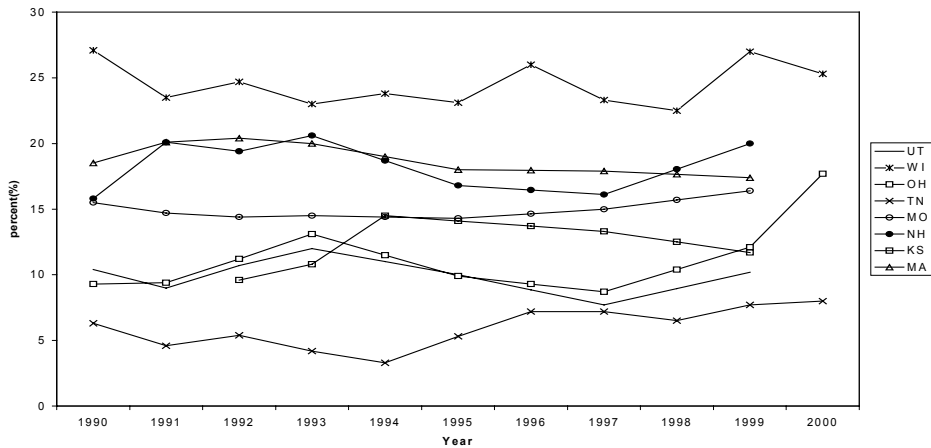
Obesity by State, 1990-2000

Obesity by Body Mass Index by State



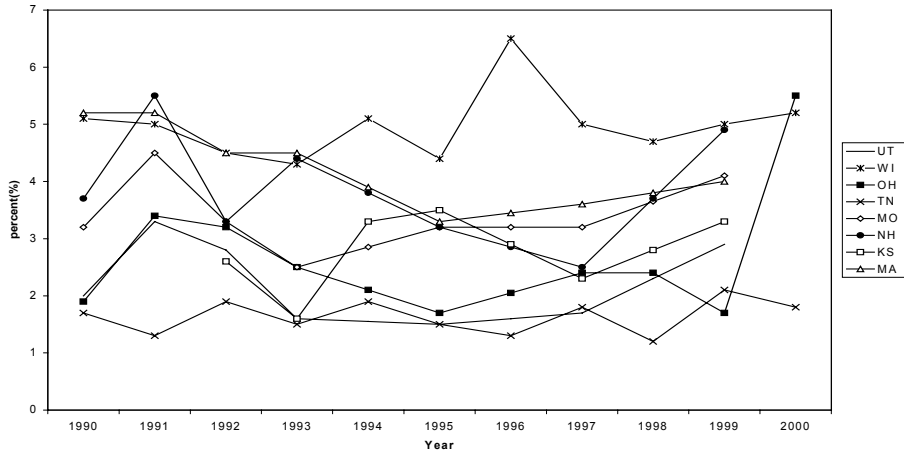
Binge Drinking by State, 1990-2000

Alcohol Use: Binge Drinking by State

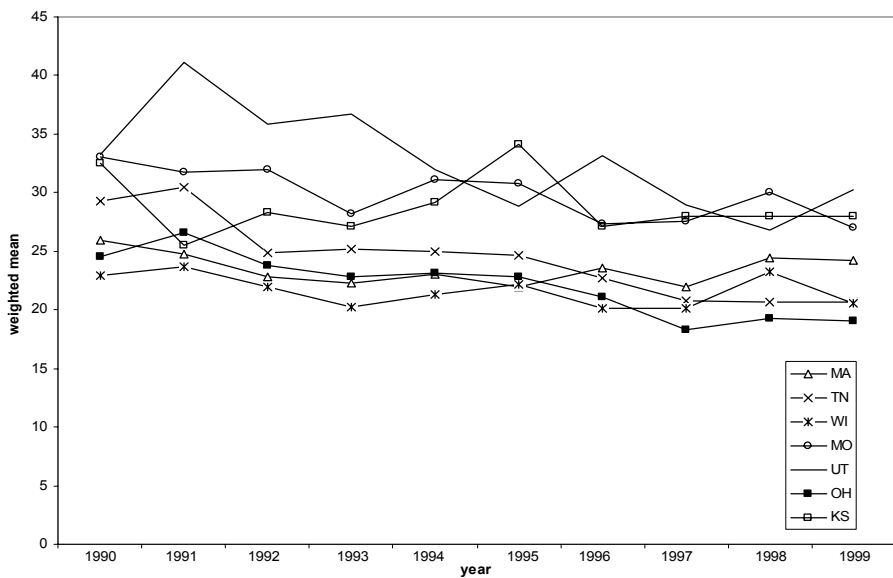


Chronic Drinking by State, 1990-2000

Alcohol Use: Chronic Drinking by State



Trends in Particulate Air Pollution, 1990-1999



Logistic Regression Results for CVD: WI control

With Cities-WI control

Risk Factor	OR	95% CI	c-statistic
MA	1.145		
TN	1.353	1.213-1.508	
OH	1.191		
KS	0.943		
MO	1.056		
UT	1.232	1.023-1.484	
NH	0.921		
No High School(%)	1.003	1.001-1.004	
80+ (%)	1.111	1.088-1.134	
Female (%)	0.937	1.920-0.955	
urban	1.000		
income	1.000		0.529

Logistic Regression for CVD: UT control

With Cities-UT control

Risk Factor	OR	95% CI	c-statistic
MA	0.929	0.874-0.988	
TN	1.098		
OH	0.967		
KS	0.765	0.736-0.796	
MO	0.857	0.834-0.880	
WI	0.811	0.674-0.977	
NH	0.747	0.629-0.888	
No High School(%)	1.003	1.001-1.004	
80+ (%)	1.111	1.088-1.134	
Female (%)	0.937	0.920-0.955	
urban	1.000		
income	1.000		0.529

Logistic Regression Results for CHF: WI control

With Cities-WI as control

Risk Factor	OR	95% CI	c-statistic
MA	1.163		
TN	1.202	1.050-1.377	
OH	1.306	1.028-1.657	
KS	0.881		
MO	0.998		
UT	1.079		
NH	0.863		
No High School(%)	1.011	1.009-1.012	
Under 80 (%)	1.727	1.686-1.770	
Female (%)	0.943	0.921-0.966	
urban	1.000		
income	1.000		0.583

Logistic Regression for CHF: UT control

With Cities-UT as control

Risk Factor	OR	95% CI	c-statistic
MA	1.078		
TN	1.114		
OH	1.210	1.126-1.299	
KS	0.817	0.775-0.861	
MO	0.925	0.893-0.958	
WI	0.927		
NH	0.800		
No High School(%)	1.011	1.009-1.012	
Under 80 (%)	1.727	1.686-1.770	
Female (%)	0.943	0.921-0.966	
urban	1.000		
income	1.000		0.583

Logistic Regression for COPD, CHF, AMI: WI as control

With Cities-WI control

Risk Factor	OR	95% CI	c-statistic
MA	0.911		
TN	1.138	1.004-1.289	
OH	1.091		
KS	0.856		
MO	0.852		
UT	0.855		
NH	0.862	0.764-0.973	
No High School(%)	1.011	1.010-1.013	
80+ (%)	1.371	1.339-1.405	
Female (%)	0.788	0.770-0.805	
urban	1.000		
income	1.000		0.567

Logistic Regression COPD, CHF, AMI: UT as control

With Cities-UT control

Risk Factor	OR	95% CI	c-statistic
MA	1.066		
TN	1.331	1.070-1.656	
OH	1.276	1.192-1.365	
KS	1.002		
MO	0.996		
WI	1.170		
NH	1.009		
No High School(%)	1.011	1.010-1.013	
80+ (%)	1.371	1.339-1.405	
Female (%)	0.788	0.770-0.805	
urban	1.000		
income	1.000		0.567

Logistic Analysis for Alcohol Related Admissions: WI control

With Cities-WI control

Risk Factor	OR	95% CI	c-statistic
MA	0.406	0.213-0.774	
TN	1.932	1.395-2.675	
OH	0.378	0.211-0.675	
KS	1.019		
MO	0.453	0.250-0.819	
UT	0.525	0.291-0.945	
NH	0.900		
No High School(%)	1.008	1.004-1.013	
80+ (%)	0.237	0.209-0.268	
Female (%)	0.562	0.526-0.600	
urban	1.004		
income	1.000		0.675

Alcohol-Related Admissions: UT as control

With Cities-UT control

Risk Factor	OR	95% CI	c-statistic
MA	0.774		
TN	3.681	2.157-6.282	
OH	0.720	0.568-0.912	
KS	1.941	1.722-2.187	
MO	0.862	0.777-0.957	
WI	1.905	1.058-3.431	
NH	1.716		
No High School(%)	1.008	1.004-1.013	
80+ (%)	0.237	0.209-0.268	
Female (%)	0.562	0.526-0.600	
urban	1.004		
income	1.000		0.675

Logistic Regression Lung Cancer: WI as control

With Cities-WI as control

Risk Factor	OR	95% CI	c-statistic
MA	1.608		
TN	1.563	1.045-2.337	
OH	1.548		
KS	0.996		
MO	1.501		
UT	0.826		
NH	1.145		
No High School(%)	1.011	1.006-1.016	
80+ (%)	0.425		
Female (%)	0.497		
urban	0.997		
income	1.000		0.655

Logistic Regression for Lung Cancer: UT control

With Cities-UT as control

Risk Factor	OR	95% CI	c-statistic
MA	1.946	1.521-2.490	
TN	1.891		
OH	1.874	1.492-2.352	
KS	1.205		
MO	1.816	1.601-2.060	
WI	1.210		
NH	1.385		
No High School(%)	1.011	1.006-1.016	
80+ (%)	0.425	0.381-0.475	
Female (%)	0.497	0.462-0.534	
urban	0.997		
income	1.000		0.655

Logistic Regression for Prostate Cancer: WI control

With Cities-WI control

Risk Factor	OR	95% CI	c-statistic
MA	0.595		
TN	0.999		
OH	0.766		
KS	0.629		
MO	0.736		
UT	0.928		
NH	0.967		
No High School(%) 80+ (%)	0.993	0.988-0.998	
urban income	1.005 1.000		0.551

Logistic Regression for Prostate Cancer: UT control

With Cities-UTcontrol

Risk Factor	OR	95% CI	c-statistic
MA	0.641	0.494-0.832	
TN	1.077		
OH	0.826		
KS	0.677	0.578-0.795	
MO	0.793	0.719-0.875	
WI	1.077		
NH	1.042		
No High School(%) 80+ (%)	0.993	0.988-0.998	
urban income	1.005 1.000		0.551

Logistic Regression for Breast Cancer: WI control

With Cities-WI control

Risk Factor	OR	95% CI	c-statistic
MA	0.234		
TN	1.05		
OH	0.189	0.046-0.784	
KS	0.208	0.047-0.923	
MO	0.227		
UT	0.236		
NH	0.938		
No High School(%)	1.000		
80+ (%)	0.528	0.469-0.594	
urban	1.014		
income	1.000		0.564

Logistic Regression for Breast Cancer: UT control

With Cities-UT control

Risk Factor	OR	95% CI	c-statistic
MA	0.991		
TN	4.444		
OH	0.801		
KS	0.882		
MO	0.960		
WI	4.233		
NH	3.969		
No High School(%)	1.000		
80+ (%)	0.528	0.469-0.594	
urban	1.014		
income	1.000		0.564

L.R. for CHF, COPD, Pneumonia, HTN and AMI: WI control

With Cities-WI control

Risk Factor	OR	95% CI	c-statistic
MA	1.014		
TN	1.347	1.194-1.521	
OH	1.213		
KS	0.902		
MO	0.983		
UT	0.987		
NH	0.945		
No High School(%)	1.009	1.008-1.011	
80+ (%)	1.464	1.431-1.497	
Female (%)	0.759	0.743-0.775	
urban	1.000		
income	1.000		0.572

L.R. for CHF, COPD, Pneumonia, HTN and AMI: UT control

With Cities-UT control

Risk Factor	OR	95% CI	c-statistic
MA	1.028		
TN	1.366	1.018-1.682	
OH	1.229	1.152-1.312	
KS	0.915	0.873-0.958	
MO	0.996		
WI	1.014		
NH	0.958		
No High School(%)	1.009	1.008-1.011	
80+ (%)	1.464	1.431-1.497	
Female (%)	0.759	0.743-0.775	
urban	1.000		
income	1.000		0.572

Conclusions

- Hospitalization rates follow assumptions based on cigarette smoking, alcohol consumption
- Trends do not appear to be consistent with air pollution

Critique-CONS

- No data on individual-level risk factors
- Other ways of looking at outcomes:
 - By time
 - Multiple admissions

Critique: PROS

- Complete cohort of Medicare elderly
- Spans long period of time (1989-1993)